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Environmental Guidelines for Small-Scale Activities in Africa:

Environmentally Sound Design for Planning and Implementing Development Activities

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CONTENTS

Part I **Introduction**

	Acknowledgements	i
	Foreword	ii
	Table of Acronyms	v
Chapter 1	About These Guidelines	1-1
Chapter 2	Environmentally Sound Design	2-1

Part II **Environmental Issues and Best Practices for Particular Sectors**

	Introduction	
Chapter 1	Agriculture and Irrigation	1-1
Chapter 2	Community-Based Natural Resources Management	2-1
Chapter 3	Construction	3-1
Chapter 4	Ecotourism	4-1
Chapter 5	Energy Sources for Small-Scale Development	5-1
Chapter 6	Fisheries and Aquaculture	6-1
Chapter 7	Forestry	7-1
Chapter 8	Healthcare Waste: Generation, Handling, Treatment and Disposal	8-1
Chapter 9	Housing	9-1
Chapter 10	Humanitarian Response and Natural Disasters	10-1
Chapter 11	Livestock Production	11-1
Chapter 12	Pest Management: Integrated Pest Management	12-1
Chapter 13	Pest Management: Safer Pesticides	13-1
Chapter 14	Rural Roads	14-1
Chapter 15	Solid Waste: Generation, Handling, Treatment and Disposal	15-1
Chapter 16	Water Supply and Sanitation	16-1

Part III **Micro and Small Enterprises (MSE) Sector Briefing**

Chapter 1	Introduction	1-1
Chapter 2	Mechanisms for MSEs to Control Environmental Impact	2-1
Chapter 3	Institutionalizing Environmental Capacity	3-1
Chapter 4	Sub-Sector Specific Cleaner Production Briefings	4-1
	4.1 Brick and Tile Production	4-3
	4.2 Food Processing	4-11
	4.3 Leather Processing	4-23

	4.4 Metal Finishing	4-33
	4.5 Small-Scale Mining	4-51
	4.6 Wet Textile Operations	4-65
	4.7 Wood Processing	4-74
Chapter 5	References	5-1
Chapter 6	MSE Annexes	6-1
	Annex A Sample Environmental Screening Report	6-2
	Annex B Classifying MSEs	6-9
	Annex C Sample Loan Screening Form	6-15
	Annex D Sample Environmental Commitment Form	6-19
	Annex E Sample Terms of Reference for Consultants	6-21

Part IV

Appendix	Topic Briefing: Introduction to Environmental Assessment	1-1
	Index	

Acknowledgments

The first edition of the *Environmental Guidelines for Small-Scale Activities in Africa* was published in June 1996 by the Bureau for Africa's Office of Sustainable Development. Distributed widely, and reprinted many times for USAID and the Agency's implementing partners over the years, it served as a useful and basic reference for development professionals engaged in environmentally sound design and management of small-scale development activities.

This second edition of the *Guidelines* represents a collaborative effort involving over 20 compilers, editors and reviewers. The materials were drawn from the work of many highly knowledgeable, field-oriented authors and organizations. It is our hope that this combined effort now provides in one location some of the most up-to-date and useful resources currently available.

Both the original guidelines and this expanded and updated version owe their existence to the dedication and foresight of Dr. Walter Knausenberger, currently USAID's Senior Regional Environmental Officer for East and Southern Africa. For over a decade Walter championed the need for USAID, and the Africa Bureau in particular, to widely disseminate and apply the best available materials on environmentally sound design, best management practices, environmental assessment, and environmental mitigation and monitoring to USAID and the Agency's partners.

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Special appreciation must go to Stephanie Rosch, whose coordination of editorial refinements and the revision process kept us all from being drowned in a river of multiple edits and re-edits.

Finally, these acknowledgements would not be complete without recognizing Mark Stoughton's contribution. Mark's ability to organize, consolidate, and clearly communicate environmental impact assessment and environmentally sound design principles has been central to this revision.

Foreword

Experience has shown that following environmentally sound design (ESD) principles in planning and carrying out new small-scale projects and programs helps people to avoid potentially costly mistakes and often makes development activities more sustainable over the long run.

Since the first edition of USAID's *Environmental Guidelines for Small-Scale Activities in Africa* appeared in June 1996, the literature on environmental impacts associated with small-scale development activities, ESD, and "best management practices" for mitigating potential impacts has grown dramatically.

This updated and expanded version of the *Guidelines* is intended to capture this past decade of experience. Each sector module draws on literature and materials developed and applied by a number of leading *field-based* practitioners and institutions.

However, like the first edition, this edition of the *Guidelines* cannot provide a comprehensive treatment of best management practices in each sector. Rather, it focuses on key issues, impacts and mitigation measures and guides users to more detailed sources.

To this end, this version of the *Guidelines* includes annotated bibliographies of the most useful source materials. In each case, we have emphasized materials available via the Internet. The online version of the *Guidelines* at www.encapafrica.org contains HTML links to these sources, while the CD-ROM version of the Web site contains both the *Guidelines* and much of this source material. We therefore hope that development practitioners will be able to quickly find and consult extensive practical sources on specific sectors.

Because ESD for small-scale activities requires the people responsible to understand ESD principles and integrate them into project design and implementation, it cannot and should not be the exclusive concern of environmental professionals. We have therefore worked to keep the language of the *Guidelines* as straightforward and as free of technical jargon as possible.

The development of the *Guidelines* was funded by USAID to meet the needs of its staff and its partner organizations. However, they are broadly applicable to other donors, community-based and non-governmental organizations, local governments, and others engaged in small-scale activities.

We encourage suggestions and comments. We hope users will point us to materials we may have overlooked and to new materials that advance the state of the art in this critical area. Note that the online version of the guidelines at www.encapafrica.org will always contain the most recent versions of all materials and bibliographies.

Finally, we encourage broad dissemination of these materials, including photocopying and electronic distribution. However, we do request that all such excerpted or copied materials be properly attributed.

The *Guidelines* Core Team
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March 2003

Acronyms

AEC	Agency Environmental Coordinator
AFR	Bureau for Africa (USAID)
AIDS	Acquired Immune Deficiency Syndrome
ANR	agriculture and natural resources
BDS	business development services
BEO	Bureau Environmental Officer (USAID)
BOD	Biological Oxygen Demand
CAMPFIRE	Communal Areas Management Program for Indigenous Peoples Project (Zimbabwe)
CBNRM	community based natural resource management
CBOs	community based organizations
CE	Categorical Exclusion
CEQ	Council on Environmental Quality (United States)
CFR	Code of Federal Regulations (United States)
CFR 216	CFR Part 216, U.S. Federal regulations covering USAID's Environmental Procedures
CGIAR	Consultative Group for International Agricultural Research
CIDA	Canadian International Development Agency
CIP	Commodity Import Program
CP	cleaner production
CSP	Country Strategic Plan
DANIDA	Danish International Development Agency
DCHA	Bureau for Democracy, Conflict and Humanitarian Assistance
DO	dissolved oxygen
EA	Environmental Assessment
EGAT	Economic Growth, Agriculture and Trade, Pillar Bureau (USAID)
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EMS	Environmental Management System
ENCAP	Environmental Capacity Building Program (USAID Africa Bureau)
ENR	Environmental and Natural Resources (USAID/EGAT office)
ENV	Environmental Protection Unit (technical unit in USAID/AFR/SD/PSGE)
EPA	US Environmental Protection Agency
EPIQ	Environmental and Natural Resources Policy Indefinite Quantity Contract
ERF	Environmental Review [or Screening] Form
ESA	East and Southern Africa
ESD	Environmentally Sound Design
ESF	Environmental Screening and Reporting Form

FAA	U.S. Foreign Assistance Act
FAO	Food and Agricultural Organization
FEWS NET	Famine Early Warning Systems Network
FFP	Food for Peace
FOG	Field Operations Guide
FSC	Forest Stewardship Council
FSN	Foreign Service National
GDP	gross domestic product
GIS	Geographic Information Systems
GPS	Global Positioning Systems
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit (German Technical Cooperation Agency)
HIV	Human Immunodeficiency Virus, cause of AIDS
H.R.	House resolution (U.S. Congress)
HVLP	high-volume low-pressure
ICDP	integrated conservation and development project
ICIs	Intermediate Credit Institutions (ICIs)
IDPs	internally displaced persons
IEE	Initial Environmental Examination (USAID environmental review procedure)
IPM	integrated pest management
ISDR	International Strategy for Disaster Reduction
IUCN	World Conservation Union
IVM	integrated vector management
LAUs	Limits of Acceptable Use
LC	local currency
M&E	monitoring and evaluation
MEO	Mission Environmental Officer (USAID)
MSEs	Micro and Small Enterprises
NEAP	National Environmental Action Plan
NGO	nongovernmental organization
NO_x	Nitrogen Oxides
NPA	nonproject assistance
NRM	natural resources management
O&M	Operation and Maintenance
OFDA	Office of U.S. Foreign Disaster Assistance (in USAID DCHA Pillar Bureau)
P&D	Planning and Design
PA	protected area
PCBs	polychlorinated biphenyls
PEA	Programmatic Environmental Assessment
PL	public law

PRA	Participatory Rapid Appraisal
PVCs	polyvinyl chlorides
PVO	private voluntary organization
RDC	regional district councils
REA	rapid environmental assessment
REA	Regional Environmental Advisor
REDSO/ESA	Regional Economic Development Support Office, (USAID)
Reg. 216	Regulation 216 (informal shorthand for 22 CFR 216)
REO	Regional Environmental Officer (USAID)
SD	Office of Sustainable Development (USAID/AFR)
SIDA	Swedish International Development Cooperation Agency
SL	sustainable livelihood
SMEs	Small and Medium Enterprises
SO	Strategic Objective
SS	Site Selection
SSI	small-scale irrigation
STD	sexually transmitted diseases
Title II, TII	One of the main provisions of P.L 480 applying to food aid programmed by PVOs
TSP	trisodium phosphate
TSS	total suspended solids
UNCHS	United Nations Commission on Human Settlements
UNDHA	United Nations Department of Humanitarian Affairs
UNDP	United Nations Development Program
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNHCR	United Nations High Commissioner for Refugees
URL	uniform resource locator
USAID	U.S. Agency for International Development
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USLE	Universal Soil Loss Equation
VOCs	volatile organic compounds
WFP	World Food Program
WHO	World Health Program
WUA	water user association
WWF	World Wildlife Fund

Chapter 1
About these Guidelines

Contents

Purpose and Intended Audience	1-1
What Types of Activities are Covered?	1-2
How to use these Guidelines	1-2
Limitations	1-3

USAID increasingly relies on two types of partner organizations to implement its development programs: private voluntary organizations (PVOs) and nongovernmental organizations (NGOs).[1]

USAID's mission is to create "sustainable development." Assuring that USAID projects and activities are environmentally sound is vital to their sustainability. This is more than just a desirable development outcome; USAID is legally required by Chapter 22 of the Code of Federal Regulations, part 216 ("Regulation 216) to apply its environmental review procedures to *all* projects, programs or activities.

As the involvement of partner organizations in the work of USAID increases, assuring the environmental soundness of small-scale activities poses particular challenges:

- Partner PVOs and NGOs must satisfy USAID environmental requirements which are often unfamiliar and can be confusing.
- USAID personnel must adapt environmental procedures designed for larger-scale activities and contractors, who are familiar with USAID procedures, to smaller-scale activities and indigenous organizations.
- Institutional procedures alone do not guarantee environmentally sound design. Shared basic knowledge about environmentally sound design is equally necessary.

About these guidelines

Using these guidelines will help you:

- Take steps to ensure projects in sectors from agriculture to construction and road building are environmentally sound
- Understand and meet USAID requirements
- Learn about environmentally sound design principles and practices
- Find references and information on design, implementation, monitoring, mitigation and evaluation of small-scale development projects

Purpose and intended audience

These guidelines were developed to help USAID and its partners meet the challenges posed by the need for environmentally sound design (ESD) in small-scale activities. Specifically, this book is:

- An introduction to ESD, both in general and specific sector activities. The guidelines set out ESD's basic principles and should assist PVOs and NGOs in integrating environmental concerns into activities and programs.

[1] In these guidelines, PVO is used to refer to organizations whose headquarters are outside Africa. NGO refers to indigenous national or regional institutions in Africa.

- A reference for PVOs and NGOs operating in Africa on USAID environmental procedures and requirements. These guidelines should help PVOs and NGOs write concept papers and creating proposals, as well as implementation plans and associated mitigation, monitoring and evaluation plans, that conform to USAID's environmental procedures.
- A reference for USAID staff for evaluating and classifying project concept papers,;proposals, implementation plans,;and mitigation, monitoring and evaluation plans.

What types of activities are covered?

- Small-scale activities at the community level. (Small-scale activities are defined here as being under $100,000 in total project size.)[2]
- Longer-term development activities, including agriculture, rural development and natural resources management.
- Integrated conservation and development activities, which require careful balancing of needs for biodiversity and ecosystem protection with the economic and social development needs of human populations.
- Emergency relief and disaster rehabilitation activities (including food-for-work programs).

How to use these guidelines

Figure 1-1 depicts the basic structure of the guidelines.

- All users are encouraged to read chapter 2, which introduces ESD concepts and terminology.
- Part II serves as a reference and resource for environmental issues associated with particular sector activities.
- Part III discusses cleaner production and micro- and small enterprises, with a more detailed look at several subsectors of MSEs.
- A separate booklet provides stand-alone references and information on environmental impact assessment (EIA) and USAID environmental review procedures, respectively. These serve as key references for the ESD process presented in Chapter 4. They may also be consulted independently.

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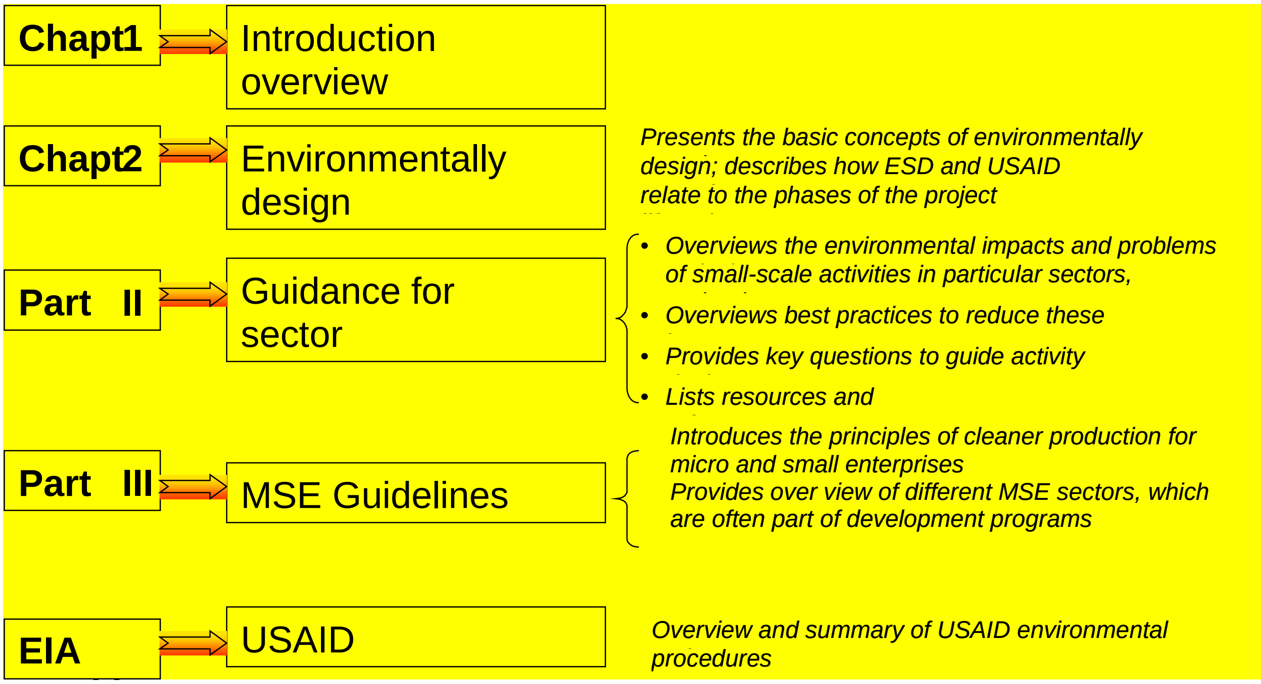
[2] However, such small-scale activities are often within umbrella projects for which total funding may exceed $1 million.

Figure 1-1: Overview of the Small-Scale Guidelines



Limitations

The guidelines are a summary for experienced development professionals. They are not a substitute for detailed sources of technical information or design manuals for projects implemented by PVOs and NGOs. Users are assumed to have background and experience in the technical aspects of project design.

Please refer to the accompanying list of references for additional information.

These are guidelines only and have no legal standing. Please refer to the separate Environmental Impact Assessment booklet for a fuller description of USAID environmental procedures and for the actual text of USAID's Regulation 216.

Chapter 2
Environmentally Sound Design[1]

Contents

What is Environmentally Sound Design?	2-1
Environmental Impact Assessment	2-2
The Relationship of Environmentally Sound Design to Sustainable Development	2-2
Environmentally Sound Design and Best Development Practices	2-3
Community Participation is Central to ESD	2-6
ESD Is not Enough to Assure Sustainable Activities	2-7
Integrating ESD, USAID Environmental Procedures and the Project Lifecycle	2-7

What is environmentally sound design?

For the purposes of these *Guidelines,* environmentally sound design (ESD) is the design and implementation of activities and projects such *that the environmental harm associated with a particular development objective is kept to a practicable minimum.*

ESD is necessary to prevent:

- Failure of economic or social development projects due to environmental causes.
- Damage to the environment which imperils future economic and social development.

Environmentally sound design is prevention-based across the project lifecycle. Prevention begins with the choice of *means* by which a development objective is achieved.

For example, the development objective (or goal) of a project or activity may be to improve agricultural productivity. Potential means to achieve this objective include; introducing new crop varieties; promoting the use of chemical inputs; introducing irrigation; changes to tilling and soil

Common Sources of Environmental Design Failures

- Failure to anticipate potential "critical events"—drought, famine or civil strife and related emergency assistance
- Failure to consider the effects of increased scale. For example, the immediate effects of a small-scale animal husbandry project may be minor. BUT if the project succeeds and animal holdings multiply, the effects may pose serious problems.
- Failure to consider the environmental effects of increased income and population growth.

[1] This chapter was originally developed in support of USAID's Africa Bureau course "Environmental Assessment and Environmentally Sound Design for Small Scale Activities."

conservation practices; integrated pest management; or some combination of these measures. Environmentally sound design dictates that each alternative be considered, and that the environmental impacts associated with each choice be weighed *alongside* technical, economic and social criteria.

Once the means are chosen, environmentally sound design also takes a prevention-based approach to the specifics of project design. Can changes in location, construction techniques, or operating practices significantly reduce critical environmental damage?

Finally, where negative impacts cannot be entirely prevented or minimized by design choices, environmentally sound design mandates that they be mitigated during project operation, or remediated after the project is decommissioned.

Examples of Environmental Failures of Small-scale Activities

- Improperly sited waste disposal from a new community health post contaminates the community water supply,
- Soil salinizes and becomes infertile due to improper irrigation practices
- Poor siting and construction of a market access road cause siltation of a stream which serves as both a community water supply and fish hatchery.

Environmental impact assessment: a process for ESD

Environmental impact assessment (EIA) is a formal process for identifying the likely effects of particular activities or projects on the environment and on human health and welfare.

As such, we view EIA as a tool to organize, facilitate and document the practice of environmentally sound design. Stated another way, *environmentally sound design is the goal or objective of any EIA process.*

EIA is useful to both project designers and planners and those who must assess project proposals for funding:

- EIA provides a structure for clearly listing environmental review requirements. Such review requirements are “safety checks” for environmental soundness.
- The documentation required by the EIA forms a basis for anyone making an environmental evaluation of a projects design and implementation. Evaluators may include funders, regulatory agencies, and the implementing organization itself.
- The systematic nature of the EIA process reduces the errors and oversights which are likely when people use ad hoc approaches to environmental design.

USAID’s environmental procedures are one particular means of implementing the general EIA process described in a separate publication.

Note that in addition to assessing a project’s potential negative environmental impacts, EIA encompasses the development of mitigation measures and management plans to reduce such impacts.

The relationship of environmentally sound design to sustainable development

Sustainable development is the overall objective of any process of economic and social development.

Meaningful movement towards more sustainable development requires both: (1) that development activities themselves be sustainable; and (2) that a set of enabling conditions be fulfilled.[2] Because ESD occurs at the project or activity level, it addresses the first sustainability requirement: ESD is essential to implementing *sustainable activities*.

As its name implies, ESD is primarily concerned with environmental sustainability. However, since ESD involves *environmental justice*, it also has an important application to *social sustainability*. Environmental justice is the idea that the poor should not bear a disproportionate part of the economic and health burdens of environmental degradation.

Environmentally sound design and best development practices

ESD requires that possible environmental damage associated with projects be predicted and its effects mitigated. This is not sufficient, however. Environmentally sound design must also adhere to a set of principles which apply to sound project design, management and implementation *in general.* These principles have grown out of the experience of development organizations in the field. In very general terms, they represent a current consensus on "best practice" in development:

- Assure technical feasibility
- Understand the social and policy context
- Secure stakeholder commitment
- Engage in supportive capacity-building
- Practice adaptive management

This document is not intended to be a primer on these best practices. As development professionals, the users of this document are well aware of their importance. Each best practice, however, has specific applications to ESD. The remainder of this section discusses these applications.

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[2] Enabling conditions for achieving more *environmentally* sustainable development include:

- a legal and policy framework enabling sustainable private-sector and public initiatives
- clearly defined national objectives related to environmental design and management
- good information regarding national/regional environmental resources and conditions (e.g., assessments or management plans)
- sufficient host county capacity to implement and apply environmental laws and policy (includes financial resources, trained professionals, effective institutions)—and clearly defined responsibility and accountability for this implementation.

Note that consideration of the enabling conditions for *economically* and *socially* sustainable development would expand this list dramatically.

Assure technical feasibility

All projects must be *technically feasible.* The construction techniques, materials, and technologies employed must meet their intended purpose over the lifetime of the project.

In the area of the environment, technical feasibility means that the design is appropriate and robust in terms of the environmental conditions of the project site(s). Environmental conditions include climate (e.g., patterns of rainfall, temperature ranges), soil types, aquifer characteristics, and the probability of extreme events such as cyclones and earthquakes. For example:

- Are the choices of crops or trees appropriate to climate and soils?
- For buildings and infrastructure, are construction methods and materials appropriate to the anticipated use and lifetime, given environmental conditions?

National Environmental Action Plans (NEAPs)

National Environmental Action Plans (NEAPs) are intended to be demand-driven, action-oriented national strategies that integrate environmental management into a country's economic development process. The first NEAP was launched in Madagascar with World Bank assistance in 1987. By 1995, more than 30 NEAPs had been initiated in Africa, and more than 50 worldwide. The Bank has often aided the NEAP process by coordinating donors and mobilizing their support.

Nonetheless, NEAPs are meaningful only if they are implemented. Early on, NEAPs enjoyed a high political profile, funding and significant momentum. Most plans, however, had inadequate implementation strategies. Translating early momentum into long-term commitment on the part of developing country governments and institutions, donors, and NGOs remains the central challenge.

Understand social and policy context

Projects and activities do not exist in isolation. They are implemented within an environmental, social, economic and institutional context. This context can determine whether a project or activity is viable or even desirable. Social and policy context issues particularly important to ESD include:

- **De facto and de jure national environmental and resource management policy.** Project design and implementation should conform to national environmental laws and regulations. They should be compatible with national environmental strategy (e.g., as set out in National Environmental Action Plans, see sidebar 2.C).

  However, there is often a large difference between official environmental law or policy in African countries ("de jure"), and what is actually implemented and enforced in practice ("de facto"). Project planners cannot assume that the protections such laws may provide in theory will be achieved in reality. For example, the upstream drainage of a village water supply may lie within a national park. In theory, the purity of the water supply is secure, as its source is protected. In reality, government laxness or corruption may leave the park open to illegal logging or mining, either of which could pollute the water sources.

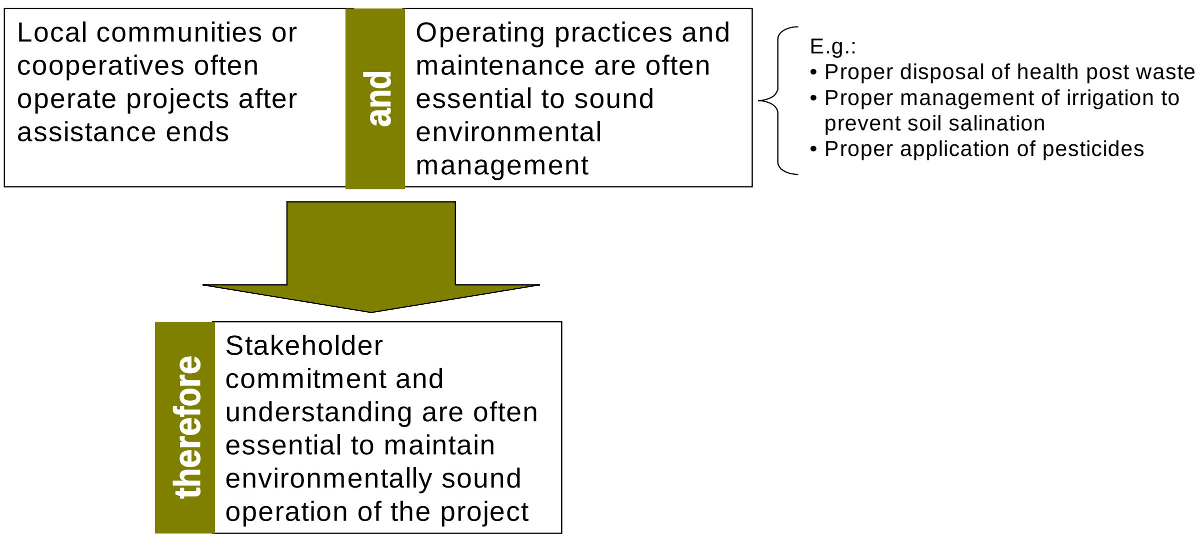
- **Local or traditional systems of resource management and allocation**. Systems of land tenure and resource management have clear relevance to most rural development projects. In rural areas of African countries, land tenure is often a mix of de jure and traditional systems—and projects must frequently obtain approval for land or resource use through *both* systems.

  Moreover, traditional systems of resource management are often *gender-specific.* That is, customs may assign the responsibility for monitoring and managing a given resource only to women, or only to men. Project designers cannot assume that the men in a community can speak for the women, or vice versa.

- **National economic policy and ongoing policy reform**. Many African governments are pursuing sectoral or structural adjustment programs to stimulate economic growth and international trade. Examples of macroeconomic tools used in such programs include altering exchange or interest rates, reducing government budgets, promoting market liberalization and enhancing the role of the private sector. These reforms can influence—both positively and negatively—how resource users manage their environment.

  For example, liberalization of export laws and/or development of transport and export infrastructure can encourage timber exports, whether or not this is a targeted activity. Inappropriate or poorly enforced forestry policies can result in an acceleration of deforestation or significant declines in forest productivity.

Figure 2.1: The importance of stakeholder commitment



Secure stakeholder commitment

Stakeholders are those groups most directly affected by the project. This includes the intended beneficiaries, the funders, and those whose use of, or access to, local resources is likely to be affected. Here, we focus on residents of local communities and users of local resources.

Figure 2.1 illustrates the importance of stakeholder commitment when local communities or cooperatives take over a project or activity after assistance ends—a very typical situation from small-scale activities. Often a project will maintain its environmental soundness only if proper operation and maintenance procedures are followed; the figure cites a few examples. Without stakeholder commitment, these proper procedures are likely to be violated. In the worst case, the project may actually do more harm than good. (for example, if waste from a health post sickens the community at large).

Capacity-building

Capacity-building is an essential complement to and means of securing stakeholder commitment. In an environmental context, capacity building means helping local users or project beneficiaries to acquire:

- the knowledge or skills required to operate and maintain a project in an environmentally sound manner
- an understanding of how project activities affect environmental health, and why these operation and maintenance practices are important. Such understanding is essential to secure stakeholder commitment.

Adaptive Management

Under adaptive management, managers adjust the way they carry out a project in response to feedback from the field. Adaptive management requires both project monitoring and decision-making based on monitoring results.

Sharing knowledge

Adaptive management extends beyond individual projects. At its best, it means learning from other projects and other organizations. Formal and informal communication among NGOs and PVOs is essential to this learning.

As applied to the environment, adaptive management means changing project operation or design when monitoring shows unexpected, adverse environmental outcomes. For example, members of a community involved in a fertilizer project may observe that algae and plant growth in a local water body has increased markedly. This is a sign of eutrophication, possibly caused by fertilizer run-off from fields, and probably indicates a need to change fertilizer application processes.

Adaptive environmental management requires an *environmental monitoring and mitigation plan*, and explicit allocation for environmental monitoring and evaluation activity in the project budget. Monitoring and mitigation plans identify funding sources and responsibility for monitoring and evaluation from the onset of project design.

ESD and Community Participation

The need for community participation is a clear consequence of applying "best development practices" to the environmental aspects of small-scale project design and implementation. Community or stakeholder participation beginning early in the design process is key to at least three of these practices:

- **Assuring technical feasibility**. The detailed knowledge community members have of local conditions is often critical in anticipating and identifying a project's potential environmental impacts.
- **Securing stakeholder commitment**. By participating in design, implementation and monitoring, participants gain *ownership* and *responsibility*, as well as a clear understanding of objectives and

anticipated outcomes. Ownership, responsibility and understanding create incentives to identify and mitigate adverse impacts.

- **Practicing adaptive management.** Local participants are in the best position to monitor long-term environmental effects of project activities, and monitoring is a key aspect of adaptive management. Further, local participants or communities need the understanding and capacity to adapt activities to future change after donor support ceases.

Finally, community participation is an important mechanism for assuring environmental justice. Development activities often involve tradeoffs between economic or social development and environmental quality. These tradeoffs should not be imposed unilaterally by external authorities. Because local residents must *live with* the environmental consequences of activities, it is only just that they understand and have a voice in any tradeoffs that are ultimately made.

Community Participation and Gender

"Community participation" must involve both men and women:

- Women are often key to a developing country's food production, nrm and economic systems.
- Often "farmers" and "smallholders" are simply synonyms for the women in a community
- In many rural areas, women are the majority of the adult population
- Women have extensive knowledge of the environment and natural resource base, as they affect subsistence agriculture, the use of wood for fuel, water availability and quality, gathered foods, and certain medicines.

However, obtaining women's input may require special effort. In many cultures, gender roles prevent women from making their opinions known directly to project designers.

ESD and sustainable activities

The focus of this manual is *environmentally* sound design. ESD is necessary—but *not* sufficient—to design and implement truly sustainable activities. Environmental considerations must be weighed together with economic and social criteria. Critical questions include:

- Is the activity financially sustainable without continuous external support?
- Do the benefits of the activity outweigh costs?

Integrating ESD, USAID Environmental Procedures, and the Project Life Cycle

Environmentally sound design should be an integral part of the project design and implementation process, not an afterthought. USAID's Environmental Procedures create a framework in which to organize key ESD-related elements and tasks of the project lifecycle. The procedures should *not* be treated as simply an administrative requirement.

The diagram on the overleaf presents ESD-specific activities and USAID environmental compliance procedures in the context of the project's life cycle.

Project phase	(comments and description)	ESD-specific activity	USAID regulatory compliance
A. ID project objectives	What is the NEED that the project serves? (e.g., improved market access, improved access to health care)		
B. ID alternatives to achieve objectives	For example, if the project objective is to improve agricultural productivity, possible alternatives include: introducing new crop varieties, promoting the use of chemical inputs, introducing irrigation, integrated pest management, changes to tilling and soil conservation measures, or some combination of these.		
C. Conduct initial screening of alternatives	Assess project alternatives on the basis of : • economic criteria • social criteria • environmental criteria (requires a back-of-the envelope project design AND a social, economic and environmental profile of the project site)	Conduct preliminary environmental screening. Consult Chapter 3 of these *Guidelines* or other sources for likely impacts and mitigation options	For each activity in project, conduct a preliminary screening to determine which USAID environmental review category is likely to apply to the project. The category determines HOW MUCH ENVIRONMENTAL STUDY of the project is required. This has implications for (1) how likely project approval is; and (2) the effort required to submit the project proposal. USAID screening process is outlined on page XX
D. ID preferred alternative	Based on preliminary screening, what is the best compromise between economic, social and environmental criteria? (A concept paper may be written at this stage)		
E. Formulate detailed project design		Apply project best practices to environmental aspects of project design. (This Chapter): Incorporate best monitoring and mitigation practices into project design and budget (Consult chapter 3 or other sources. For general discussion of mitigation and monitoring, see Chapt 5.)	Verify initial screening result based on detailed project design. Conduct Initial Environmental Examination (IEE),* Environmental Review (ER) or Environmental Assessment (EA), as indicated. An IEE or ER will likely require some additional data collection. An EA will require significant additional data collection, establishment of a professional EA team, and a formal process for public participation. Eas assess all the alternatives considered in Phase B of the project lifecycle
F. Submit proposal for funding approval			Proposal MUST include either CATEGORICAL EXCLUSION form or IEE. For subgrants, proposal must always include a screening form and, if indicated, an ER.
G. Funding agency review			For IEE, review occurs at headquarters level (USAID's Bureau Environmental Officer). For ER (subgrants within umbrella project), review occurs at mission level.
(if approved)			
H. Construction/ implementation (and hand-off)		• Environmental monitoring • Adaptive mitigation (that is, mitigation which is adjusted depending on monitoring results)	Annual environmental status report

(conditional approval requiring changes to design)

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http://europa.eu.int/comm/environment/eia/eia-studies-and-reports/5years.pdf

This review of the implementation of Directive 85/337/EEC covers the time-period from 1990 to the end of 1996. It is mainly based on the answers to questionnaires sent out to member states. The review examines the extent of formal compliance, practical compliance, and the effectiveness of implementation.

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This report comprises the framework, findings, conclusions, and recommendations of the International Study of the Effectiveness of Environmental Assessment. It presents key points and issues related to the practice of environmental assessment.

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Ahmed, Y.J., S. El Serafy, and E. Lutz. 1989. Environmental Accounting for Sustainable Development. Washington, DC: World Bank.
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This document contains selected papers from a series of workshops jointly sponsored by the World Bank and UNEP. The chapters reflect different aspects and approaches to environmental accounting, mostly to do with financial and economic considerations and modifications of the UN system of national Accounts to reflect environmental and natural resources issues.

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Iannariello, M.P., Edwards, P.M., Blair, R., and D. Reed, Environmental Impact Assessment for Macroeconomic Reform Programs, World Wide Fund for Nature, Macroeconomics for Sustainable Development Program, 2001, 40pp.
http://assets.panda.org/downloads/eia.pdf

This document provides a basic framework for understanding environmental consequences of macroeconomic reforms and a process for applying EIAs to such efforts.

International Institute for Sustainable Development. Measurement and Indicators for Sustainable Development. http://www.iisd.org/

Website devoted to developing robust sets of indicators for public and private sector decision makers to measure progress toward sustainable development and to build an international consensus to promote their use. Includes tools, case studies, and reports from field studies.

Kirkpatrick, Colin, Geoge, Clive, and Curran, Johanna. Development of Criteria to Assess the Effectiveness of National Strategies for Sustainable Development. Institute for Development Policy and Management, University of Manchester. 2001. http://idpm.man.ac.uk/iasdu/nssd.doc

The study consists of a review of the literature on national strategic planning processes, which includes a review of monitoring that has taken place to date, the development of a set of criteria by which a national strategy may be assessed, and guidance on the application of the assessment methodology. While the results are applicable to all countries, they have been developed in a manner that is intended to be of particular assistance to developing countries in their implementation of national strategies.

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The Population-Environment Research Network is a project of the International Union for the Scientific Study of Population (IUSSP) and the International Human Dimensions Programme (IHDP) on Global Environmental Change. The network exists to advance academic research on population and the environment by promoting on-line scientific exchange among researchers from social and natural science disciplines worldwide. The site includes a database of grey literature, publications, projects, conferences, datasets, software, course syllabi and other resources for research on population-environment dynamics; Cyberseminars to discuss articles, methods and issues in population and environment research; and a biweekly newsletter.

U.S. National Research Council. 1986. Ecological Knowledge and Environmental Problem Solving: Concepts and Case Studies. Washington, DC: National Research Council.
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This report explores how the scientific tools of ecology can be used in dealing with a variety of environmental problems, such as prediction and management of environmental impacts, management or renewable resources, protection and restoration of species and ecosystems, and control of agricultural problems.

UNEP Global Resource Information Data Base (GRID). http://www.grida.no/index.htm

Located in Arendal, Norway, they are charged with fostering improved State of the Environment Reporting data gathering. Its focus is, however, on Nordic countries and Newly Independent States. Of particular interest to baseline sustainability analysis is UNEP/GRID- Arendal's Cookbook for State of the Environment Reporting on the Internet, available at: http://www.grida.no/soe/cookbook/index.htm. It provides generic methodological guidance for the development of electronic environmental status reports and elaborates on the "Driving-Forces-Pressures-State-Impact-Response (DFPSIR)" Concept. Also, the site has links for UNEP/GRID Nairobi, http://www.unep.org/unep/eia/ein/grid/web/document/grid.htm, and Environmental Information Systems in Sub-Saharan Africa (EIS-SSA), http://www.grida.no/eis-ssa/index.htm.

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http://web.worldbank.org/WBSITE/EXTERNAL/PROJECTS/0,,contentMDK:20120746~menuPK:51551~pagePK:41367~piPK:51533~theSitePK:40941,00.html.

World Economic Forum's Global Leaders for Tomorrow Environment Task Force, The Yale Center for Environmental Law and Policy, and the Columbia University Center for International Earth Science Information Network (CIESIN). The Environmental Sustainability Index. http://www.ciesin.columbia.edu/indicators/ESI/

The Environmental Sustainability Index (ESI) is a measure of overall progress towards environmental sustainability, developed for 142 countries. Scores are based upon a set of 20 core "indicators," each of which combines two to eight variables for a total of 68 underlying variables. The ESI permits cross-national comparisons of environmental progress in a systematic and quantitative fashion.

Part II

Environmental issues and best practices for particular sectors

This chapter summarizes the environmental issues associated with particular sector activities. It also describes environmental best practices to minimize and mitigate potential environmental impacts arising from these activities.

Environmental issues in each of the sectors addressed can be—and are—the subject of stand-alone books and reports. The sector briefings in this chapter are only a summary and introduction. Each is followed by an extensive list of resources and references for the practitioner or USAID evaluator who requires a more detailed understanding of the issues.

All sector descriptions follow a general outline:

- Brief description of the sector
- Potential environmental impacts of development programs in the sector and their causes
- Guidelines for sector program design
- Environmental mitigation and monitoring—issues and guidance
- Resources and references

Chapter 1

Agriculture: Soil and Water Resources, including Irrigation

Contents

1.1 Agriculture Overview **1-1**

Potential Impacts 1-3

Sector Program Design 1-8

Mitigation and Monitoring 1-15

1.2 Irrigation **1-21**

Brief Description 1-21

Potential Impacts 1-23

Sector Program Design 1-28

Mitigation and Monitoring 1-32

1.3 References and Resources **1-37**

1.4 Appendix: A Checklist for Planning Environmentally Sound Small-Scale Irrigation **1-45**

Lacking farm inputs, new technologies or other sources of income, the rural poor often drain the remaining life out of their fragile land, which only worsens their poverty and vulnerability. The linkages among poverty, hunger and environmental degradation are the reasons why environmental oversight must be an important part of agricultural development programming.

1.1 Agriculture Overview

Agricultural development has long been a mainstay of USAID's programs throughout the Africa region. Helping rural people to develop sustainable and productive farming systems generates income and reduces food insecurity. Given the key role agriculture plays in African economies, and its importance to rural households' food security, small-scale agricultural development activities targeted at the rural poor are likely to increase.

Two major factors strongly constrain productivity and rural prosperity in Africa: reduced soil fertility and declining available soil moisture. An estimated 95 percent of Africa's lands face challenges from soils, topography and climate. Soil fertility depletion, in particular, severely limits production in Africa. Yet many responses to this problem are available. Expanding the use of tested management practices, such as watershed management to conserve moisture on hillsides and rock phosphate, nitrogen-fixing tree fallows, and biomass transfer, can overcome/reduce these constraints to crop production. Encouraging profitable alternative land uses such as wildlife farming or forestry is another approach.

Note: This chapter focuses on crop agriculture and is divided into two sections: dryland agriculture management and irrigation management. The first section deals with project design and the environmental impacts of rain-fed cropping. The second looks at environmental impacts associated with irrigated agriculture.

Agrochemical use and its impacts on the human and natural environment are addressed in two completely separate chapters, "Integrated Pest Management" and "Safer Pesticide Use." Other agriculture-related issues are addressed in the chapters on forestry, livestock, and community-based natural resource management.

The increasing demand for fresh water for domestic and industrial use is another limiting factor to agricultural productivity. It is estimated that, of all the water now being used by humans (2–3 percent of the world's total water), 70 percent is already used for agriculture. Water is a critical source of asset development through livestock and irrigation. Irrigation can boost productivity, but farmers are increasingly in competition with other users, and water deficits will ultimately mean food deficits. Poor irrigation management has lowered groundwater tables, damaged soils and lessened water quality. Wetlands are rapidly disappearing or being degraded.

Again, concerned parties can draw on a wide range of approaches to address African farming's water problems. Water-sparing technologies are available, such as drought-tolerant crop varieties and low-cost drip-and-trickle systems. With a supportive policy and legal framework, irrigation management can be transferred to farmer associations to increase efficiency. And with access to markets, farmers can choose to grow higher-value cash crops.

USAID formally launched the **Initiative to End Hunger in Africa (IEHA)** in 2002 at the World Summit on Sustainable Development in Johannesburg, South Africa. IEHA was created to promote rapid and sustainable increase in agricultural growth and rural incomes as a key solution to cutting hunger and poverty in Africa.

In combating hunger, IEHA recognizes that success requires sustained investments in agriculture-based strategies, programs and policies, together with improvements in health, education, infrastructure, environment and public policy management. IEHA includes a wide-ranging, extensive partnership of African leaders, civil society, donors, private concerns and African governments to work and invest in a smallholder-oriented agricultural growth strategy. See http://www.afr-sd.org/Agriculture/AgInitiative.htm for more information.

Indeed, myriad programs address agricultural productivity, by introducing a new technology, an improved input or a new approach into the existing local farming system. However, these farming systems may be unsustainable from an environmental perspective. This is not because farmers do not understand their "environment"—far from it—but because of off-farm externalities, such as market forces or a lack of savings. To feed their families or generate household income, farmers are frequently driven to make trade-offs—shortened fallow periods, lack of crop rotation and other poor land-use measures—which undermine sustainability of the farming system and cause environmental harm. So it is critical that environmental effects be taken into account when planning agricultural initiatives.

Good agricultural practices allow sustainable use of the natural resources—soil and water—needed for crop production. However, with a rising population burden, rural residents are farming on more marginal terrain—sloping lands, infertile soils and areas of low and/or irregular rainfall. The pressure to cultivate marginal lands is often exacerbated by a lack of resources, an inadequate policy framework and poor input supply and market systems.[1] Lacking access to productive technologies, agricultural inputs or employment alternatives, the rural poor often drain the remaining life out of their fragile and marginally productive land, which only worsens their poverty and vulnerability. These linkages among poverty, hunger and environmental degradation are the reasons why environmental oversight must be an important part of agricultural development programming.

This chapter of the *Guidelines* examines natural resources management (NRM) activities that can play a role in fortifying farming systems' sustainability. Soil and water conservation—or on a larger scale, watershed management—can build local farming systems' resilience to climatic extremes and add incrementally to their agricultural productivity through sophisticated use of soil, water and vegetation. Such activities can also buy

[1] The construction, upgrading or maintenance of "farm to market" roads is dealt with in the chapter on rural roads.

enough time to allow a more diversified and robust rural economy to emerge capable of generating off-farm employment opportunities. In the long run, the most sustainable solutions for poverty, hunger and environmental degradation in Africa include options drawing people away from farming on marginal lands into a nonfarm economy.

Potential Environmental Impacts of Agriculture Programs and Their Causes

Natural habitat destruction or degradation. Agriculture can adversely affect a variety of ecosystems. These impacts may come from expanding the area used for crop or livestock production or from using environmentally unsound practices on existing farms. The most common problems include:

- **Degradation of marginal lands**. For a variety of reasons—population pressure, lack of access to land or social equity issues—marginal or degraded lands may be used for agriculture. This new land use may be unsuitable because of inherent constraints on variables such as climate, vegetation, slope, soil depth, soil texture and water availability. Expansion onto these suboptimal lands not only causes further degradation, but also displaces previous land uses (firewood gathering, livestock grazing, hunting, medicinal plant gathering, etc.).

Slash-and-burn agriculture can quickly lead to deforestation, erosion and the loss of soil nutrients, with devastating environmental effects.

- **Deforestation.** Natural forests are often degraded by encroachment, by excessive or uncontrolled harvesting, by roads dividing them into smaller blocks, or by being cleared for charcoal, crop and livestock production. Slash-and-burn agriculture, where the land is cleared by burning ground cover, replaces the protection given by perennial tree vegetation with short-lived crops that also remove scarce soil nutrients. It is true that when forests are burned to clear the trees for planting, the resulting ash enriches the soil. Unfortunately, these burned areas rapidly lose the initial fertility the ash gives them, and the deforested area—

already more liable to runoff, flooding and soil erosion—becomes increasingly fragile. Destruction of forest areas also leaves local populations without the fuelwood, timber, and non-wood forest products they use both to meet household needs and to earn an income.

- **Desertification.** Desertification is the degradation of land in arid, semiarid and sub-humid areas. This process includes deterioration of vegetative cover due to overgrazing, wood cutting, and burning; wind and water erosion resulting from improper land management; and salinization due to improper use of irrigation water. This results in a loss of soil depth and fertility, reduced regeneration and a progressive transformation of the initial ecosystem to a less productive system, culminating in barren desert. In extreme cases, the capacity to support the local population is lost, and residents may leave in search of food and employment elsewhere.

- **Drainage and degradation of wetlands and riparian areas.** Wetlands provide a number of environmental services, including recharging groundwater supplies, acting as natural water-treatment plants, and providing habitats for vulnerable and endangered species. However, wetlands and their edges are often used for agriculture, either in the dry season or after draining. The soils are often fertile at first, and water is available for irrigation. Unfortunately, as wetlands are drained for agriculture or development, the landscape loses its capacity to absorb and control runoff, increasing the potential for downstream flooding. In certain situations, post-drainage aerobic reactions increase the soil's acidity considerably, and the drained land becomes unsuitable for farming.

- **Degradation of coastal areas.** Agricultural activities can degrade coastal areas in a number of ways:
  - Using coastal wetlands for agriculture releases acidic compounds into drainage waters, changes sedimentation patterns and water circulation/drainage, causes loss of protective barriers (mangroves), and increases the likelihood of waterborne diseases.
  - Sand dunes that lose all or part of their vegetative cover to agriculture or livestock grazing can become unstable and expand over previously fertile areas.
  - In industrial-scale agriculture, such as sugar plantations, the fertilizer used can increase nutrient loads and cause eutrophication2 of estuaries and ponds. This undermines reproduction of commercially important species, including fish, mollusks and crustaceans. In extreme cases, the consequences can include smaller

Potential Environmental Impacts from Agricultural Development

- Destruction or degradation of natural habitat, including deforestation, desertification and drainage of wetlands
- Loss of biodiversity
- Introduction of exotic and non-native animal and plant species
- Erosion and loss of soil fertility
- Siltation of water bodies
- Reduction in water quality

[2] Eutrophication is the process by which a body of water becomes enriched with excess dissolved nutrients (such as nitrogen and phosphates) that stimulate the growth of aquatic plant life, usually resulting in the depletion of dissolved oxygen.

fish yields, fish deaths, destruction of coral reefs, and ecosystem instability or collapse.

  - Large-scale dams and irrigation schemes that divert freshwater from coastal areas can make estuaries saltier, reduce water circulation and flow, and/or allow saltwater to contaminate groundwater. They may also reduce sediment, leaving less material for beaches and altering patterns of shoreline erosion.

- **Degradation or destruction of protected habitats.** Protected zones may exist as small areas of fragmented habitats surrounded by agricultural land. This undermines the effectiveness of the park by limiting animal migration and supporting unsustainably small wildlife populations. Also, if there is population pressure nearby, people will seek to use the land up to the margins of the protected area and even within it, reducing the park's usefulness as protective habitat.

Biodiversity loss. Increasing homogenization of crops and livestock is replacing diverse varieties with uniform genetic stock. These pure stands may be more vulnerable to a catastrophic disease outbreak, may need more inputs than local crops or livestock to produce well, and may have less market value than better-adapted, more popular local varieties. In addition, farmers generally remove wild plant and animal species from their lands to reduce the negative effects of pests, predators and weeds. However, there are complex interactions between crops and their wild neighbors: certain insects, plants and micro-organisms may play a key role in crop reproduction, maintining soil fertility, controlling pests and floods, and ensuring clean water supplies. Finally, as noted earlier, agriculture can fragment the original landscape, breaking wild species populations into breeding units that may be too small and making them more vulnerable to extinction.

Introduction of exotic species. It is widely accepted that introducing a non-native species to a new ecosystem must be done with great care. Quarantine laws are set up to avoid the potential adverse consequences of such an introduction. Introduced exotic species may spread diseases, out-compete native species for resources, become feral, act as predators or pests, or interbreed with native species. Lack of local competition or predators may give rise to "weed species," such as water hyacinth or Nile perch.

Cropland degradation. Cropland degradation—a decrease in the ability of suitable land to support agricultural production—has two primary elements: soil erosion and loss of soil fertility. Each is described below. As land degradation becomes more severe, farmers often have few options other than to look for another piece of land on which they can earn a livelihood. Expansion onto marginal land is closely linked to a lack of productive potential on existing land.

- **Soil erosion.** Unsustainable practices—such as badly managed open-furrow agriculture, a crop grown in the wrong way or place, deforestation, or draining wetlands—can all cause soil erosion. As the soil erodes, less rainfall is absorbed and the excess runs off. This runoff removes the fertile topsoil necessary for crop production and can have disastrous off-site consequences, including gully formation, landslides,

Losing Valuable Topsoil—What Erosion Really Means:

Studies carried out in various countries—Jamaica, El Salvador and Taiwan—measured soil erosion rates of 100 to 200 metric tons per hectare per year on slopes less than 25 degrees under smallholder traditional cultivation packages. This is the equivalent of losing up to 10 mm of soil depth in a year or 50 mm (2 inches) in five years. The actual rate of loss at a site depends on the farming system, slope, soil type, and climate. Unless soil conservation is practiced, high rates of soil loss can be expected, especially on steep sites farmed extensively by marginal smallholders in the higher-rainfall areas.

Source: Sheng, 1989.

siltation and sedimentation of water bodies, downstream flooding, and damage to productive infrastructure.

In sub-Saharan Africa, particularly in arid and semiarid areas, the wind can also erode away the soil.

- **Reduction of soil fertility.** Soil fertility is dependent on three major nutrients (nitrogen, phosphorous and potassium), various trace elements, and organic matter content. A productive soil contains sufficient quantities of each of these factors. The factors can be removed by repeated cropping without fertilization, rainfall leaching, lack of a restorative fallow, and removal or burning of crop residues, either alone or in combination. The subsequent decline in soil fertility often occurs in conjunction with soil erosion, with each problem exacerbating the other.

  Fertilizers can be used to deal with soil fertility problems. But in sub-Saharan Africa, chemical fertilizers are often scarce, expensive or not economical to use. Farmers are reluctant to assume the extra price risk of fertilizers because of the vagaries of the rainfall pattern and the low market prices for the increased yield.[3]

Siltation of water bodies. Eroded topsoil is carried by runoff into water bodies. Once in the slower-moving water, the soil settles, altering the terrain, water depth and water clarity, which can harm fish and bottom-dwelling populations. Siltation can intensify downstream flooding by reducing channel capacity and can also fill the upstream areas behind a dam. One remedy for siltation, dredging, is an expensive process that must be repeated at intervals. Siltation in wetlands and coastal areas can reduce productivity and marine populations. Large-scale siltation impairs shipping and river transport, flood control, the efficiency of dams, fisheries and aquaculture, urban sewage treatment, and drinking water supplies.

Reduction in water quality. Incorrectly applied agrochemicals, fertilizers or manures can migrate from a farmer's field to local water sources, causing environmental harm and adversely affecting human health and activities.[4] Animal manures transported from fields into water bodies through rainfall, runoff or irrigation can pollute local drinking water sources and spread human and animal diseases. Nutrients from manures/fertilizers can also cause nutrient loading in local water bodies, resulting in degraded water quality, reduced wildlife, fish and mollusk populations, and toxic algal blooms. Moreover, such reductions in water quality can impact other uses of water bodies as well, such as drinking water, sanitation, fishing, aquaculture, recreation and tourism, and other farms. The direct environmental impacts of irrigation are discussed later in this chapter.

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[3] Paradoxically, farmers may also apply too much fertilizer, apply it too frequently, or use it inappropriately; the excess nutrient may burn the crop as a result.

[4] The impacts of pesticides on the environment are discussed in the *Guidelines'* chapters on integrated pest management (IPM) and safer pesticides.

The effects of policy on the environmental impacts of agriculture. National agricultural and economic policy alters the costs and benefits of particular agricultural investments and practices. Policy can inadvertently discourage environmentally sound agriculture and livestock husbandry practices, or it may unwittingly reinforce others that have adverse impacts on the environment and the land's long-term productivity. Aspects of the policy environment that may cause unintended harm include:

Conflicts between herders and farmers often result from uncertain land tenure arrangements and poorly defined land use policies.

- **Uncertainties about land tenure.** Without clear title or guarantees of future control of land, farmers have little incentive to practice wise stewardship or invest in conservation practices. Farmers may also hesitate to leave their land fallow for fear someone else may claim it.

- **Subsidies and pricing.** Government control of markets and prices all influence farmers' behavior and production goals. Means of control may include mandated prices of agricultural goods and services, taxes, tariffs and subsidies, import/export quotas, exchange rate policies, and preferences for state-run parastatal marketing. For example, subsidies for inputs such as fertilizers and chemical pesticides can lead to their overuse, resulting in resistant pests, reduced populations of beneficial insects and predators, water pollution, and damage to human and animal health.

- **Resettlement programs in fragile lands**. Traditional (and even improved) farming practices are typically poorly adapted to fragile lands. This is particularly true in lowland tropical areas where higher rainfall quickly leaches nutrients from the soil. Resettlement programs that move people into these areas for agriculture frequently result in unsustainable projects, land degradation and ecosystem damage.

- **A focus on agricultural expansion.** Policies that promote conversion of new lands into agricultural use, instead of measures to intensify yields on existing plots, frequently result in destruction or degradation of ecosystems. This is especially true when the new land's capacity to support agriculture has not been properly or correctly assessed.

- **Nonparticipatory and undifferentiated extension policies.** Extension programs that apply a "package" of new approaches and technologies over large, diverse areas result in sub-optimal or even incorrect techniques for parts of the range of conditions. Ideally, smallholder farmers would participate in adapting packages—e.g., for soil conservation and improved agronomy and livestock management—to their local circumstances**.**

Sector Program Design—Some Specific Guidance

Agricultural activities that are designed and implemented according to sound environmental principles should produce economic benefits for farmers while maintaining long-term land fertility and stability. *To be economically sustainable in the long run, agriculture needs to be environmentally sustainable.* Unfortunately, for reasons already noted, short-term considerations often drive farmers' decisions and choices. Some aspects of environmentally sound agricultural activity design and implementation are discussed in this chapter.

Soil and Water Conservation

Soil and water conservation technologies can both protect land from degradation and reclaim land that has been degraded. Using the correct techniques may make it possible to maintain or even intensify cultivation, or to continue cultivating land that would otherwise become unsuitable for agriculture.

Soil and water conservation technologies may be structural or vegetative; ideally, the two types should be applied in combination (Table 1). All of these measures aim to reduce the rate of runoff and, thus, erosion. These structural engineering or vegetative solutions are usually established on the contour to slow rainfall runoff and contain any soil erosion. Some vegetative measures also have the secondary benefit of improving soil quality.

Table 1: Soil and Water Conservation Technologies

Engineering or Structural Technologies	Vegetative Treatment Measures
Side Hill Ditches or Similar Diversion Structures—very typically separating higher, nonarable land from cultivated land below and diverting runoff **Contour Bunding or Ridges**—built from stones or soil at intervals along the contour as part of the field layout **Grassed Waterways**—carry away runoff channeled by contour structures to a central drainage point without erosion **Terraces**—radical conversion of sloped land into a series of graded steps approximating flat conditions **Small-Scale Terracing**— discontinuous use of terracing, usually small platforms on which trees are planted **Microbasins**—pits or half-moon structures built in a pattern across the slope to hold rainfall, usually in drier areas **Gully Plugs**—barriers built perpendicular to the slope across drainages to slow runoff and contain transported soil	**Strip Cropping or Contour Farming**—plowing and tilling along the contour to trap rain and avoid runoff and erosion **Living Barriers**—e.g., contour hedgerows or grass strips planted along the contour to trap and/or filter runoff and retain soil **Leguminous Cover Crops**—used as green manures or mulches, to fix nitrogen, raise organic matter content, cover the soil and protect it from raindrop impact **Zero or Low Tillage**—crop residues are left after harvest on the site, and the next crop sown with a minimum of disturbance **Adjustments to Agronomic Practices**—include intercropping, improved plant spacing and appropriate crop rotation **Compost Application**—to improve organic matter content and texture of the soil and its ability to infiltrate rainfall **Agroforestry Practices**—admixture of tree crops to crop and/or livestock farming system

Predicting soil erosion. Some soil erosion and/or displacement accompanies any agricultural practice. Physical parameters of the climate and the land's site, slope, soil depth and soil type all affect the potential for runoff and the actual rate of erosion. Assessing the impact of these parameters as they interact and combine requires careful measurement. One way to simplify the assessment process is to use broad land capability classifications, which relate the suitability of a combination of slope and soil depth factors to a particular set of land uses.

Table 2 presents a land capability classification suggested by FAO for small farmers in the tropics (Sheng, 1989).

Table 2: Land Capability Classification Scheme

Slope Class	Slope (%)	Soil Depth (cms)	Land Capability	Major Conservation Treatment	Applicable Tools	Land Use
1	0–12	>15	C1	Mainly agronomic conservation measures; simple terraces on slopes approaching 12%	Large machine or hand	Any crop
		<15	P	Grass cover	—	Pasture
2	12–27	>30	C2	Bench terraces & simple terraces	Medium-sized machine or hand	Any crop
		<30	P	Hillside ditches	—	Pasture
3	27–36	>45	C3	Bench terraces & simple terraces	Hand or small machine	Any crops
		<45	P	Hillside ditches, zero grazing	—	Pasture
4	36–47	>55	C4	Simple terraces & benches	Hand or walking tractor	Annual & perennial crops
		<55	P	Hillside ditches, zero grazing	—	Pasture
5	47–58	>60	FT	Orchard terraces	Hand	Tree crop
		<60	F or AF	Forest cover or agroforestry	Hand	Trees or tree crop
6	>58	All depths	F	Forest cover	—	Forest only

Legend: C = cultivatable land; P = pasture; FT = land for food, fruit and tree crops; F = forest land; and AF = agroforestry.

Classifying an area on the basis of standard land capability parameters—slope, soil depth, and soil quality—and/or actual land use is useful for defining specific intervention units. During design, specific needs and opportunities for each area can be captured, preventing mismatches between land capability and land use. Classification also highlights important interrelationships within the landscape that allow for a more integrated approach to natural resources use and development.

The risk of soil erosion is quantified through models like the Universal Soil Loss Equation (USLE), the Water Erosion Prediction Project model, and the European Soil Erosion Model. These use formulas to determine potential soil losses in terms of tons per hectare per year, based on rainfall, soil erodibility, topography, crop practices and conservation efforts. Models may be valuable in monitoring soil and water conservation efforts, which are typically gradual improvements and incremental reductions in the erosion rate over time. Their formulas, however, require data (such as rainfall intensity or soil erosivity) that may be difficult for small projects to obtain.

Guidance for soil and water conservation projects. Maintaining and restoring soil through soil and water conservation programs can be a lengthy, costly, difficult process, often well beyond the means of small farmers. Understanding certain practical realities about how programs should be designed and implemented can markedly increase their chances of success, make local farming systems more sustainable and increase returns to farmers.

Guidance for Soil and Water Conservation Projects

- Focus on land management, not degradation
- Consider economic impact of conservation on small holders
- Combine soil conservation with improvements in soil quality
- Focus on priority issues
- Avoid "institutionalizing" subsistence agriculture
- Prevent erosion from roads and paths

- **Focus on land management, not degradation.** Degradation is the result of inappropriate land use. To break the degradation cycle, soil and water conservation projects need to move beyond treating the symptoms of degradation to an integrated land management approach. For example, if gullies are forming as a result of overgrazing and excessive runoff, planting trees to rehabilitate the degraded area is not enough. Action must be taken to manage the causes of the grazing pressure, rather than just shift animals to other areas that may be equally fragile.

- **Consider economic impacts to smallholders.** Conservation efforts involve investments and changes that frequently displace other land uses or require production trade-offs. The costs of these displacements and trade-offs are particularly pronounced for smallholders. To achieve the long-run benefits to society of improving environmental stability and assuring long-term productivity, consideration should be given to short- and medium-term incentives that make smallholder participation in conservation schemes attractive. Incentives can include helping farmers to intensify production activities on their better lands.

- **Pair conservation with improvements in soil quality.** Many soil and water conservation programs promote installing vegetative barriers, both live and dead, to contain erosion, plus ditches and trenches to capture transported soil and water runoff and manage the farm/watershed drainage. Typically labor–intensive, these practices benefit production and the farmer community, but only slowly and often with diffuse impact. They should be complemented by actions to enhance soil quality on the farmed plots between the barriers or ditches. The increased productivity that results gives individual farmers a direct payoff on their efforts. Such interventions may be biological or agronomic; examples include conservation tillage and plowing techniques, green manuring, nitrogen-fixing legumes and cover crops, compost and animal manure, crop spacing, intercropping, and improved crop rotations.

All can return several benefits: they increase organic matter levels in the soil, improve its fertility, produce better crop yields and help encourage and validate longer-term investments in erosion control.

- **Focus efforts on priority issues.** Although a so-called integrated approach is important, the interventions must be manageable and must target priority problems identified by local communities. Many soil and water conservation and watershed projects fail because they attempt too much. They spread capabilities, expertise and resources too thinly, especially at the field level. Technical staff may understand the mechanics of a given intervention in general, but not the specific adjustments needed for the conditions at a particular site.

- **Avoid "institutionalizing" subsistence agriculture.** Subsistence agriculture on poor lands is not a long-term means to personal and community economic development. Farmers have aspirations beyond soil and water conservation or increased agricultural productivity. They wish to secure opportunities for their children, see broad development of rural infrastructure, and have access to economic opportunities. Soil and water conservation projects need to be wary of simply reinforcing and maintaining an inequitable status quo.

- **Recognize the contribution of roads to soil erosion.** One cause of soil erosion is a misaligned road, track or path, which channels and concentrates runoff and leads to soil erosion and gully formation. An FAO study conducted in El Salvador in the late 1970s found that as much as 25 percent of the erosion in upland watershed areas was caused by poorly designed roads and paths. Agricultural programs often include farm-to-market roads to improve market access for products; it is vital that such roads be designed in an environmentally sound way. See the chapter on rural roads in these *Guidelines*.

Tied ridges like these can be used to catch runoff, prevent erosion and conserve top soil and soil fertility.

Other Considerations in Agriculture Program Design

Promote farmer and community participation. Managing natural resources and the environment is most often a social act involving both individual and collective choices about the sharing and wise stewardship of resources. It is essential for farmers and communities to take part in designing agricultural development activities, in judging the chances for harmful environmental impacts, and in controlling and mitigating such impacts.

The most important impacts to avoid are those that directly affect the health and well-being of human populations. In the agriculture sector, these include soil erosion and soil fertility depletion, which reduce the farming system's productivity; lowered water quality and quantity; agrochemical contamination; and damage to human health from irrigation system development. Avoiding or minimizing these impacts generally involves education and behavioral changes in the way people farm. Without agreement and buy-in from the participant community, farmers may make less than optimal environmental choices because they seek short-term returns without looking at longer-term costs.

Building local skills, systems and commitment to environmental review and resolution can lead to real development results. Such activities (a) increase local people's capacity for analyzing problems and finding collective solutions; (b) build greater self-reliance; and (c) enable communities to justify support for their needs within civil society and to the government.

Special Considerations for Project Design

- Promotion of farmer and community participation
- Characterization of site conditions for best mitigation and monitoring results
- Protection of watersheds and riparian buffer zones, including springs, stream and river banks, and wetlands
- Management of exotic animal and plant species
- Promotion of use of agroecological techniques

Characterize site conditions. Many small-scale agricultural development activities occur in areas with heterogeneous (non-uniform) site conditions. Such conditions make planning activities more difficult. Choosing the most appropriate set of interventions in these areas depends on accurate, detailed area or site description **(characterization)**. Characterizations in turn are based on *geographic information*. The most basic tool is a georeferenced map at a suitable scale (1:10,000 or better) on which is plotted field survey data. Geographic Information Systems (GISs), Global Positioning Systems (GPSs) and high-resolution, small-scale satellite imagery (e.g., Ikonos imagery) are efficient and effective means for obtaining and managing basic geographic planning information. Georeferenced databases make it substantially easier to monitor programs' impacts, whether the focus is on measuring results or ensuring that mitigation measures are doing their job.

Protect watersheds and riparian buffer zones. It is extremely important to ensure that agricultural activities do not undermine communities' potable water supplies. Although the chapter on water supply and sanitation in these *Guidelines* deals with these issues in depth, agriculture project design should consider these water quality and quantity issues:

- **Protection of springs and seeps.** Groundwater springs and seeps[5] are important rural water sources and need special safeguards to ensure they remain viable, sanitary sources of potable water. Typically, a spring is the result of water infiltrating the ground, running along an impermeable rock or soil layer, and emerging at the surface. Springs usually occur in ravines or gullies, fed by a catchment basin. Often, a community may protect the spring by leaving vegetation in the fringe area immediately around it. Unfortunately, contaminants can still enter through the catchment area that supplies the water. Effective protection of the spring or seep requires ensuring that there is a protective vegetative cover over all of the steeper areas on the slopes above the spring.

- **Protect riparian areas.** Riparian (waterside) areas and wetlands require similar protective efforts. Such areas serve many important ecological functions and often have multiple uses. They need protection to insure clean water supplies, such as buffer strips along stream margins. How wide these strips must be depends on soil, slope and land use. Narrower buffers may be acceptable if, along fields fronting on a watercourse, people put in berms, bunds or filter strips (e.g., vetiver grass or similar vegetative barriers) to keep the direct runoff out of the stream.

[5] A seep is a type of wetland where water flows to the surface in a diffuse flow.

Manage exotic species. A project should carefully review what has happened in the past when a particular nonindigenous species has been allowed to enter a similar ecosystem before planning its use or risking introducing it by accident into a project area. Plant quarantine and *phytosanitary* (plant health) regulations should be strictly observed.

Use agroecological techniques. Under agroecology (or ecoagriculture), lands are managed for both agricultural production and biodiversity conservation (see Altieri, 2002). Using agroecological techniques, farmers can protect wild species and conserve habitat while also increasing farm production and incomes. Agroecology uses the following strategies:

- **Reduce habitat loss by increasing agricultural productivity and sustainability on already-farmed lands.**
  By increasing production in fertile areas, the pressure to farm marginal land or clear new land is reduced. Increased production may translate into a demand for labor that might otherwise be involved in lower-paying, locally unsustainable practices (such as making charcoal or brick). Techniques include:
  - using improved seed;
  - using multiple cropping;
  - using fertilizers, manures and irrigation and replacing old or inadequate irrigation systems;
  - rotating crops; or
  - introducing cash crops to supplement incomes and pay for soil improvements.

- **Enhance wildlife habitat on farms and establish corridors linking uncultivated areas.**
  Most larger farms contain some areas unsuitable for production, such as riverbanks, waterways, irrigation canals, roads, drainage ways, windbreaks, borders, uncultivated field strips, and woodlots. These areas are useful as animal habitats, particularly for species that do not require large areas for nesting, food and protective cover. Techniques for enhancing habitats include:
  - Planting windbreaks and woodlots using a mix of tree species. Some are preferred food sources for birds and other animals. Wooded areas can also connect forest patches.
  - Consider using uncultivated areas in fields for bird habitats. By planting these areas with plants suitable for birds, erosion is reduced and the birds may eat harmful insects.

- **Establish protected zones near farming areas, ranches, fisheries and parks.**
  This strategy helps to prevent inappropriate uses of these areas and contributes to watershed protection. The zones can also provide income-

Agroecological Techniques

Using the following agroecological techniques, farmers are able to protect wild species and conserve habitat while also increasing agricultural production and incomes:

- **Reduce habitat loss by increasing productivity of already-farmed land.** This includes using improved seeds, multiple cropping, better use of fertilizers, crop rotation and using cash crops to finance soil improvements.
- **Enhance wildlife habitat** on farms and establish wild corridors between uncultivated areas.
- **Establish protected zones** near farming areas, ranches and fisheries.
- **Mimic natural habitats** with perennials.
- **Use farming methods that reduce pollution.**
- **Enhance habitat quality** on farmlands with proper farm resource management practices.

generation opportunities. Potentially, the buffer zones around natural parks can be partially managed by local communities (see the chapter on community-based natural resource management in these *Guidelines*).

- **Mimic natural habitats by integrating perennial plants.**
  Natural environments include myriad annual and perennial plants. Designing farm landscapes that reproduce natural ecosystems helps to conserve water and soil nutrients and provides wild animal habitats. Techniques for recreating natural habitats include:
  - Planting trees in pasture. Trees provide shade for cattle, habitats for birds, and timber, firewood and other products for farmers.
  - Creating agroforests to shelter annual crops (see the chapter on forestry and agroforestry in these *Guidelines*.)
  - Growing shade-loving cash crops, such as shade-grown coffee.
  - Flooding rice fields during fallow periods to mimic wetlands. These environments harbor fewer predators than natural wetlands, making them safer habitats for birds and amphibians.

"In eastern Zambia, 3,000 farmers began to use improved, two-year tree fallows that nearly tripled annual net farm income from maize, their most important crop."

Source: McNeely and Scherr, 2001.

- **Use farming methods that reduce pollution.**
  Techniques for pollution prevention in farming include:
  - Planting buffer strips between farms and water bodies.
  - Practicing integrated pest management (IPM) (see the chapters on IPM and pesticides in these Guidelines).
  - Practicing organic farming, which uses no synthetic chemicals, antibiotics or hormones. **NB:** Organic produce needs certification before it can be sold as such in the export market.
  - Leaving rows uncultivated during contour plowing. Natural vegetation grows in these unfarmed areas, reducing soil erosion, providing organic matter for the soil, and serving as animal habitats.

- **Adapt farm resource management practices to enhance habitat quality around farmlands.**
  Managing habitat quality around farmlands can help to prevent crop losses due to external activities, such as deforestation and wetlands depletion. Techniques for managing habitat quality include:
  - Practicing low-tillage agriculture. Low- and zero-tillage techniques reduce soil compaction, improve conditions for beneficial organisms such as earthworms, and use the cover crop to replenish soil nutrients and prevent erosion.
  - Improving irrigation efficiency.
  - Allowing fields to lie fallow to replenish soil nutrients. Planting fast-growing trees and shrubs in fallow fields can increase food security.
  - Practicing sustainable forestry (see the chapter on forestry in these *Guidelines*).

Mitigation and Monitoring Issues

Monitoring is needed to ensure that the desired results—whether improved productivity, social welfare, or minimal environmental impacts—are actually being achieved. Impact monitoring is complicated by variations in the site conditions, which may reflect natural variability, past use, or differing decisions made by individual farmers. Documenting pre-project baseline conditions is critical to determining if mitigation is working and results are being achieved; however, results of project interventions may take many years to appear.

Participatory mitigation and monitoring: Community involvement in monitoring the impacts and results of the program helps to build capacity among farmers and local organizations, and helps the project achieve long-term success. Farmers should be involved in defining and analyzing their problems, identifying potentially adverse impacts, designing and implementing mitigating activities, and measuring success in terms of participant satisfaction and other indicators.

Drawing conclusions about the success or failure of their efforts reinforces the notion of accountability, both within the community and with respect to the program staff. It also strengthens organizational management skills, creates better understanding of the causes and effects of environmental impacts, and helps avoid the problems of top-down project programming.

Accordingly, program proponents should schedule routine monitoring and evaluation sessions with the participants as a prelude to preparing the formal year-end mitigation and monitoring reports required by USAID. Semi-structured encounters with farmers (which should also include an opportunity for ad hoc responses by participants) may address environmental issues that need special monitoring, such as ensuring that:

- project practices do not lead to erosion, clearing, or conversion of marginal lands not suited to agriculture;
- soil conservation measures are actually reducing and/or arresting erosion and runoff problems;
- any livestock development activities are not leading to overgrazing or making it worse; and
- interventions meet the community’s expectations so residents will continue to replicate them as designed.

Monitoring for complex situations: As shown above, many variables can affect productivity growth and environmental impacts in agricultural development activities; trying to account for them all can make monitoring burdensome. Efficiencies can be achieved by simultaneously monitoring for performance and environmental impact. For example, programs may record the number of participants involved or the size of the area treated, though not as indicators of program performance or environmental impacts. In certain cases, productivity, yields and social welfare changes can act as

Mitigation and Monitoring Issues

- Ensure community and farmer involvement in mitigation and monitoring
- Design monitoring programs to handle complex situations
- Plan to include analyses of the economic and environmental impacts of monitoring and mitigation
- Use proper, efficient monitoring tools, including well-organized data sets, control plots, stream and weather monitoring stations, photo and video records, and monitoring of technology adoption and dissemination.

proxy indicators of environmental stability and program sustainability. Plans for combined performance and impact monitoring should also ensure that data from the monitoring will be analyzed; the analyses can feed back into improved program design.

Economics and environmental impact monitoring: Under marginal conditions, development programs aimed at improving agricultural productivity and/or containing environmental degradation tend to raise production costs. Project planners must carefully examine the real costs and benefits of the project from the farm household perspective **(microefficiency)**. This is particularly important when labor-intensive conservation interventions are proposed.

Rural people, especially those coping with difficult subsistence conditions, are typically very rational about economics and risk. If benefits come too slowly, are too intangible over the near term, or are insignificant compared to the marginal costs of interventions, farmers are unlikely to continue them. Thus proposed interventions should aim to have a rapid, beneficial impact on productivity, household food security or opportunities to generate income.

Project planners and managers must also establish realistic costs for unit area treated **(macroefficiency)** during initial or pilot efforts. Two factors must be considered in a macroeconomic assessment: the costs to society of *not* reversing the degradation or increasing farm productivity, and the magnitude of the problem across the region where the program is operating.

In other words, if the costs of continuing environmental degradation are high both on-farm and off-site, then government and its partners (NGOs and donors) can better justify high costs per unit area. Nonetheless, before launching an expensive plan, they also have to consider the size of the problem: How many hectares in the program area would have to be treated to begin to have a real impact on the degradation?

Tools for monitoring: Collecting quantitative data and other information for monitoring purposes can be both costly and time-consuming; the tools listed below can help to make it a more efficient process.

- ***Data organization.*** Sound baseline data sets are essential to monitoring of any kind, whether the goal is to detect adverse environmental impacts or to quantify project results. Classifying the program or community area into distinct treatment blocks, along with GPS and GIS technologies, can be useful in making quick surveys of changes in vegetation or land-use patterns when compared to baseline conditions.

- ***Formal control plots for soil erosion.*** Assessing the benefits of soil and water conservation technologies may require controlled test plots to be set up that ensure a minimum number of variables for reasoned analysis of cause and effect. Often, these test plots are found on agricultural research stations. If not, depending on the program, it may be necessary to set them up and collect the data to measure and demonstrate impact.

- ***Stream-gauging and meteorology stations.*** Soil erosion is typically proportional to rainfall, and without localized data, it is difficult to draw conclusions about the efficacy of erosion control measures. The importance of accurate meteorological and hydrological data for agricultural development cannot be overemphasized. Almost any program can justify a small weather station—or, in the case of small-scale irrigation or watershed management, a stream-gauging station. The data collected are useful in helping to define the impact of weather on crop productivity and environmental stability. Development of the monitoring plan must also recognize realistic needs. For example, providing the program's technical staff with rain gear and boots (so they can get out in the rain) can help them to understand erosion through firsthand observation.

- ***Photo and video records and technologies***. The intricate nature of applying soil and water conservation technologies across a mosaic of farm fields makes it extremely difficult to measure results. While sampling techniques can help to overcome this constraint, a number of modern technological advances are well-suited to collecting and managing data on changing site conditions. Seasonal conditions in the program area can be recorded using digital photography and videography, ideally taken from the same vantage points and at the same points in the agricultural calendar. Using GPS and GIS equipment can make it easier to survey for changes in site conditions or land-use patterns that indicate whether soil and water conservation technologies have actually taken hold. These tools can also enhance projects' ability to train staff and participants and can be used to demonstrate results for public relations purposes.

- ***Technology adoption, dissemination, and maintenance.*** One of the most appropriate proxy indicators of the success of soil and water conservation technologies is farmer satisfaction with the application. This is easily detected by gauging adoption rates, the extent of the technologies' spread to other farmers, and the degree to which the farmers carry out the ongoing maintenance that is often critical for maintaining optimal impact.

Specific Mitigation Measures

Table 3 provides specific guidance for mitigating and monitoring adverse environmental impacts for activities in agriculture. Although the mitigation and monitoring measures suggested below are geared to several distinct categories of sector activities, program implementers also need to be aware of the implications and constraints (as well as potential beneficial outcomes) of the policy framework in which they are working.

Table 3: Impact Monitoring and Mitigation for Small-Scale Agriculture Sector Activities

Category	Problem	Root Cause	Mitigation Measure
Land degradation	Loss of soil from agricultural land	Water- and wind-induced soil erosion	Improve overall farming system Match land use to land capability Apply appropriate soil and water conservation measures
	Loss of soil from marginal areas	Water- and wind-induced soil erosion combined with inappropriate land use	Reduce pressure on marginal areas through alternative income sources and/or changed land uses Encourage revegetation of degraded and marginal areas to reduce runoff
	Soil infertility: significant increase in fertilizers necessary for crop production	Nutrient exhaustion due to farming techniques	Rotate crops Allow land to lie fallow Intercrop with legumes or other nitrogen-fixing species Practice low-tillage farming Combine crop and tree production (agroforestry)
	Overgrazing leading to erosion, vegetation loss and gully formation	Noneconomic reasons for large herds (e.g., prestige, marriage dower) Lack of alternative fodder sources	Increase average animal productivity through health and nutrition Improve market options for culls Improve grazing management systems Improve communal land management
	Land barrenness: sand dunes encroaching on productive agricultural land	Desertification due to climate change, poor land-use practices and farming techniques	Use trees, grass, grass mats, or mesh to stabilize dunes and prevent their spread Plant vegetative windbreaks to reduce soil erosion from wind Revegetate denuded areas to reduce soil erosion from runoff Take other conservation and prevention measures, such as more efficient use of fuel, improved dryland farming, and livestock improvement programs, to reduce crop and herd quantities and improve quality
Runoff from land use	Polluted and eutrophic lakes and rivers Low fishery yields	Poor water quality caused by being downstream from livestock farms; agrochemical and fertilizer use on cropland	Vegetate areas around fields to prevent nutrient runoff from croplands Vegetate riparian areas to prevent erosion along stream banks, leaving 50-m-wide strips between waterways and croplands

			Collect agricultural wastewater from intensive livestock operations in holding lagoons
	Pollution of exposed wells and springs	Increased incidence of waterborne disease	Implement minimum setback limits for grazing and agriculture around water sources Ensure that wellheads and springs are properly constructed and protected
	Contamination of environment, especially soil and water	Subsidies for farm inputs Inappropriate input packages	Improve training of farmers in input use, especially chemicals Train providers and venders of agricultural inputs
Siltation	Flooding and decreased navigability of rivers and waterways	Deposition of silt in rivers and water bodies from erosion	Revegetate critical watershed areas and apply soil and water conservation measures to the upstream areas for better erosion control
	Flooding and soil erosion after rainstorms	Watershed destabilized due to deforestation and reduced area or capacity of wetland	Revegetate degraded and marginal areas to reduce runoff Vegetate riparian areas to prevent erosion along stream banks Maintain condition of existing wetlands and construct additional artificial wetlands if appropriate
	Changes to river deltas, coastlines, and estuaries	Destruction of coastal areas from erosion and siltation	See above measures for erosion control along river and critical watershed areas Protect mangroves from agricultural and other uses
Degradation of protected habitats	Destruction in and around protected areas and parks	Poor land-use policies that foster unsustainable use of protected lands	Institute community-based natural resource management (CBNRM) to manage park lands
Biodiversity loss	Decrease in wild plant and animal species	Biodiversity loss due to habitat destruction and competition from foreign species	Use ecoagricultural techniques Create corridors connecting protected habitats Revegetate areas in and around fields to create habitat Use appropriate native plant and tree species Obey plant and animal quarantine rules

1.2 Irrigation

Brief Description of Sector

Irrigation is used in arid and semiarid regions to counter drought, to supplement water requirements in areas where total seasonal rainfall is poorly distributed during the year or variable from year to year, and to prolong the effective growing season to permit multiple crops per year instead of a single one. In areas where traditional rain-fed agriculture has a high risk of crop failure, irrigation helps to ensure stable production.

Irrigation systems are used on 14.3 million hectares in Africa, although the number of irrigated areas varies widely among countries. According to FAO's Aquastat database, Egypt, Sudan, South Africa, Morocco, Madagascar, Nigeria, Algeria, Libya, Angola and Tunisia account for more than 80 percent of the water-managed areas. Where rainfall is less scarce, as in many in equatorial African countries, irrigation is used for off-season cropping, for rice cultivation, to produce high-value crops like vegetables, or as a supplemental water source in wetlands and valley bottoms.

Weirs like this are used to divert water from a river to irrigate farms. They can have significant effects on the hydrology and quality of the river flow.

There are many obstacles to increased irrigation in sub-Saharan Africa. The region has limited and diminishing freshwater resources. In a number of areas where water is scarce, such as Southern Africa, planning is not possible due to the absence of any regional agreement on the use of potential resources. Even where water resources are available and adequate, other conditions may hinder irrigation development. These include unfavorable topography and soils; distant markets; inadequate infrastructure, training and management; and lack of credit or extension services. Moreover, the many environmental problems associated with irrigation (see next section) should encourage project planners to approach it with caution.

Types of Irrigation Systems

- Diversion systems, to divert a river or stream flow for irrigation use
- Spate systems, which rely on occasional flooding of a stream or river to collect water
- Spring systems, drawing water from springs and groundwater
- Storage systems, which rely on water captured by small dams
- Lift systems, using pumps or other mechanical means to move water from water source to fields
- Sprinkler systems, which mechanically move water from a source for dispersal over a field
- Center pivot systems, a specialized sprinkler system rarely seen on small farms
- Drip, or trickle irrigation, which applies small amounts of water directly to the ground close to the roots of a plant

Small-scale irrigation projects in Africa typically irrigate 100 hectares or less. Surface and gravity-flow irrigation are the most widely used techniques, although sprinkler systems are used on the larger commercial farms in Zimbabwe, South Africa, Kenya, Zambia and various countries in North Africa. Expansion of other systems such as trickle, drip, or treadle pumps has been slow. Surface irrigation schemes include:

- **Diversion systems.** Diversion or off-take systems divert a portion of river flow for irrigation use. These systems use a natural river or stream flow, diverting it into a canal system and, possibly, a storage tank. Diversion systems can operate with or without a control structure at the head of the system. Occasionally, a structure is constructed in the watercourse to increase the amount of water that may be diverted. Primary canals, sometimes lined, transport water from catchment areas to the flatter croplands below. Diversion systems can deliver irrigation water during the dry seasons and/or supply supplemental irrigation during rainy periods.

- **Spate systems.** Similar, but less sophisticated, spate systems use occasional flood-level flows in a watercourse. They are typical in arid areas with intermittent streams that only flood during high rainfall. This type of system, which is sometimes called “wild flooding,” depends on climate and topography for the opportunistic capture and spreading of floodwaters (see Prinz and Singh, 1999).

Under USAID Reg. 216, irrigation, no matter what the scale, is considered to fall within the “class of actions normally having a significant effect on the environment” (216.2[d]) and therefore requires a formal environmental assessment.

- **Spring systems.** Spring systems use water from natural springs, often collected overnight, to irrigate crops. Spring waters are typically divided among irrigation, livestock and household needs. The area irrigated is usually small, and irrigation water is often carried by hand.

- **Storage systems.** Storage systems are another simple form of small-scale irrigation, capturing water from a stream and storing it behind a dam for use during the dry season. Outlets in the dam channel the water into canals leading to irrigated perimeters downstream, typically in the same valley. Earthen dams are the most common storage system used, and pumps may be used on larger dams.

- **Lift systems.** Lift systems involve using manual or mechanical pumps to raise water out of a river course or well in combination with a surface irrigation channel. Such systems can be used to feed surface irrigation systems or sprinkler systems. They may also be combined with a storage tank into which the water is pumped to increase delivery pressure. Hand- or foot-operated treadle pumps, which originated in Bangladesh, are being seen increasingly in Africa, especially on small vegetable farms near urban centers.

- **Sprinkler systems.** Gravity-driven sprinkler systems are common in some highland areas, often being used for producing horticultural (garden-type) crops. This type of system captures water from a spring or diverts it from a river or stream high up in the catchment, sometimes storing it in a tank, and carries it via PVC pipes for dispersion over a small plot of land. These systems can be used for either supplemental irrigation or dry-season use.

- **Center-pivot irrigation system (CPS).** A specialized sprinkler irrigation system for large flat areas, the CPS is seen occasionally on the largest farms; such systems are capital-intensive and not typically applicable to smallholder conditions.

- **Drip irrigation.** Drip irrigation, sometimes called trickle irrigation, involves dripping water from small pipes onto the soil very slowly (2–20 litres/hour). Water is applied close to plants so that only the soil around the plant gets wet, unlike surface and sprinkler irrigation, where the whole soil surface is wetted. Depending on the crop and the climate, crops are watered every one to three days, which maintains a high moisture level in the soil while minimizing water loss from evaporation. Drip irrigation is often used for vegetable production; however, the initial cost of a drip irrigation system may be prohibitively high for smallholders.

Potential Environmental Impacts

An array of adverse environmental impacts may be associated with irrigation, and some of the most severe may be in newly irrigated areas. Modifications to existing irrigation projects may also generate new, unanticipated impacts, which vary according to the stage of implementation. For example, specific health and other social risks may occur during irrigation construction that relies on migrant laborers living in temporary and unsanitary accommodations. Also, after years of operation, cumulative impacts may emerge that could have only been predicted through environmental impact assessment.

Soil salinity. Intensified agricultural production on irrigated lands can reduce soil fertility over time by making it more salty (saline). A high level of salt in the soil limits what crops can be grown, reduces crop germination and yields, and may make soils more difficult to work. Excessively saline soils force farmers to abandon fields. Salts build up in soils in four main ways:

- Irrigation water contains salts. Water is taken up by plants or evaporates into the atmosphere, but the salts accumulate. Flatter, low-lying areas, water tables with a low hydraulic gradient, or low-permeability soils are most susceptible. Depending on what is happening upstream, the water source itself may become more saline over time, increasing the salinization rate of the soil. Also, systems that reuse the drainage water during water shortages make salt accumulate faster.

- Artificial and natural fertilizers may not be fully absorbed by plants, leaving salts which accumulate in the soil.

- Salts may occur naturally in the soil, and adding extra water through irrigation mobilizes them. This problem is often severe in desert or arid regions where natural rainfall is inadequate to remove the salts from the root zone by leaching.
- If the water table is high, water will rise through capillary action and evaporate, leaving salt in the upper layers and on the surface of the soil. Excess irrigation can also raise the water table and is often associated with salinized arid regions, where large areas of once-arable land have become unusable.

Potential Environmental Impacts of Irrigation

- Increased soil salinity
- Alterations to hydrology and watersheds
- Increased erosion and sedimentation
- Threats to human health
- Damage to water quality for all users
- Damage to sensitive ecosystems, such as rivers, wetlands and coastal estuaries
- Disruption of local socioeconomic arrangements
- Inefficient use of scarce water resources
- Cumulative and area-wide effects on environmental quality

Excessive salt can cause irreversible damage to the soil structure, particularly in clay soils. In areas with acid sulphate soils, such as tropical coastal mangrove swamps, irrigation removes cations (positively charged ions) from the soil and reduces the availability of nutrients to plants. As an acid sulphate soil dries out, the change in pH also decreases the organic content and may release elements that can have toxic effects on the ecosystem.

On islands and in coastal areas, saline intrusion into groundwater sources is a major problem associated with drawing water for irrigation and drinking water. If too much groundwater is drawn, salt water can enter the aquifer. Not only will this have a major impact on other aquifer users, but the entire coastal ecosystem, particularly plants and fisheries, will be affected.

Hydrology. Diverting water for irrigation affects watersheds by altering rivers' flow regimes (patterns of flow volume) and affecting the depth of the water table. Without irrigation, rivers may experience large seasonal variations, flooding during the rainy season (flood regime) and carrying small water volumes during dry seasons (low-flow regime).

- **Low-flow regimes.** Irrigation takes water from the already limited supply available during low-flow regimes. This may leave too little water for downstream uses such as drinking water, hydropower, transportation, and other irrigation projects. In addition, reduced water quantity often translates into reduced water quality, because there may not be enough water to dilute pollutants to acceptable limits. Turbidity also increases as flows are diminished. If the river is linked to wetlands or an estuary, reduction in water volume or quality may harm critical animal habitats, fisheries, and flora as well as drinking water supplies.
- **Flood regimes.** Irrigation reduces river flooding, which may be helpful in that it lessens the potential for property damage and loss of life. On the other hand, irrigation also alters natural irrigation and fertilization of flood plains, disrupting traditional agricultural practices. Fisheries and aquaculture projects in estuaries and coastal areas may be harmed by reduced floodwaters. Diverting floodwaters leaves less water to recharge groundwater supplies and wetlands. Furthermore, floods are important for transporting sediment downstream. When they are reduced, the decrease in flow may contribute to greater siltation upstream, making rivers less navigable.
- **Dams.** Reservoirs are often used to supply irrigation water during dry seasons, provide power, and prevent flooding. Like other water diversions, dams worsen low-flow states and add to the potential

adverse impacts of reduced flooding. Creation of new dams may require local populations to relocate and deprive villages of farmlands or forests. Shallow reservoirs can become clogged with weeds, impeding water flow and preventing livestock from reaching drinking water. Reservoirs may also be breeding grounds for vectors carrying diseases like malaria, schistosomiasis (bilharzia) and river blindness.

- **Water table.** Lowering the volume of water in rivers has a similar effect on groundwater levels. Less river water means less groundwater recharge and lower water tables. This may make springs and wells dry up, leaving people to collect water from more distant sources, or it may make water less potable, possibly increasing the risk from diseases such as guinea worm, schistosomiasis, dysentery and typhoid. Long-term reductions in water table levels can lead to land subsidence (slumping).

  Conversely, problems such as irrigation canal leakage and over-irrigation lead to waterlogging and raise groundwater levels on and around farm plots. Waterlogging implies higher numbers of waterborne pathogens (organisms that cause disease), afflicting plants, livestock, and humans.

Erosion and sedimentation. Because irrigated land is already wet, it may be less able to absorb rainfall. Runoff from irrigated croplands during a storm can thus be heavier than runoff from unirrigated areas, carrying sediment and any farm chemicals into water bodies. The effects of sedimentation on rivers are compounded by any changes in flow regimes caused by irrigation structures. Increased sedimentation upstream can also clog irrigation intakes, pumps, filtration operations and in-field channels downstream.

Poor design, construction and placement of water inlet points for irrigation can all erode the soil at the head of an irrigated field. The eroded soil may accumulate in the middle or at the tail ends of the field where the water moves more slowly, interfering with in-field water distribution.

Human health. On one hand, irrigated agriculture can improve human health through greater food security, better nutrition, improved local infrastructure and higher incomes that allow access to medicines and health services. On the other hand, irrigation also supports many waterborne diseases in both humans and animals, including malaria, schistosomiasis, dengue, bancroftian and lymphatic filariasis, river blindness, loiasis, roundworm, tapeworm, guinea worm, yellow fever, sleeping sickness, cholera, typhoid, hepatitis and leishmaniasis.

For example, stagnant or low-flow water bodies, such as clogged irrigation canals, waterlogged fields and rivers under extremely low-flow regimes, breed malaria-carrying mosquitoes and the snails that transmit schistosomiasis. Lowered water tables in arid regions can increase the incidence of sandflies, which transmit leishmaniasis. Using polluted wastewater for irrigation can spread roundworms and tapeworms in both livestock and humans. Finally, pollutants, including pesticide residues, excess nutrients from fertilizers, and saltwater intrusions in groundwater, all threaten drinking water sources, leading to increased sickness and death.

Water quality. As mentioned earlier, irrigation can affect downstream water quality by reducing the amount of water available to dilute contaminants and by potentially increasing agrochemical pollution.

- **Toxic substances.** Modern agriculture uses a variety of toxic and potentially toxic substances. Pesticides and herbicides can endanger human and animal health, persist in nature, and interfere with natural pesticide controls (such as predatory insects).[6] Applying too many agrochemicals can cause many of these elements to build up in water. Use of sewage or industrial wastewater can spread disease and contaminate soils and food; sewage sludge may also contaminate soils with heavy metals, which can have toxic effects on ecosystems and human health.
- **Nutrient pollution.** Commercial irrigated farming projects normally use fertilizers, but overusing them puts excess nutrients in the ecosystem. Nitrates, which are water-soluble, are quickly transported into rivers and estuaries. Phosphates attach to soil particles, but may eventually seep through to contaminate groundwater or be carried in rainwater runoff to rivers, streams and lakes. As phosphate concentrations rise, they may stimulate rapid growth of aquatic vegetation and algae. Excess nitrates in water sources can be toxic to aquatic life and young children. Also, if human excreta is used as fertilizer or deposited in irrigated fields, rainwater runoff may transport them into open water bodies where they may spread diseases such as cholera, hepatitis and worms.
- **Anaerobic effects.** Loading water bodies with nutrients encourages algal blooms, which deplete life-giving dissolved oxygen and harm aquatic life and fisheries. These conditions are most severe in shallow and slow-moving water bodies, such as reservoirs and low-flow regime rivers. Reservoirs may also become anaerobic (i.e., lacking oxygen) near the bottom due to decaying organic matter. When organic matter decomposes under these anaerobic conditions, the process yields hydrogen sulphide, methane and ammonia, all of which are poisonous to humans and aquatic organisms.

Impacts on ecosystems. Diverting water for irrigation leaves less for downstream ecosystems, including wetlands, mangroves, and coastal estuaries. Discharge water from irrigated fields may contain more salt, less dissolved oxygen, more pollutants, and a heavier silt load than the incoming flow. It also tends to be warmer than receiving rivers and streams. These changes can encourage weed growth and harm fish and bird populations.

Less water downstream in wetlands decreases the recharging of local groundwater and hampers wetlands' natural water treatment functions. A long-term reduction in water flow to wetlands will cause them to shrink and will alter the composition of wetland vegetations. These changes in flora cause loss of animal habitat, flood protection, and coastal erosion buffers. Mangroves, in particular, require large volumes of fresh water and sediment

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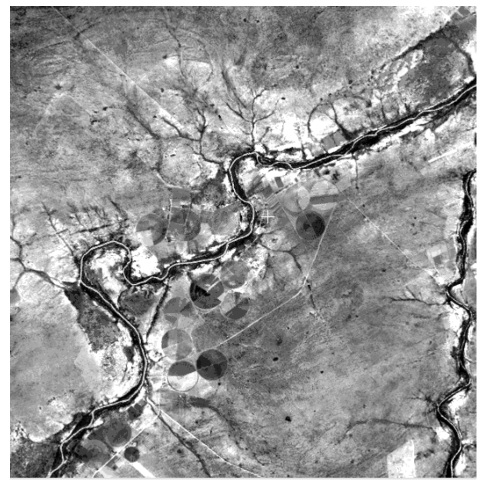
[6] For a discussion of pesticides' effects on water quality, see the sections on IPM and safer pesticides in these *Guidelines.*

to protect coastal areas and make them flourish and to support commercially valuable spawning grounds.

Increased erosion and consequent siltation of water bodies damages fisheries and aquaculture. Land clearing for irrigated agriculture, particularly for monoculture crops, may destroy sensitive and important animal and plant habitats. As discussed earlier in this chapter, wetlands are often deliberately drained and used as sites for irrigated agriculture because of their high soil fertility, but while the fertility is often short-lived, the wetlands' environmental benefits are lost for good. Larger areas of irrigated monoculture are especially prone to crop pests and diseases. Waterborne vectors of human and animal diseases (snails, mosquitoes, etc.) may also be encouraged. All of these impacts may harm local species that use wetland habitats, as well as migratory bird populations.

Socioeconomic impacts. Although irrigation is usually introduced to improve economic conditions and support development, it may wreak social and economic havoc. New irrigation schemes can disrupt communal land-use rights and highlight discontinuities between traditional and legal land rights. Individual water rights may need to be negotiated, particularly for small plots. Changes to field layouts may be necessary and some cultivated land may be lost, which will require adequate compensation. Even successful irrigation projects can harm downstream users by reducing water volumes and/or quality.



Irrigation systems, such as the dark, circular center-pivot lands and other systems visible in this photo, can have a significant impact on water quality and add extra competition for the use of scarce water resources.

Moreover, successful irrigation projects tend to result in *induced settlement* and *in-migration.* Disrupted communities and displaced settlers may be more likely to exhibit behavior that puts them at high risk for HIV/AIDS. In addition, this growth is typically unplanned, without adequate provision for potable water supply, waste disposal, housing, roads or other services. Public health in settlements can actually *worsen* as a result of an irrigation project. Larger, denser populations in a newly irrigated area undertake related activities with environmental impacts of their own, such as more agriculture, grazing, and harvesting of forest products. This phenomenon, called the Hinterland Effect, must be planned for before beginning any irrigation project.

Irrigation generally benefits landowners more than tenants or communal land users. While women and children may benefit from higher income and improved nutrition, they may also lose access to lands traditionally used to collect fuelwood or grow vegetables. Also, irrigation projects may involve pastoralists with little or no experience with irrigation farming techniques. They are less likely to benefit from such projects than are outside investors or entrepreneurs who hire the workers as tenant farmers.

Inefficient use of scarce water resources. As a result of poor site choice—e.g., sloping lands that increase runoff—scarce water resources may be used inefficiently. There may be major leakage and evaporation from canals and storage dams, as well as poor water management by farmers within the scheme; these problems are particularly acute under arid or semiarid conditions. Poorly maintained canals result in water losses and the growth of vegetation in the canals, with noticeable effects on efficiency, distribution and leakage.

Cumulative and areawide impacts. Before creating a new irrigation project, it is crucial to consider the cumulative impacts of other NGO/donor projects in the watershed. Although a single project may only divert 1 percent of a river's flow for irrigation, many such projects using the same river may severely alter its flow regimes and negatively impact downstream users. The importance of leaving adequate flows for drought or low-flow regimes cannot be stressed enough. When too much water is diverted, rivers can be reduced to a series of stagnant pools of water along the riverbed where mosquitoes breed and spread disease.[7] Also, excessive diversion of water may have unforeseen impacts on biodiversity by exacerbating conditions that already threaten local populations of endemic species.

Traditional Irrigation in Africa

Throughout Africa, farmers irrigate shallow, seasonally waterlogged depressions, called *dambos*. Also known as *banis, bolis, fadamas, marais, and vleis,* these wetlands are variable in soil and water regimes over a short distance. Good farmers use bed size and height, plus different crops and cultivars, to manage this diversity. By contrast, large-scale interventions often focus simply on removing the water and lowering the water table, without considering the negative impacts these changes cause.

Properly managed dambos can yield twice as many crops per unit of land and water as mechanical irrigation systems, and less expensively. Dambo cultivation can also benefit the watershed, since no extra groundwater is necessary, watershed downstream flows are not affected, and wetland habitats for biodiversity are conserved.

Source: McNeely and Scherr, 2001.

Sector Program Design—Some Specific Guidance

Designing an irrigation system from the ground up, or rehabilitating an existing one, demands attention to a multitude of factors—social, economic and technical. It is essential to take local, national and regional experience in the sector into account, and to involve knowledgeable local staff in preparing for the project. Considerations include, but are not limited to:

- capacity of land and water resources to support irrigation;
- optimum scale of the scheme;
- crops best adapted to the soils and seasonal water availability;
- sources of extension information, technology and input supply for the scheme (tools, seeds, machinery, etc.);
- output markets for increased production;
- role of the community in managing the system;
- farmers' experience with irrigation farming techniques; and
- whether population has to be relocated to the project area to supply the scheme with workers, impacting on local health and increasing demand for housing, health, education and other services.

Complete success in irrigation development is elusive, and large-scale changes should not be undertaken lightly. Even minor modifications to such traditional wetland management schemes as *dambos*, *marais* and *bas-fonds* (see box, left) can cause major problems.

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[7] For photos and examples, see T.M. Catterson et al. (1999).

Community involvement. Community and farmer participation in planning and designing new irrigation schemes (or rehabilitating existing ones) is critical to minimizing adverse socioeconomic impacts and maximizing community benefits. User feedback on particular needs for extension, marketing and credit will also help to generate community involvement and support for infrastructure changes, and it can be the key to successful development and implementation of annual mitigation and monitoring plans.

Some sample questions to consider when soliciting community input for a new irrigation project are:

- What are current land tenure arrangements?
- How will the project guarantee equitable access to irrigated lands? Equitably shared benefits from production?
- Are there differences in men's and women's roles and relationships that may affect the long-term future of the scheme and the environment?
- Will there be adequate access to markets?
- Will farmers have enough demand for their production?
- What is happening to the quality of the soil in the area? What are existing and future soil maintenance needs (e.g., will soil fertility decrease due to intensive cropping and nutrient leaching)? What changes have farmers observed in the last 30 years?
- What is the potential for soil salinization or other long-term, cumulative effects?
- Are there any current pest problems?
- What is the condition of the potable water supply? Are there potential health issues?
- What is the current incidence of malaria? Bilharzia?
- Is there potential for introduction of nonindigenous seed, etc.?
- What are the long-term prospects for maintaining canal and irrigation structures? Who will maintain them? How? Who will pay for maintenance?
- What are the cumulative effects of similar irrigation schemes? Are other potentially unsustainable land-use practices occurring in the watershed (such as charcoal or brick making)?

Irrigation Sector Program Design Principles

Incorporate community involvement in planning and operation

Design for local soil conditions

Account for water availability

Design for local crop conditions and varieties

Plan for operation, maintenance and management of the project

Ensure that the design accounts for health risks

Follow environmentally sound construction practices

- What are possible secondary impacts—particularly induced settlement? Is there adequate provision for drinking water, waste disposal and other services for settlers?

- What realistically may happen when the project ends? What will the project area look like in 30 years?

Design for soil conditions. Choose an irrigation system suited to the type of soil available. Low-quality irrigation water should not be used on clayey soils, but might be used on more permeable sandy soils where pollutants will not accumulate. In high-salt situations, salt-tolerant crops should be chosen. In addition, salt levels in the soil should be reduced through such mitigation measures as adding gypsum to either the irrigation water or the soil before irrigating, or growing a catch crop[8] of a salt-tolerant plant such as *Sesbania*. Construct adequate groundwater drains (either pipe/tile drains or deep ditches) to control the water table.

Soil erosion causes sedimentation of reservoirs, irrigation intakes and pumping stations, requiring expensive, annual desilting. Soil erosion rates, however, can be predicted and planned for, based on soil type, field size, structure drop size, slope, and field layout. Leveling fields before planting will reduce soil erosion, as will constructing field bunds. To stabilize soils, farmers should always plant vegetation on bunds and on areas around control structures and new irrigation construction. (See guidance on controlling soil erosion in the chapter on agriculture above and in the references.)

Design for water availability. It is very important to install stream-gauging stations or water-level gauges to collect a historical record of regular and lean conditions. Without such information, it is difficult to plan for additional irrigated fields and new crops, or to determine if maintenance or new infrastructure will be required. This information is also needed to develop and establish legal agreements between farmers and communities over water use and distribution. Any major irrigation scheme must have this hydrological data in hand from the start to ensure a good plan. Local personnel should be trained to use stations or gauges to record measurements.

When creating a new irrigation project, it is wise to start with a smaller area for irrigation in Phase 1, using conservative estimates of water availability. As more data about low-flow conditions become available, the irrigated area can be expanded to match the water supply. Be aware that growth of both population and industry in the area will, over time, create competing uses for surface water and groundwater.

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[8] A catch crop is a quick-growing crop sown between seasons of regular planting to make use of temporary idleness of the soil or to compensate for the failure of a main crop. Examples of catch crops include rapid-maturing vegetables as radishes or spinach (planted between rows of slower growing crops); quick-growing crops such as rye, millet, or buckwheat; or an annual legume, such as soybean, which can be used as fodder or plowed under to increase soil fertility. (Source: *The Columbia Encyclopedia,* sixth edition, 2001.)

Gravity-flow irrigation uses gates, siphons and checks to evenly distribute water in a field. Other systems, such as overhead, drip or trickle, while they grow more crop per unit of water, are more capital-intensive. These require availability of the systems themselves and of spare parts, as well as crop prices that allow returns from the increased production to justify the investment.

If soils require leaching beyond what occurs naturally during rainy seasons, extra water will be required and should be budgeted for over and above crop requirements. Saline drainage water should be disposed of properly, either to the ocean through dedicated channels or to evaporation ponds.

Design for crop conditions. Irrigation systems should control where, when and how much water is supplied to promote yield and enhance the economic efficiency of crop production. Watering requirements, both volumes and frequencies, will change based on time-variable crop needs. System design should aim for optimal growing conditions in a specific plot or season while protecting the fields against long-term degradation.

Design for operation and management. Regular maintenance will be necessary to keep irrigation canals free of weeds, reduce effects of sedimentation, and prevent wasteful leaks. Farmers and communities must devise and implement a workable approach to operation and maintenance *before* any irrigation program is undertaken. System design should include who will be responsible for maintenance, monitoring, and regular operations.

Operation and maintenance (O&M) questions to be answered before project launch include:

- Who will be responsible for O&M?
- When will irrigation take place?
- How will fair delivery be determined?
- Who will be responsible for developing and implementing the mitigation and monitoring plan?
- How much will O&M cost?
- Who will pay for O&M?
- Who will manage the funds for O&M?
- How will appropriate use of the funds be guaranteed?

Design for health risks. Surface, contour, and furrow irrigation typically present more health risks than sprinkler, central pivot, or drip irrigation schemes. Contamination of groundwater and surface waters by pesticides and fertilizer can likewise imperil health. The risk of such contamination should be assessed and design and operation measures taken to minimize this risk.

Dam and reservoir design. To prevent anaerobic conditions in reservoirs, clear out organic matter like trees before filling, and design multilevel dam outlets to make sure downstream waters are sufficiently oxygenated.

Reservoirs and irrigation canals can also be used for aquaculture and as bird habitats. Aquaculture in canals can help to control weeds while providing a source of protein and income. Bird sanctuaries and wildlife parks can be established around reservoirs to protect wildlife and stabilize shorelines against overuse and erosion.

Follow environmentally sound construction practices. Constructing irrigation works involves a whole set of construction-related environmental concerns, including worker sanitation, location and management of borrow pits, construction of access roads, etc. (see the chapters on small-scale construction, roads, and water and sanitation in these *Guidelines*).

Environmental Mitigation and Monitoring Issues

Mitigation and monitoring plans should be created to protect sensitive ecosystems and protected areas from changes in flow regimes or water quality. Effective planning of irrigation projects demands a sound environmental baseline (e.g., stream flow, groundwater levels) as well as ongoing monitoring of critical conditions.

Planning environmentally sound small-scale irrigation. Because of the importance of small-scale irrigation activities in the food security efforts supported by USAID in Ethiopia in the late 1990s, a Programmatic Environmental Assessment (PEA) of these activities was carried out (see Catterson et al., 1999). One of the PEA’s outcomes was development of a *Checklist for Planning Environmentally Sound Small-Scale Irrigation (SSI) in Ethiopia*. Because of the breadth and variety of the SSI program in Ethiopia, it is likely that this checklist could be successfully used in other African countries. The *Checklist* is included as an appendix.

Table 4 provides specific guidance for mitigating and monitoring adverse environmental impacts for irrigation activities.

Table 4: Mitigation and Monitoring Table for Irrigation Impacts

Category	Problem	Root Cause	Mitigation Measure
Soil problems	Waterlogged soil	Overwatering; inadequate drainage	Use good irrigation management, matching water demand and supply by location. Provide drainage and line canals in highly permeable areas to prevent leaks. Redesign irrigation infrastructure to reduce waste; use sprinkler or drip irrigation systems instead of gravity-flow systems. Encourage farmers to value water resources by establishing a system of water user fees tied to consumption.
	Salt buildup on irrigated land	Irrigation system does not adequately leach salts from soils	Design system to allowing leaching with excess water. Alternate irrigation methods and schedules. Install and maintain subsurface drainage system. Adjust crop patterns (fallow times, crop selections, etc.) to prevent further salt buildup. Incorporate soil additives. Add gypsum to either the irrigation water or the soil before irrigating. Plant salt-tolerant catch crops such as *Sesbania*.
	Crops wilting or dying	Changes to soil chemistry, including acidification and alkalization	Monitor soil chemistry. Identify indicator plant species. Consult soil scientists. Apply soil nutrients, conditioners and chemicals where feasible.
Water problems	Crops not growing over entire irrigated field	Intrafield distribution system is malfunctioning	Maintain irrigation canals. Clear weeds. Line canals against leaks. Encourage farmers to value water resources by establishing a system of water user fees tied to consumption.
	Dry wells for drinking water and irrigation	Groundwater depletion	Reduce off-take or pumping to allow natural aquifer recharge. Encourage farmers to value water resources by establishing a system of water user fees tied to consumption.

Water problems, cont.	Salt water in wells for drinking water and irrigation	Saline intrusion in coastal aquifer due to excessive groundwater pumping	Reduce groundwater pumping to allow natural freshwater to recharge the aquifer, in order to lower salt concentration in the aquifer.
	Water quality problems for downstream users	Discharged irrigation water is saline or contaminated	Treat irrigation drainage water before release.
	Reduced water quantity for downstream users, waterways and wetlands; intermittent streams run dry.	Too much water diverted for irrigation Poor understanding of stream flows and available water	Reassess water available for irrigation; may need to irrigate a smaller area. Use pipes instead of open canals to prevent water loss from evaporation. Promote local and regional watershed management. If available, consider using treated wastewater for irrigation, leaving freshwater resources for other users.
Health problems	Increased incidence of water-related diseases	Stagnant waterways providing breeding grounds for disease vectors Inappropriate design causing suitable conditions for vectors Shared use of water for irrigation and home use	Periodically flush slow or stagnant waterways with water from dams to remove snails (which cause schistosomiasis). Note that this is effective only for a few hundred meters from where the water is released. Clear clogged irrigation canals. Control mosquitoes, snails and blackfly along reservoirs by periodically fluctuating water levels, making shorelines steeper, and removing weeds. Periodically drain waterlogged fields to prevent mosquitoes. Train women in health issues.
Social problems	Increased inequity	Inequitable access to irrigation waters or crops	Design and manage system to improve access by “tail-enders” (users whose fields are farthest from the water source). Establish and enforce a volume-based water fee. Improve system management, including maintenance of main canals.
	Hinterland effect	Increased migration into area due to successful project	Ensure adequate social and other infrastructure to meet needs of immigrants.

Water transport and storage problems	Weeds growing in reservoirs, irrigation canals, and drains	Siltation or blockages reducing flow	Mitigate weeds in reservoirs, canals and drains by using linings, shade, intermittent drying-out periods, mechanical removal, and weed-eating fish and insects. The removed weeds may also be used for composting, biogas generation, and fish and animal feed.
	Poor water quality downstream from a dam	Insufficient water flow from dam, or poor-quality water behind the dam	Use dam operations to maintain minimum flow conditions to dilute pollutants. To prevent anoxic conditions in reservoirs, clear organic matter, such as trees, before filling.
Ecosystem problems	Damage to downstream ecosystems from reduced water quantity and quality	Too much water diverted for irrigation or storage Saline intrusion at coasts	Use dam operations to mitigate changes in flow regimes of rivers and prevent weeds and diseases.

1.3 Resources and References

Internet Sites Pertinent to Environmental Review of the Agriculture Sector

- U.S. Environmental Protection Agency, Public Information Center (3404), 401 M Street, S.W., Washington, D.C. 20460; tel. (202) 260-2080: http://www.epa.gov

- Environment and biodiversity conservation issues, as well as the relationships between natural resources management and agricultural productivity, have become important topics considered by the 16 international research centers that form the Consultative Group for International Agricultural Research (CGIAR): http://www.cgiar.org

- The UN Food and Agricultural Organization (FAO) Aquastat Web site: http://www.fao.org/ag/agl/aglw/aquastat/main/index.stm

- Conservation Agriculture in Europe: http://www.ecaf.org/English/First.html (good definition of conservation agriculture in executive summary)

- UN Environment Program (UNEP) Programme on Success Stories in Land Degradation/ Desertification Control: http://www.unep.org/desertification/successstories/

- Good Web site under the University of Pennsylvania's African Studies Center: http://www.sas.upenn.edu/African_Studies/About_African/ww_food.html

- FAO. *Agriculture Food and Nutrition for Africa: A Resource Book for Teachers of Agriculture*: http://www.fao.org/docrep/W0078E/w0078e00.htm

- FAO. *The State of Food and Agriculture 2001*: http://www.fao.org/docrep/003/x9800e/x9800e00.htm

- About desertification: http://cals.arizona.edu/OALS/ALN/aln40/WebResources.html

- International Development Research Centre (IRDC). This Canadian institution is a constant source of information on sustainable agriculture in the developing world: www.idrc.ca

- Swedish International Development Agency (SIDA). A major international donor supporting soil and water conservation development programs in many countries: www.sida.org

- Revised Universal Soil Loss Equation project version 2: http://www.ars.usda.gov/research/publications/Publications.htm?seq_no_115=175643

- U.S. Global Change Research Information Office, Geoindicators report: http://www.lgt.lt/geoin/

Tapping the U.S. Comparative Advantage in Soil and Water Conservation and Sustainable Agriculture

- U.S. Department of Agriculture (USDA) listing of agencies, services and programs: http://www.usda.gov/wps/portal/!ut/p/_s.7_0_A/7_0_1OB?navtype=MA&navid=AGENCIES_OFFICES

- USDA's Sustainable Agriculture Research and Education (SARE) Program is an emerging program administered by the Cooperative State Research, Education and Extension Service (CSREES). Although targeted at farming conditions in North America, the conceptual approach and many of its findings can be applied in sub-Saharan Africa: http://www.sare.org/publications/index.htm Some of its more noteworthy publications include *Building Soils for Better Crops*, *The Small Dairy Resource Book*, *Managing Cover Crops Profitably* and *Source Book of Sustainable Agriculture*. It also operates a free e-mail discussion group; to subscribe, send a message to listserve@sare.org, and in the body of the message, write "subscribe sanet-mg."

- The USDA's Natural Resources Conservation Service Web site offers links to a broad spectrum of information about its programs and information sources related to soil, water and natural resources conservation: http://www.nrcs.usda.gov/

- The Soil and Water Conservation Society of the United States is an international organization with programs and publications of interest to those in Africa concerned with soil and water conservation and watershed management: http://www.swcs.org

- The Alternative Farming Systems Information Center offers information resources for farmers and extension agents: www.nal.usda.gov/afsic/csa

- Another site providing assistance, publications and resources free to farmers, extension educators and other agriculture professionals is the Appropriate Technology Transfer for Rural Areas (ATTRA) network: www.attra.org

- The Cornell University–managed Agricultural Network Information Center, or AgNic (www.agnic.org), is an unparalleled guide to quality agricultural information on the Internet from the National Agricultural Library, land-grant universities, and other institutions. It includes access to Cornell's Soil Health Portal (http://mulch.mannlib.cornell.edu), which uses a distributed database technology.

- The Sustainable Rural Development Information System (SRDIS), cosponsored by Columbia University, the Center for International Earth Science Information Network (CIESEN), and other partners (http://srdis.ciesin.org/), is another specialized online library of Internet-based resources.

Agriculture and Soil and Water Conservation References

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1.4 Appendix: A Checklist for Planning Environmentally Sound Small-Scale Irrigation (SSI)

Introductory Note

This checklist for environmental planning is based on small-scale irrigation (SSI) work done in Ethiopia and was designed to assist NGOs there in environmental review of small-scale irrigation activities. If done correctly, using the checklist will accomplish several things:

- users will have identified potential negative environmental impacts associated with the proposed site;
- users can certify to USAID that they are aware of these impacts and have taken the appropriate steps to avoid and/or mitigate them;
- the completed questionnaire and the information it contains, submitted as part of an IEE, will enable USAID environmental officers to verify that the determination is valid and the activity can be approved; and
- everyone involved in the small-scale irrigation activity, including USAID staff, will be aware of which specific elements of the activity require monitoring.

It should be noted that this checklist is not intended to give scores or rankings or to compare one proposed small-scale irrigation site with another. It is further assumed (as specified below) that the provisions for supervision, inspection and monitoring related to the typical mitigation needs of small-scale irrigation will be in place. The checklist is intended chiefly as a guide to ensuring that issues related to the environmental soundness of SSI are addressed iteratively throughout the planning and design steps.

Each item on the checklist needs to be considered and the information duly recorded. Doing so will make it easier to prepare the IEE (or amended IEE); it may also be possible, depending on the outcome of using the checklist, to append it to the IEE itself, allowing the IEE to deal in a more summary fashion with the usual categories of required information. Users are encouraged to add any other information or categories of data that emerge as important in preparing the plan for development of the specific scheme.

To successfully use this checklist, the basic studies, measurements and community consultation regarding the feasibility and design of the proposed activity should have already been carried out. The checklist can also serve as a tool for structuring the consultation needed with the community and any water user associations about:

- the basic design of the SSI site;
- the potential for negative environmental impacts;

- the roles, rights and responsibilities of the different parties (community, water users, project staff, partners, government agencies) in addressing these impacts; and
- the agreements to be achieved among all parties to ensure the sustainability of the activity/investment.

This template does not cover all the potential precautionary measures, nor all possible issues related to the feasibility of small-scale irrigation at every site. Finally, it is not intended to be a substitute for planning and designing the SSI activity.

Note: The abbreviation “masl” used in the checklist = meters above sea level.

Environmental Planning for Small-Scale Irrigation: A Checklist

1. Small-Scale Irrigation Site Identification and Characteristics (fill in the blanks)

Date project planning began: ____

Expected completion date:__________ Present status:____

Site/community name: ____

Location (region, district, village):____

Approximate altitude of scheme:_________________(masl): Agro-ecological zone: __________________

Project Design by:____

Brief project history (proposed by, how identified, by whom):___________________________________

____

Community concurrence:__________ How reached:____

Water user association (WUA) established? [yes/no]:________ Name:_______________________________

How established:____ Date:______________

Number of beneficiary participants in WUA:_________________________

Number of males:_____________________ Number of females:________________________

Percentage of total community to be included in scheme:_____________________________

Area to be irrigated:_________________(hectares)

Type of irrigation (spring, diversion, storage, spate, or lift):________________________

Average size of household irrigated plot:______________ (hectares)

Previous use of irrigated area:____

Is this (check all that apply): a new scheme:________, rehabilitation of traditional scheme:________, upgrading of traditional scheme: ________, rehabilitation of modern scheme: ________

Proposed crops: wet season: ____________________________, dry season:___________________________

Average household holdings outside the scheme:____

Other major infrastructure or investments linked to SSI: ____

____(e.g., roads, potable water, watershed management)

What is the total cost of the scheme?: ___________; broken down by cash costs:___________ food aid cost equivalents (if applicable):___________; community contribution in labor and in kind:___________

Estimate the costs in either US dollars or local currency. Include all necessary investments required for the scheme to operate. Food aid costs can be calculated by multiplying the number of person/days of labor by the equivalent value of the day's ration. Community contribution can also be factored into the calculations, including contributed free labor, if any, and the estimated value of the materials provided (stone, sand, soil, etc.).

What is the expected unit cost per hectare of irrigable land within the command area during the dry season?__________$/hectare.

What percentage of the annual operating budget does the project cost represent, for the district:__________, for the local area:__________, for the program of the project organizer:__________?

Sketch map included: (to scale at 1:10,000 or larger)

2. Analyzing the Basic Parameters

Prepare a brief narrative response for all of the headings below that apply to this site.

Water Resources Availability

- How much water (liters/sec) is available for irrigation purposes?
- Is there a historical record of river/stream hydrology (yes/no)? If so, how was it compiled?
- If not, how was amount calculated? Briefly describe method. (An additional sheet showing calculations should be added.)
- Are there upstream users of the water, or could there be? Explain.
- Are there downstream users, and how do they use water?
- Are they actively pursuing irrigation, and are they using water for potable water supply or for animal consumption? Estimate their requirements (liters/sec).
- How were downstream users consulted?
- What percentage of stream flow will be abstracted during lean (low-flow) periods?

Other Uses and End Users

- Has the potential usage by people or animals been factored into the calculations of water use within the scheme? If so, how?
- Will the scheme attract additional herders and their animals in search of water, including from beyond the present community?
- Is there a need for maintaining minimum ecological flow during the lean season? If not, why not?
- What precautions are being undertaken to guard against unnecessary leakage/evaporation within the scheme?
- Describe the methods by which government staff, WUA officials and the users themselves will measure/know about the annual/seasonal/periodic water availability.

Catchment Status

- What is the estimated size, in hectares, of the catchment that supplies water to this scheme?
- What are the present land uses of the catchment? A sketch map may help to illustrate this point.
- What is the condition of the catchment (good or natural, slightly degraded, moderately degraded, highly degraded, being rehabilitated)?
- Do the present activities include rehabilitating/improving the catchment? If so, what will this entail?
- What percentage of the catchment will be treated each year, and by whom?

3. Estimating Crop Water Requirements

Prepare a brief narrative response for all of the headings below that apply to the site.

- What crops will be planted and in which season?

- What are crop water requirements per hectare?
- An additional sheet describing likely crops and their water requirements in different seasons could be added.
- What is the source of information for the crop water requirements? Describe.
- Which publications are the basis for this estimate of crop water requirements, or how else were these amounts determined (see bibliography)?
- What will be the likely percentage mix of the project's main crops during the wet season and the dry season?
- How will the size of the area under irrigation change from wet season to dry season?
- Are there expectations/intentions about building up the command area during the break-in stage of implementation? (Explain.)
- Are these crops that are familiar to the users or already being grown by them?
- In years of poorest rainfall, what will be the estimated area of irrigable land, and how will the cropping pattern change during the dry season? (Explain).
- What are the expectations regarding production increases, in good rainfall years (percent increase) and in poor rainfall years (percent increase)? What would be the worst-case scenario? (Explain).
- Give some examples of the expectations regarding increases in yield, by crops.

4. Farm/Scheme Land and Water Management and Conservation

Prepare a brief narrative response for all of the headings below that apply to the site.

- Do the proposed users have experience with SSI?
- Will there have to be land redistribution? (Explain—regularly/annually/periodically?)
- What sort of water management technology will be used within the irrigated plots?
- Will the users be able to maintain the fertility of their irrigated plots, and how will they do so?
- What is the average slope of the land within the command area?
- Will soil conservation measures within the scheme be required? If so, briefly describe them.
- Are there indications of salinity problems in similar SSI schemes nearby?
- What did the measurements of water quality (grams/liter) and soil salinity (salinity class) reveal?
- Is salinity likely to become a problem in this scheme? If so, what measures will be taken to manage the problem? Describe.

5. Postconstruction Follow-Up and Technical Assistance

- Where will the farmers get extension support from—government or private sources?
- Are there extension agents available?
- Have the extension information sources been specifically trained in irrigated agriculture, and have they received training specific to this site and its operations?

- Do the information sources need transport to reach the scheme, and do they have it?
- Is there an operations manual to guide these extension services?
- What other services will be provided by the information sources? Input supply? Marketing? Pest and disease diagnostic services? Other?
- Briefly describe any training provided and planned for the WUA officers and users.
- Is there a water user's fee system, and what are its principles? Briefly describe.
- Briefly describe the operations and maintenance requirements of the scheme and who will be charged with its implementation.
- What level of technical assistance from the project designers will be required by the WUA during the start-up phase of the irrigation activities?
- Have the necessary resources (staffing and budgetary) been set aside for this purpose?

6. Water-Related Disease Hazards

Because of the importance of environmental health, particularly in the hotter, lower altitudes, the project designer should provide, if possible, a citation of the environmental health study findings as a supplement to the response to this section of the Checklist.

- Has an environmental health assessment been part of the planning for this scheme? If so, briefly discuss its results.
- Is a health baseline data set available for the community, and what are its most important quantitative findings? Provide a list.
- Briefly discuss expectations regarding community vulnerability to water-borne diseases.
- Briefly discuss expectations regarding public awareness of environmental issues.
- Briefly explain the status of health services in the community, and describe any plans for upgrading these services.
- What percentage of the community has access to potable water, and where do they normally obtain it, in the wet season and in the dry season?
- Does the program of the project designer in this community include a potable water supply component? Briefly describe.
- Is there a community-specific nutritional baseline available?
- What are the household-level nutritional goals of the scheme? Describe.
- How will these goals explicitly be achieved? Describe.
- What measures will be taken for providing potable water to the workforce during construction and for training the workforce on water-related disease hazards? Describe.

7. Displacement and Land-Use Changes

- Will there be displacement of farm plots as a result of scheme construction? If so, briefly describe (no. of households affected/area of land affected).
- Will the command area change/shift as a result of rehabilitation or upgrading? If so, briefly describe.
- What measures are planned to account for these displacements/changes? Describe.

- What percentage of the command area is likely to be devoted to cash crops? Which crops will they be?
- Where and how will these cash crops be marketed and by whom? Describe.
- What are the expectations regarding prices for these cash crops, transport and marketing costs, and returns to the farmers? Describe with as much quantitative data as possible.

8. Monitoring Plans

- What indicators will be monitored to ensure that activities are not leading to unforeseen adverse environmental impacts?
- Which of the planned mitigative measures (see below) will require further specific monitoring to be sure it is effective, and how will this be done?
- How will environmental monitoring be linked to performance monitoring to avoid needless duplication of efforts and meet reporting requirements?

9. Mitigative Measures Planning

- Identify the specific adverse environmental impacts foreseen during planning and describe the mitigative measures for each.
- How have the costs of these measures been factored into the feasibility considerations for the scheme in question?
- Will there be resources available for post-construction mitigation measures, and who will provide them?

Chapter 2

Community-Based Natural Resource Management (CBNRM)

Contents

What is CBNRM?	2-1
Where and How is CBNRM Being Practiced?	2-4
Selected CBNRM Models	2-5
Conditions and Elements for Success	2-13
Significant Challenges to CBNRM Programs	2-20
Guided Questions for Establishing CBNRM	2-26
Environmental Screening Survey	2-31
Comparative Framework for CBNRM	2-33
Resources and References	2-47

Community-based natural resource management simultaneously addresses the problems of poverty and environmental degradation. CBNRM represents a promising approach that encourages communities to take responsibility for managing their resources so everyone benefits.

What is community-based natural resource management?

Much of the world's biodiversity is located in Africa south of the Sahara. In some locations diversity is eight times the world average, four times that of the United States, and twice that of Brazil. However, human impacts on this biodiversity are increasingly severe. Forest, savannah and coastal ecosystems are being rapidly degraded, along with protected areas, national parks, game reserves and forests. The threats to these areas of high global value come from uncontrolled clearing for agriculture, hunting, poaching, logging, grazing, and fuelwood extraction by both residents and outsiders. Often, there is extreme social and political pressure from impoverished communities to overexploit the available resources. Most African governments have neither the resources nor the effective institutions needed to implement environmental regulations deterring unsustainable exploitation.

Sub-Saharan Africa is also one of the world's poorest regions—46 percent of the population lives below the poverty line (less than $1.08/day). Impoverished communities often live in regions that enjoy high biodiversity, or remain relatively unspoiled, but support only meager subsistence agriculture. Only 5.5 percent of the land in Southern Africa is arable, for example, so a large number of people are living in areas of marginal agricultural value. Some of these areas are officially protected as parks or national forests; others are communal lands, generally with conflicting national and local claims of ownership.

Community-based natural resource management (CBNRM) attempts to address the problems of poverty and natural resource degradation simultaneously—even though their solutions are often seen as being in direct conflict. It grew out of the recognition that:

a) unsustainable local practices often drive resource degradation in Africa;

b) existing legal, social and economic policies—in particular the absence of nationally recognized individual or communal resource tenure rights—inhibit sustainable resource use; and

c) governments in developing countries often lack the financial or institutional resources to adequately manage or regulate natural resource use.

CBNRM Principles

CBNRM is premised on the idea that communities will sustainably manage local resources if they:

- are assured of their ownership of the natural resource
- are allowed to use the resources themselves and/or benefit directly from others use of them
- are given a reasonable amount of control over management of the resources

CBNRM programs are described here because they represent promising approaches to mitigating or preventing environmental damage to commonly managed or owned resources. Under CBNRM, local communities benefit from the sustainable use of natural resources. Although core principles and elements of CBNRM have been identified, they are still new and evolving. There are many adaptations, depending on variations in locations and legal, social, political and economic contexts.

The premise of CBNRM is that communities will manage local resources in a sustainable manner if they (1) are assured of their ownership of the natural resources; (2) they are allowed to use the resources and/or benefit directly from others' use of them; and (3) given a reasonable level of control over management of the resources.

Secure community tenure rights are essential to the establishment of CBNRM programs. CBNRM efforts involve processes that often help strengthen local democratic governance, increase the community's standard of living, improve gender balance in resource management, and help provide women with greater income and independence.

Ideally, CBNRM objectives are pursued through a collaborative process that includes representatives from the local community, national resource protection agencies, local and district government, sponsoring donors, and NGOs.

Several countries in Africa have created national programs to promote CBNRM. Most have focused on wildlife, since hunting—especially trophy hunting— provides by far the largest source of revenue. In many countries, international aid organizations such as USAID, and international NGOs—in particular the World Conservation Union (IUCN), the African Wildlife Foundation, the World Wildlife Foundation, and Conservation International—have sponsored, facilitated and catalyzed many current CBNRM projects.

Under model CBNRM programs, the first step is changing land tenure laws to give the community secure ownership of and responsibility for one or more natural resources in its region. With guidance from international donors and NGOs, the community defines boundaries and membership, develops an organizational structure, and decides on a set of operating principles they consider fair and representative. Partners work to help the community resolve disputes over boundaries and obtain legal recognition.

The community, together with the donor and NGO partners, works with technical staff from national natural resource agencies, and with local and regional officials, to develop a set of shared goals, objectives and desired results. As objectives and activities are defined, communities and partners choose among revenue-generating options, set targets, develop a financial management system, and build capacity in both organizational development and financial management. This effort must also ensure that communities have the necessary permits and legal standing to operate revenue-generating CBNRM programs.

Farmers in Mali demonstrate the benefits of community natural resource planning. This field was eroded and virtually useless, but community efforts at building and implementing erosion control measures helped restore the field's fertility.

In many cases, partners provide technical assistance to help communities establish joint ventures with private sector tour operators, hunting safari companies, and operators of lodges, camps and hotels. Under such circumstances, partners collaborate to ensure equitable treatment for the community and individual members through the establishment of legal contractual agreements or "trusts." If government permits or licenses are necessary to establish a community enterprise using natural resources, partners work together to obtain the permits. These then constitute a contractual agreement between the government and the community.

International partners provide the training necessary to establish and maintain the enterprise, giving particular attention to women in the community. Training may include, but is not limited to, literacy, contract negotiation, bookkeeping, environmental mitigation and monitoring, marketing, and financing. At the same time, partners may work to develop the capacity to conduct training in CBNRM by other local, regional or national NGOs, and perhaps the government's natural resource agency as well.

CBNRM Enabling Conditions

- Clarified or improved land tenure
- Local community commitment and capacity
- Experienced NGO and government partners
- Targeted technical assistance
- Regional resource management plans, setting limits of acceptable use
- Workable environmental monitoring and mitigation plans
- Access to markets and credit
- Social cohesion in communities adopting CBNRM practices
- Effective resource monitoring and policing
- Genuine economic benefits to the community

Community organizations need to develop guidelines for safely collecting, holding and distributing income, as well as making decisions on community-funded development projects. Revenues and income needs to be distributed fairly within the community and among partners. Community members may then use the funds to establish additional small natural resource–based businesses, especially those using "non-timber forest products" such as herbs, teas, medicinals, wild fruits, ornamental plants, etc. Woodcarving and folk art may also provide local income.

Once the NRM program is established, natural resource use is carefully monitored to ensure sustainability. Over time, oversight from international partners diminishes. NGO and government partners will typically retain a low level of involvement, providing assistance only when needed.

Where and how is it being practiced?

CBNRM has grown significantly in Africa over the last decade, primarily to protect and manage wildlife, but also to foster sustainable management of rangeland, forested areas, watersheds, fishing and coastal resources. Nationally sponsored programs have been developed in many countries, including Botswana, Burkina Faso, Chad, Ghana, Guinea, Kenya, Madagascar, Malawi, Mali, Namibia, Niger, Senegal, South Africa, Tanzania, Uganda, Zambia and Zimbabwe.[1] Many show promise of success, although not enough internal assessments have been conducted, and few third-party evaluations. Many features vary within and between nations, leading to considerable diversity in CBNRM project development, implementation and outcomes.

Experience has shown that a CBNRM program is more likely to be successful where enabling conditions are in place. Among the most critical of these are:

- clarified and improved land tenure;
- local community commitment and strengthened capacity; strong local institutions and participants with adequate skills;
- experienced NGO partners and functional government bureaucracies;
- targeted technical assistance;

[1] Programs involving multiple countries (transboundary programs) are beyond the scope of this document. See *Policy Environment Governing the Great Limpopo Transfrontier Park and Conservation Area: A Review of Relevant International Agreements, SADC Protocols, and National Policies,* by Dr. Candace Buzzard for an example of policy complexities associated with transboundary resources.

- regional resource management plans with set “limits of acceptable use” or “carrying capacity”;
- a workable environmental mitigation and monitoring program;
- access to markets and credit;
- social cohesion both within and across communities adopting CBNRM practices in a region;
- effective resource monitoring and policing; and
- above all, genuine economic benefits.

The establishment of CBNRM regimes can be a lengthy and complicated process. Sustainable programs may require more than a decade to take root.

Selected CBNRM models

Zimbabwe: CAMPFIRE

The first CBNRM program in Africa was established in Zimbabwe in the early 1980s. In an effort to protect wildlife, particularly elephants, from unsustainable levels of poaching, the government of Zimbabwe set up the CAMPFIRE program (Community Area Management Programme For Indigenous Resources). Under CAMPFIRE, authority over wildlife was given to the Regional District Councils (RDCs), administrative arms of government.

CAMPFIRE encourages sustainable trophy hunting of big game. Revenue from the fees paid by hunters goes to the RDCs and a portion is then distributed to lower administrative levels and/or individual households. Each RDC determines its own policy for the use and distribution of funds. Direct payments to households vary according to these policies and the availability of the most prized species of big game in the RDC, e.g., elephant, buffalo, lion and leopard. Studies of selected wards show increases in wildlife populations and habitat retention—these are considered indictors of success. CAMPFIRE communities receive an average of $1.5 million from the $15 million spent on trophy hunting each year (Getz 1999).

Critics point to serious shortcomings in the program. In particular, too little revenue from safari hunting in many districts is returned to the local residents who bear the direct costs of wildlife protection, e.g., destruction of maize crops or granaries by elephants. Instead, from 50 to 90 percent of the revenue may be retained by the RDCs. Under such circumstances, households may receive only $1 to $3 per year as their share of safari profit, while an illegally killed antelope sold for meat can bring $7 to $20 (Campbell 2000).

Botswana

Botswana has been pursuing CBNRM for over 10 years. CBNRM projects in Botswana operate within the boundaries of Controlled

Hunting Areas, a zoning system developed by the Department of Wildlife and National Parks (DWNP) to administer hunting quotas. To participate in the CBNRM program, a community must form a legally recognized community-based organization (CBO) such as a trust, association, society, or cooperative, and fulfill a specific set of requirements needed to obtain Resource Use Head Leases, which are permits for commercial activities. The permit grants authority over the use of natural resources to the community for a 15-year period. The most significant requirement is a DWNP-approved natural resource

Chobe Enclave Conservation Trust was the first CBNRM project to be developed in Botswana with USAID assistance. The Trust's objectives are to sustainably use, protect and manage the natural resources of the Chobe enclave for the benefit and development of the local communities.

development and management plan prepared by the CBO. The CBO must also be a legal entity with a registered constitution that protects the interests of all residents. Equitable membership in the CBO can be difficult to ensure.

CBOs that obtain leases from the Land Board acquire decision-making power over resource use and development. They may focus on one or more wildlife species, veld or range resources. The CBO has sole authority and acts as the community's agent in negotiating contracts for hunting (within established quotas), tourism and other uses. Leases do not, however, grant the community control over access to their territory.

The program dictates that revenues and benefits go directly to the CBO, which can apply them to communal projects or distribute them to families. In practice, distributions to families have been very limited. Families can earn income directly under the Botswana system. Individuals are thus encouraged to develop independent enterprises using the local resource base, as well as to participate in communal activities.

In Botswana in 2002, 61 CBOs are actively involved in natural resource management (NRM). Most of these groups focus primarily on wildlife resources; these have generally entered into agreements with private companies to manage tourism or trophy hunting. Some non-wildlife resources, such as marula fruit, mopane worms, and thatching grass, are being extracted. Unfortunately, ownership of these natural resources is unclear under current laws. This lack of clarity is thought to discourage sustainable management, although communities are obtaining substantial income from both wildlife and non-wildlife uses. Trophy-hunting remains by far the largest source of income, although 11 of the 18 CBOs assessed in 1999 also harvested veld products. Little monitoring data or research is available on which to base conclusions about the sustainability of these activities (Gujadhur 2000; ADC 1998).

As in other parts of Africa, the support of foreign donors and NGOs to CBNRM projects has been critical. The time from initially organizing to obtaining a lease from the Land Board averages three years. Donors and NGOs are the only source of financial and technical assistance for communities during this period. In general, indigenous governmental and NGOs lack the capacity to provide adequate technical support to CBOs, even after they have obtained their leases. However, promising attempts have been made in strengthening government units and NGOs to provide support to CBOs after foreign assistance ceases. One step in this direction has been the formation of the Botswana Community Based Organisation Network (BOCOBONET), which provides a forum for CBOs and others to meet and share information, experience, and expertise (Rozemeijer 1999). BOCOBONET also offers training in capacity building for CBOs throughout Botswana.

Namibia

The long-term success of CBNRM projects typically requires legal reform, particularly of land tenure law. Namibia is probably the southern African country that has made the greatest progress with such reform. The national government has developed policies and laws that give local communities new authority over the use and protection of wildlife. Their approach borrows from, and improves upon, the CAMPFIRE experience. Namibia's legacy of apartheid resulted in a pattern of land distribution in which 41 percent is rural African communal land, 43 percent white-owned commercial farms, and 14 percent protected area. A small percentage remains unallocated.

Traditional land tenure systems conferred ownership to the chief or king. These systems persisted under white rule, but were undermined by post-independence government policies that weakened the power and status of traditional leaders. A problem of "open access" developed, with local indigenous populations unable to control the settlement of outsiders on communal lands or the use of communal resources. Population growth at rates of 3 percent or more per year in communal areas also increased pressure on natural resources (Jones 1998).

The Namibian Government's approach to CBNRM focuses on encouraging and recognizing communally defined and owned "conservancies." Under laws enacted in 1996, communities that apply for and gain official approval receive rights over wildlife and tourism in the designated area. Importantly, all income from resource use goes directly to the conservancy.

Any group of persons residing on communal land may apply to have some or all of the area they inhabit declared a conservancy. To qualify, the community must:

- elect a committee to represent the group;
- agree upon a legal constitution that provides for sustainable management of hunting and "non-consumptive" uses of wildlife (e.g., tourism);
- establish a means of managing funds;
- approve an equitable method for distributing income; and
- define the geographic boundaries of the proposed conservancy.

Gazetted conservancies have rights of ownership over huntable game (oryx, springbok, kudu, warthog, buffalo and bushpig). Those include use for residents' own purposes, capture and sale, hunting and culling. Conservancies also have the right to apply for permits for trophy hunting of protected animals (Jones 1998).

Given the requirements and inevitable bureaucratic aspects of the process, obtaining approval for a conservancy requires considerable investment of time on the part of core leadership, and often assistance from an NGO. In some cases, the process of defining boundaries has led to conflicts with neighboring communities. Mechanisms for resolving these conflicts are now beginning to emerge.

Namibia's CBNRM program has demonstrated significant achievements over the past eight years. Wildlife populations have rebounded due to a decrease in poaching and greater understanding of wildlife's needs on the part of local communities. Policy reforms have empowered communities economically and organizationally, creating an identity and establishing authority for the conservancies. Local communities have embraced conservancies as a means of gaining legal control over their land and resources. These communities have been active in monitoring natural resources and promoting integrated sustainable development.

Fourteen communities have been registered as conservancies, and an additional 35 communities are in the process of legal recognition. Conservancies have earned over $400,000, mainly through hunting and photo safari concessions and hotel construction agreements. Community members also earn income from working as community game guards, women resource monitors and employees at hotels and lodges built under concession, as well as from the sale of thatch grass or folk art. This income is expected to increase substantially with the planned expansion of private sector tourism concessions (Jones 1998). Ensuring equitable distribution of profits among community members, however, is still at issue.

This program has substantially benefited the development community as well. Practical knowledge about CBNRM in the field has been collected, disseminated and institutionalized. Ten new NGOs have been created to support the project, and the Ministry of Environment and Tourism has increased the number of field staff nationally. The older conservancies have developed capacity and networks to assist newer conservancies as donor technical support is phased out.

Madagascar

In the first phase of Madagascar's National Environmental Action Program (NEAP), international NGOs supported community-centered activities within five-kilometer "buffer zones" around protected areas, applying an integrated conservation and development (ICDP) approach. Management plans for remaining areas of natural forest were prepared at considerable cost in time and money. Disappointingly, implementers found that unforeseen economic, social and infrastructure conditions well outside these "buffer zones" were degrading the ecosystems selected for ICDP interventions. In addition, implementing the carefully prepared management plans did not significantly reduce forest losses or improve socioeconomic well-being among communities living around the forests targeted for management.[2]

As a result, in the second phase program investments were shifted to community-based efforts to reduce slash-and-burn agriculture and to the development of a larger eco-regional approach taking into account regional economic, social and infrastructure development concerns. Major emphasis was placed on developing the capacity of local NGOs and farmer groups to prepare them to reduce slash-and-burn agriculture while protecting natural resources. A number of pilot community-based forest management efforts were initiated to begin the transfer of forest management rights to local communities and prepare them to undertake sustained-yield harvesting of forest products.

Malawi

Between 1996 and 1999, Malawi put in place a new set of natural resource management statutes covering wildlife, fisheries, forestry, water and environmental management. Collectively, they provide a strong platform for encouraging community involvement in sustainable resources management. Since 2000 new policies on land reform, wildlife and fisheries have appeared, advocating collaborative management of public resources, strengthening land tenure, and providing for revenue sharing. These policies give Malawi one of the world's strongest legal mandates for CBNRM.

Small-scale CBNRM in Malawi focuses on management of fisheries, reforestation, permaculture[3] and other sustainable agricultural practices.

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[2] USAID, *Nature, Wealth and Power: Emerging Best Practice for Revitalizing Rural Africa.* August 2002*, p. 23*

[3] Permaculture is a land use system integrating human dwellings, microclimate, plants, animals, soils and water. Farming systems and techniques commonly associated with permaculture include agroforestry, swales, contour plantings, soil and water

Malawi faces an acute deforestation problem, as fuelwood is the main energy source for 90 percent of the population. Community reforestation efforts protect agricultural land from erosion, nurture medicinal plants and trees, provide opportunities for otherwise unemployed youths, and disseminate sustainable forestry, agriculture and animal husbandry practices among the rural poor. In many cases, these projects coalesce around a motivated local leader with either experience or interest in integrated resources management. These leaders also function as local technical resource persons and operate their projects as training centers.

Larger-scale CBNRM projects focus on fisheries management. Fisheries are a critical source of employment and nutrition in Malawi, and often the only source of employment in lakeside areas. More than 200,000 people are directly employed in the fishing industry, mainly as artisanal fishermen. As a result of unsustainable fishing practices, fish populations in all of Malawi's lakes have declined, reducing food security in local communities and the incomes of fishing families. Prior to the CBRM program, fisheries resources were open and unregulated. As fish stocks decreased in Lake Malombe, for example, local fishermen reduced the sizes of their mesh nets from 3 inches to half- and quarter-inch. These small nets caught juvenile fish, exacerbating population collapse among target species.

An effort by the fisheries department to control local fishing practices failed because the department lacked funds to enforce regulations on unwilling communities. A community-based program was then instituted by the UN Food and Agricultural Organization (FAO) and the UN Development Programme (UNDP) to conserve fish stocks. Communities established beach village committees (BVCs) to create and enforce fishing policy in their local territories. The BVCs established mesh size limits, controlled night fishing, and closed waters for certain seasons. Their enforcement of these policies has succeeded, since new fishermen are required to receive permission from the local headman. To make up for lost income and food, many fishing families have started farming maize, groundnuts, and vegetables. Also, the German development agency GTZ provided small loans to families to start up small enterprises like fish processing.

Nonetheless, there are obstacles to further promoting CBNRM in Malawi. These include lack of political will or undue political influence, poor understanding of government policies, difficulties in coordinating bureaucracy with community organizations, inadequate technical assistance, inadequate short-term economic returns, and a reliance on donor and NGO external support.

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management, hedgerows and windbreaks, aquaculture, intercropping and polyculture. Permaculture uses gardening and recycling methods such as "edible" landscaping, companion planting, sheet mulching, using chickens (in movable pens) to cultivate fields, herb gardens, and composting.

Tanzania

In Tanzania, legal title to rural land is questionable. Although villages have customary land rights, village land committees are often coerced or manipulated into relinquishing these rights to outsiders. No clearly defined mechanisms for revenue sharing or for partnerships with other stakeholders exist under present natural resource laws. National legislation which would clarify ownership and land use policies has, however, been proposed. In cases where communities work with investors, contracts are used to define roles and responsibilities and to establish a framework for handling disputes. Villages involved in CBNRM generally earn income through agriculture, livestock, fisheries, forestry, mining and various other extractive activities. Adverse impacts include illegal harvesting of timber and non-wood forest products, poaching, and environmentally unsound cultivation and livestock practices. Natural resources may also be overstressed or exhausted by harvesting fuelwood, fodder, building materials, medicines, and wild fruits and vegetables, using traditional methods.

Community-based projects are managed through local authorities: the village assembly, the village finance and planning committees, the village natural resources committees, and/or the village environmental committees. Generally, game scouts and forest guards are used to police areas under community control, but all members of local communities are obliged to help monitor and report illicit activities to the village authorities.

CBNRM projects often are not structured to generate revenue for households, a barrier to adoption of such plans. For plans that involve hunting safaris as funding sources, the government retains the biggest proportion of the revenue in taxes and fees, and employment opportunities and economic linkages are small or non-existent. Most benefit-sharing programs provide social services such as schools, water or roads instead of direct income. Cash benefits were planned under one project, the Ikona Community Wildlife Management Area, but no suggestions were included for sharing money between participating communities or for disbursing funds.

NGOs, bilateral and multi-lateral donors are supporting almost all the CBNRM activities in Tanzania. Although communities have embraced the economic and environmental opportunities embodied in CBNRM, they do not initiate such projects because of high investment costs and lack of expertise. Usually, projects do not collaborate with each other, primarily owing to a lack of coordination among the donors and government agencies that fund projects.

Kakumbi Natural Resources Management Business in the Luangwa Integrated Research Development Project (LIRDP) Area in Zambia

The Kakumbi chiefdom in the Lupande Game Management Area (LGMA), the area closest to the tourism activity in South Luangwa National Park (SLNP), was experiencing significant deforestation and habitat disturbance from extraction activities associated with lodges and other tourism enterprises operating in the Park. Members of the tribe were concerned over this degradation.

In 1996, transformation of the top-down NRM system originally instituted in LIRDP to a more democratic community-based one enabled the community to initiate the expansion of NRM beyond wildlife in the Kakumbi chiefdom, and created a new revenue stream for communities.

Under the new community-based management structure, Area District Councils (ADCs) were vested with substantial authority. The ADCs, established to coordinate activities related to wildlife conservation and use of revenue from wildlife concessions, recognized that other natural resources needed a similar level of attention and should be actively managed for sustainable use. The ADCs resolved that all commercial operations should pay for any resources they used and that resources should only be harvested in a sustainable way.

The LIRDP helped set up a meeting between the ADCs and tour operators. Tour operators, whose livelihoods also depend on the health of the local environment, recognized the validity of the concern and pledged not only to pay for resources used, but to help set up an institution for collecting fees and regulating use.

The ADCs and tour operators, with advice from LIRDP, established the Kakumbi Natural Resources Management Business (KNRMB), designed to preserve biodiversity, develop and manage the area's natural resources in a sustainable manner, raise community awareness of the need for conservation, and generate income for conservation activities and community development.

The KNRMB has established pricing and guidelines for the sustainable use of the area's resources. Forest guards accompany customers during resource collection to ensure that they follow the guidelines. Each month a maximum of 40 percent of revenues is distributed to support the enterprise (administration, salaries, etc.), a minimum of 55 percent to the community for conservation and development, and 5 percent to the chief. In its first six months, the KNRMB generated $2,500 in revenue. [Phiri 1998 #10]

Zambia

The Administrative Management Design Program (ADMADE), initiated in the early 90s, is the government of Zambia's community-based wildlife management program. ADMADE offers more limited community control and benefits than programs such as Botswana's or Namibia's. Recently, however, ADMADE appears to be moving toward a more democratic approach. Under ADMADE, the government sells concession contracts to safari hunting operators in game management areas that buffer Zambia's national parks. The government passes on 75 percent of revenue to local communities. A little more than half of this (40 percent of total revenue) is dedicated to supporting actual wildlife management such as salaries and vehicle maintenance. Communities may use the remaining funds only for self-directed development projects (35 percent of total revenue).

Funds retained by the government go into a revolving fund that supports ADMADE administrative costs and subsidies for communities that are not self-sufficient. Overall, ADMADE covers 80 percent of its costs with revenue from CBNRM activities. The Wildlife Management Sub-authority, an organization made up of government officials and community leaders, uses ADMADE funds to pay for village scouts and community projects. In 1998, the Zambian government passed a new Wildlife Act that would enable any chiefdom in the country to establish a Community Resource Board (CRB) made up of representatives from the community, the local district authority, and the chief. CRBs are empowered to negotiate "co-management agreements" with safari operators, appoint scouts, and develop land-use management plans in consultation with the Zambia Wildlife Authority. ADMADE has promoted the creation of local Village Area Groups to further improve community involvement. Under the new law, the state is still responsible for collecting and redistributing money.

Populations of key species of wildlife appear to be increasing in game management areas, suggesting that ADMADE has been successful in discouraging illegal poaching, the main threat to wildlife in Zambia.

A separate program, the Luangwa Integrated Research Development Project (LIRDP), was initiated at the same time as ADMADE, with funding from the Norwegian international development organization NORAD. The LIRDP is located in South Luangwa National Park, covering an area of 9,050 sq. km, and in Lupande Game Management Area (LGMA), covering 4800 sq. km. LGMA is inhabited by approximately 36,000 members of the Kunda tribe and is Zambia's most popular tourist destination.

Before the establishment of the LIRDP, elephant populations had declined from over 100,000 in the 1960s to less than 5,000 in the mid-1980s.

LIRDP initially set up a program much like ADMADE. Hunting concessions were sold by LIRDP and resulting income was shared with the community. Interestingly, wildlife populations did not grow rapidly during the first eight years of operation. The failure was attributed to a top-down management approach and an undemocratic system for distributing income. The LIRDP kept 60 percent of the income, and the council of chiefs did not accept general community input and did not distribute the remaining 40 percent equitably. Since the community members did not receive meaningful income or benefit from game hunting revenue, they had little incentive to forego food and income from poaching.

The program was modified in 1996 so that 80 percent of the revenue went to new Village Action Groups (VAGs), and small amounts to other administrative levels including the council of chiefs, the chiefs themselves, and newly established Area District Councils (ADCs). VAGs, community groups of approximately 200 households, elect an oversight committee and choose how to distribute their income at annual general meetings of the whole community. They can assign funds to development projects, or distribute funds directly to households as they see fit. ADCs coordinate activities of VAGs and set broad policy. Elephant populations in the LIRDP area are steadily increasing and now number more than 10,000, more than double the levels in the mid-1980s. Equally important, local communities are using their income on valuable development projects and creating new non-wildlife sources of revenue (see box).

For the most part, the various Zambian CBNRM experiments have succeeded in creating new income- generating activities over which communities have some degree of control, and whose revenues are returned to the communities (Gujadhur 2000; ADC 1998; Phiri 1998).

Elements That Contribute to CBNRM Success

- Tenure security for local community property rights
- Clear legal, regulatory and administrative frameworks
- Rights of self-definition, legal recognition and exclusion for local communities
- Devolution and decentralization of authority to the lowest levels
- Functional government services
- Adaptive management
- Absence of corruption
- Proper program scale
- Economic returns to the community
- Information and knowledge management systems in place
- Local input into land use planning
- Need for national NGOs to represent CBNRM and community interests
- Strong involvement by the tourist industry
- Open discussion of environmental issues by local media
- Disaster planning

What conditions and elements contribute to success?

Pilot programs in Africa show that while CBNRM success requires action at the national or regional level, other elements must be developed at the local level and/or by project managers. While no existing CBNRM program meets all the conditions for success described below, many are operating relatively effectively, improving conditions for wildlife populations and providing local communities with income. As experience grows, the likelihood that CBNRM programs will achieve a measure of long-term stability and sustainability grows as well.

Management at the national/regional level

Tenure security. Colonialism left a legacy of conflicting official and customary laws that contributed to unsustainable resource exploitation by eroding residents’ or communities’ confidence in their ownership of the land. Lack of clear tenure rights discourages responsible stewardship. The longer the guaranteed time of control, the greater the confidence communities and individuals will have that the resources belong to them and their heirs. For this reason,, relatively short periods of tenure, such as the 15-year life of Botswana’s community leases, may not be ideal.

Absolute tenure is not essential for creating a functioning program. Tenure may be granted only over a particular natural resource, or for limited amounts of time, or only in a particular region. Nevertheless, the growing consensus among CBNRM practitioners and researchers is that sustainable use requires that communities receive tenure that is as close to permanent as possible. Only when community members are confident that the resources will remain under their control–and thus should not be degraded–will communities invest labor and resources in sustainable use.

A clear legal, regulatory and administrative framework. In order to foster smoother and more efficient interactions among participating entities, clear roles, rights, rules and responsibilities are needed for national and local government, NGOs, donors, communities, and individuals. Community-level agreements, officially negotiated with the state, can be an effective way to formally establish respective roles and responsibilities. In the absence of land tenure reform, they also can offer some measure of tenure security and confidence for local communities, as in Botswana.

Rights of self-definition, legal recognition and exclusion. For CBNRM programs, where the community is expected to play a meaningful role, communities must have the right to define themselves, their membership and their boundaries so that their identity is unambiguous. If they are to manage the use of resources and revenue, especially if they are contracting with commercial enterprises such as safari or hotel operators, they need to be able to form legally recognized associations. Finally, communities need the right to exclude or license outsiders who may be attracted either by the area's resources or by the prospect of sharing in the revenue generated by the CBNRM project.

Keeping the community's money safe

Embezzlement of revenue from CBNRM projects by community members or others designated as custodians has occurred. The Kakumbi Natural Resources Management Business (KNRMB) Program in Zambia mentioned earlier, developed detailed protocols for the handling and disbursement of money to prevent such occurrences.

- Only four of the 12 members of the oversight committee are authorized to sign checks and two signatures are required.
- A Luangwa Integrated Research Development Program (LIRDP) staff person accompanies the treasurer during monthly collections from customers.
- Money is disbursed to the community and chief on a monthly basis and so does not accumulate.
- Accounts are audited quarterly by LIRDP and can be reviewed at will by the Luangwa Safari Operators Association.

Devolution of authority to the lowest level. Those involved in developing and maintaining CBNRM projects in Africa increasingly believe that projects work best when management decisions are devolved to the lowest functional level. This can be done by decentralizing authority (so that local units within an existing government hierarchy are given greater autonomy), or by delegating authority to a non-governmental organization (such as a CBO), or through some combination of both. The combined option may be best, assuming the community has significant overall control, since local representatives of state agencies may be able to provide guidance and resolve disputes as they arise. Some problems, such as water usage for irrigation, may require management at a higher level. Ultimately, it may be necessary to establish institutions, such as LIRDP's Area District Councils in Zambia, to coordinate CBNRM activities for multiple communities.

Functional government services. The participation of government natural resource agencies is usually critical to the long-term success of CBNRM programs. Generally, they coordinate national CBNRM activities. They may also give official recognition to a community (as in Namibia), co-manage the resource, or provide technical assistance. For a CBNRM project to proceed smoothly, government agencies need to adequately perform their functions at the local, regional and national levels. Natural resource agencies in some African countries are hampered for reasons which include insufficient funding, lack of personnel, and personnel without necessary skills. NGOs or the private sector may fill this gap by providing resources and training to local communities. Farmer-to-farmer groups and networks may also serve in this function. Nevertheless, long-term sustainability of CBNRM programs depends on the full partnership and involvement of government agencies throughout design and implementation.

Adaptive management. Long-term success is more likely when project decision-makers are ready to adapt management plans to respond to changing knowledge and circumstances. Adaptive management uses current research and continuously integrates feedback from stakeholders in order to tailor NRM programs to new political and economic conditions, and/or focus on localized market-driven opportunities.

Absence of corruption. Government corruption at all levels often is not discussed, since mentioning it risks offending partner governments and can harm an international organization's ability to work in that country. However, corruption may prevent government CBNRM policies from actually being implemented, sap revenue and resources that should rightly go to local communities, and severely undermine community initiative. The large sums of money (in local terms) generated under safari-hunting CBNRM projects may be especially subject to misuse.

Program scale. Like all NRM programs, CBNRM programs are effective at preventing environmental harm through integrated assessment and planning. Resources for NRM are limited and investments are required at all levels, from micro to national. Local community actions must be factored into an overall ecosystem plan. Programs involving multiple countries (transboundary programs) must balance international policies and institutions with potentially different national and local customs and resource extraction requirements.

Economic return. Programs that encourage cost-effectiveness and provide economic benefits to local communities have better adoption rates than programs that don't provide direct revenues. Privatization may help to encourage financial sustainability, improve program quality and promote accountability to communities. Programs should encourage market development and partnership with private enterprises to increase the value of natural resources and improve the efficiency of resource use. Trend analyses may be useful for designing programs that address future community needs. The creation of rural organizations to manage savings and establish microcredit enterprises should also be encouraged.

Donor funding can often be channeled through NGOs, which then assist communities in managing and reinvesting profits from CBNRM projects. Community investment priorities generally include building infrastructure such as market access roads, schools, water supply and sanitation, and health posts.

Information and knowledge management systems. Successful CBNRM programs rely on networking to share experience and information. These networks promote capacity-building and policy development, as well as reduce training burdens on government departments. Programs also require monitoring and evaluation at multiple levels in order to make sound management decisions. Local monitoring can be combined with advanced tools like remote sensing and geographic information systems (GIS) to provide decision-makers with more complete information. Data collection, such as resource inventories, should be performed to answer specific management questions. Developing historical baseline data for key indicators is especially important. However, although programs should use science to examine trends and alternatives, deciding among possible courses of action must also involve subjective evaluation of the social, economic and political context.

Land use planning. Devolution of local authority for land use planning and zoning is critical for sustainable management and local enforcement of regulations. Communities must understand, and agree to, the boundaries of the areas of control. They must also have the authority to control membership and privileges within their zones. Setting boundaries should be a participatory process involving all user groups. Communities may require assistance in partitioning resources and mediating land use conflicts. Programs should also incorporate planning for farming, as it is one of the most critical uses of land among the rural poor.

National non-governmental organizations representing rural development and CBNRM interests. These organizations serve as centers for national CBNRM information exchange and as networks for local CBNRM initiatives. They can also play essential roles as advocates for change, promoting increased government financial and technical support and incentives for CBNRM, as well as sound and equitable tourism development and protected area (PA) management.

Strong involvement from the tourism industry. The potential interest of tourism/safari industries operating in Africa has barely been tapped. They represent one of the strongest economic forces available in Africa to promote sustainable management of the ecological resource base, areas and sites of special tourism value, wildlife populations, and unique fauna and flora. With modest organizational support and incentives they could play a critical role in convincing national and local governments that the entire country would benefit economically from (1) creating a secure and attractive experience for visitors; (2) improving monitoring of resource use; (3) developing regional land use and ecological resource management plans; (4) allocating increased financial and technical resources for policing and PA management; (5) ensuring adherence to resource use standards and quotas; and (6) pushing for reform of patronage systems, fiscal mismanagement or malfeasance, and judicial impropriety.

They, and national level civil society organizations representing local NRM interests, could foster needed policy and legislative changes in countries like Uganda, Tanzania, Kenya and Ethiopia, and increased allocation of national and local budgets to various programs necessary for sustainable CBNRM.

Open discussion through the media. One of the most promising developments in governance across Africa over the last three decades has been a growing free press able to cover the environmental harm associated with development and the improper use of natural resources. A healthy press is vital to ensuring that national laws and policies are taken seriously and that political and judicial systems operate with integrity.

Plan for disasters. The benefits of CBNRM projects may be undone during times of crisis—floods, drought, conflict, etc. Such disasters can push people to disregard careful management plans and drain any resources within reach. Programs that include safety nets, e.g., food storage and public works, can provide a buffer against temporary resource overexploitation.

Management at the project level

Protected areas and ecosystems with strong ecological significance and high potential for community and private sector benefits from sustainable management. Projects or management regimes cannot be established everywhere. Until sufficient resources are available, sponsors must carefully select areas that have both high ecological value and the potential for successful community management. Projects must be tailored to accommodate the unique features of each country and region, its history, the socio-economic circumstances of residents, laws and regulatory systems, available natural resources, and existing resource management systems.

Development of common or complementary objectives by partners early in design. Different partners usually enter into projects with different, and sometimes incompatible, purposes, but believe they are pursuing common objectives. Explicitly stating objectives and then working to reconcile differences is an important exercise. Sponsors should avoid focusing exclusively on environmental issues.

Economic viability. Questions of profitability and return on investment are vital to the sustainability of CBNRM ventures. Trophy hunting can generate large and rapid returns. Production of timber and non-timber forest products can also be profitable, if markets exist. Tourism, on the other hand, is harder to establish and less dependable as a source of income. Areas can experience sudden declines in tourism because of national or regional events or instability.

Where income is derived from product sales in distant markets, a strong demand for the product needs to exist, or its development must be supported by outside interests, since many individuals or communities do not have the resources to engage in marketing. Even when markets exist, systems that provide access to markets must ensure goods can be delivered dependably and, for perishable goods, without significant spoilage or loss of inventory. CBNRM projects often target lands adjacent to protected areas that are distant from primary economic

CBNRM Project Level Management Issues

Focus on ecological significance areas or those with potential economic benefits for the community

Encourage partners to develop common or complementary objectives in the early planning

Identify the most likely avenues for economic viability of the project

Ensure that community organizations possess legitimate authority to make decisions

Provide for genuine community participation and benefit in the project

Train communities to use the knowledge they already possess about local conditions and environmental threats

Resist imposing organizational structures from the outside

Recognize the importance of women as CBNRM implementers

Access and use local, traditional community knowledge

Provide good technical and capacity building

Ensure access to credit

Encourage long term, dependable donor and NGO commitment to the project

Help develop mutual trust between communities and sponsors

Ensure that the community members are functionally literate

Focus attention on monitoring project evaluation centers. Under these circumstances, transport costs must be carefully assessed in determining economic viability.

Legitimacy of authority. An organization representing a community's interests can only influence community behavior if the population recognizes its authority as legitimate. This legitimacy might come through democratic election of its directors or through the traditional status of its leaders, such as a chief.

Energy and commitment to natural resource management and operation of CBNRM enterprises develops only when community members believe they truly have control and management authority over resources. Land and resource tenure rights, organizational structures that are perceived to be fair and representative, and the use of a non-paternalistic development approach all contribute to this process. Sponsors need to resist the tendency to maintain the leading role, and need to progressively cede primary control of the project to the community.

Genuine community participation and benefit. To achieve the dual objectives of economic development and resource conservation, communities must receive a substantial degree of control over management of the resource and use of the revenue. CBNRM experience to date demonstrates that local residents are the best positioned to manage resources sustainably and to allocate income toward development projects that serve their needs, whether this is constructing a fence to protect crops or supplementing household income in times of need. Many projects fall short of providing for genuine community participation and benefits, despite being labeled "community-based."

Women, who collect wood, water and natural forest products, often have better knowledge of the local environment than men. Their involvement in a project can be crucial to its success, and is an important to CBNRM program management.

Community members in rural villages are entirely capable of assessing both the conditions and the threats to their environment and can determine appropriate actions. Their ability to do so is enhanced if they are given minimal training.

Organizational structures should not be imposed from outside. Projects should take advantage of existing organizational structures and institute operating procedures that are in harmony with local cultural and social norms. Attempts by sponsors to impose their own structures and processes will impede CBNRM efforts.

Recognize women as key CBNRM implementers. As farmers and as gatherers of wood, water and natural non-wood forest products, women may have more direct knowledge of the local environment than men. And as able entrepreneurs, they may be more likely to use extra income for health, education and general welfare, as long as they receive it directly.

Access to traditional knowledge and expertise. Community members with traditional knowledge and expertise can provide valuable insights into past and current ecological conditions. They may be in the best position to identify potentially marketable flora and fauna as well. Typically, they also know the most about the local socio-cultural context. However, this information is not always available where populations in the region have been recently relocated or internally displaced, and thus are not truly indigenous to the area. Also, traditional knowledge is lost as new generations migrate to the cities.

Good technical and capacity building assistance. Communities may need technical assistance with many different functions:

- developing applications for official recognition;
- drawing up environmental management plans;
- obtaining access to financing;
- setting up management and accounting systems;
- negotiating contracts for concessions;
- setting quotas;
- monitoring and regulating resource extraction;
- enforcement;
- or resolving internal or external disputes.

The ultimate goal is for the community to be self-sufficient

However, for a CBNRM program to be viable, some entity must supply high-quality assistance. Government agencies and local or regional NGOs often have insufficient capacity to support CBOs. For this reason most CBNRM projects have relied heavily on technical and financial assistance from international donors or aid organizations, in cooperation with the government natural resource agency or a local NGO.

Access to credit. In programs where communities or their members are encouraged to develop new resource-based enterprises (such as production of wild fruits, berries, herbs or medicinals), the availability of credit on reasonable terms is essential. Frequently, the amounts involved are small, perhaps no more than $100 for tools and equipment. Microfinance lending programs are becoming increasingly available in Africa, but many rural populations still lack access to them and have only local moneylenders to borrow from, often at unfavorable rates.

Long-term, dependable donor/NGO funding. CBNRM projects generally take many years to develop. On the other hand, international funding agencies' resources—and their choices of projects to support—tend to fluctuate and are often based on five-year project cycles. Sometimes local NGOs and CBOs receive too much funding, sometimes too little. When funding is suddenly and unexpectedly reduced, it erodes community confidence and seriously jeopardizes CBNRM program activities.

Mutual trust between communities and sponsors. Sponsors need to develop and express genuine respect for the knowledge, opinions, insights and decisions of the community. Communities will work with technical service personnel as equal partners if they are treated with respect and clear objectives are developed collaboratively.

Challenges Facing CBNRM in Africa

- Social dysfunction within host communities
- Sudden wealth accumulation in traditionally poor communities
- Lack of technical capacity to plan, manage or monitor CBNRM projects
- Lack of community sanctioned environmental management plans
- Absence of ecological monitoring
- Community inability to control resource use by outsiders
- In-migration into a region with successful CBNRM program
- Long term, cumulative impact of population growth in CBNRM areas

Functional literacy. To operate moderately sophisticated enterprises, community members must have adequate abilities in reading, writing and calculating. Literacy and numeracy skills training is essential and needs to be integrated with CBNRM training.

Increased attention to project evaluation and independent environmental monitoring. CBNRM can provide economic benefit to local communities. Well-conceived CBNRM programs also show evidence of success in growing populations of wildlife and in managing natural forests, protected areas, fisheries and coastal zones more sustainably. Nevertheless, the impact of CBNRM programs on restoring or protecting biodiversity and ensuring long-term ecosystem stability is less clear. Evaluating results is difficult, in part because so many variables can affect both baseline conditions and program success. Some work has been devoted to developing appropriate indicators, but more attention needs to be given to actual measurement and reporting. Without adequate monitoring it is impossible to know whether a program is operating sustainably.

What are some of the most significant challenges facing existing CBNRM programs?

Many CBNRM programs are currently encountering what could be called Phase II challenges—those that become most evident only after an initial program is in place. These challenges arise from several sources:

- varying degrees of social dysfunction within host communities;
- the sudden arrival of large amounts of money in historically poor communities with little or no capacity for managing it;
- lack of technical capacity within the community to address planning, management and monitoring issues;
- absence of community environmental management plans for extraction and/or production of non-wood forest products;
- absence of systematic ecological monitoring in most programs;
- lack of power or capacity to control resource use by outsiders;
- in-migration of people from other regions seeking to benefit from CBNRM income; and

- the long-term cumulative impact of population growth in CBNRM areas.

The solutions for some of these challenges are more evident than for others, but mechanisms for addressing all of them must be developed to create programs that provide lasting benefits to community members, while also protecting biodiversity and the integrity of natural resource systems.

Problem Area	Description	Suggested Intervention
Project Design		
Social dysfunction within host communities	Many CBNRM communities are affected by adverse social conditions that may make CBNRM results much harder to achieve. Dysfunction may stem from a variety of sources: the relative geographic isolation and poverty of the area, alcohol abuse and the high percentage of younger adults (especially men) moving away from the area. Recent resettlement of the community from other areas, economic or political instability, civil strife, war or disaster may impede or undo CBNRM efforts. As mentioned earlier, the areas best suited for CBNRM may often be located where agriculture is marginal and on land sufficiently remote from urban centers to have avoided over-exploitation. Because many younger adults leave to seek opportunities in the cities, these communities often have an unusual make-up, with larger numbers of children, women, and older people.	CBNRM may help reverse some of these destabilizing factors in communities. Where opportunities for employment improve through CBNRM, remoteness may be less of a factor influencing the decision of young adults to move away. Some CBNRM practitioners have also developed strategies for reducing alcohol abuse (T. Gujadhur 2000) and for assisting communities in restoring well-being
Vulnerability to natural and man-made disasters	Too little attention is directed to the potential effects of droughts, famines and floods, etc., on CBNRM programs. These programs are often located in areas that are especially vulnerable to climatic shocks (e.g., semi-arid woodlands and savanna, wetlands and coastal ecosystems).	Sound CBNRM program and activity design should examine the interaction between environmental pressures on ecological services and social and political realities by applying Vulnerability Assessment methodologies (see UNDP Disaster Management Training Programme, 1994). Approach interventions with caution where these assessments indicate the risk of program or project failure is high.
Continuing population growth near or within protected areas and in-migration of people seeking to benefit from CBNRM income	Population growth rates of 3 percent or more are not uncommon in CBNRM areas. These rates may be unsustainable over the long term, with increasing cumulative impacts on ecosystems and the physical environment. The creation of new infrastructure (schools, roads, health posts, market centers) may encourage an expansion of population in the CBNRM area, with increased stress on the resource base and ecological function. In situations where CBNRM produces significant community benefits, there may be population movements into the area by extended family members and other individuals who become aware of the relative improvement in economic conditions. Over the long term this in-migration, combined with increased population growth, could undo resource management efforts. This is perhaps the most serious long-term issue confronting CBNRM sustainability.	Prepare long-term regional environmental action plans or regional environmental impact assessments (EIAs), and set “limits for acceptable use” and human carrying capacity, with full participation from affected stakeholders. Establish a system of permits, deeds or licenses for existing residents, which can be transferred or sold to outsiders. Provide families with incentives to limit family size and discourage additional in-migration. Closely link primary education, health and family planning services to income-generating CBNRM initiatives. In developing CBNRM plans, use zoning strategies to reduce potential adverse impacts of infrastructure development on sensitive areas or sites of exceptional value. Where possible, consider siting new infrastructure well away from sites of exceptional value, so as to encourage community relocation to less sensitive areas.

Problem Area	Description	Suggested Intervention
Potential adverse impacts from expanded extraction and/or production of non-wood forest products	Increasingly, CBNRM programs are incorporating efforts to promote the extraction or production of non-wood forest products. Technical assistance is also being provided to develop markets for these products. Marginal areas generally unsuitable for agriculture may, by contrast, support production of unusual fruits and berries, herbs, medicinals, and ornamental plants that have an appeal to western consumers for their "exotic" quality. Other potential products include insects, birds and reptiles. While potential income-generating benefits are important, there are also risks associated with extraction or commercial production of flora and fauna whose biological characteristics, ecological relationships, and effects on the biophysical environment may not be fully understood.	Support biological and ecological research for potential non-wood forest products considered for commercial extraction or production before developing markets for these products. Prepare environmental assessments for all flora and fauna under consideration for commercial production or extraction.
Project Operations		
Inequitable distribution of CBNRM benefits	This is a continuing problem, not only with resource flows down to communities, but also from CBNRM governing bodies within communities to individual households and farmers.	Continuing efforts are needed to inculcate principles of local democracy and governance at all levels—from local community to the management of national programs. It is probably easier to ensure accountability at the local level. However, improving the status of women requires emphasis on changes in social and political environments at the national level, especially through programs promoting the education of women and girls.
Inadequate community experience managing funds generated through CBNRM	Embezzlement and mismanagement of CBNRM income are risks that project managers have not yet fully addressed. When CBNRM works, communities may suddenly find themselves in possession of much larger sums of money than they have handled in the past. The community may have no experience managing such sums, or have little capacity to do so. These sums can be exceptionally large relative to the average income of community members. The temptation to embezzle is therefore large for anyone given exclusive control over some or all of these funds. The absence of experience managing money often makes theft easier. When community money is stolen it undermines confidence in the CBNRM system.	Some CBNRM communities have received assistance in building their own capacity to manage money or to set up protocols that prevent any single individual from having control of large sums (see box on "Keeping the community's money safe"). In many cases guidance and training in secure financial management is still needed.
Internal conflict at the local level	Where resource management involves decision-making among diverse ethnic or social groups—for example, within a large geographic area—efforts to reach consensus may become protracted and in some cases lead to open conflict.	Apply Vulnerability and Conflict Prevention Assessment methodologies to prevent or mediate conflicts. (see Warner, 2000).

Problem Area	Description	Suggested Intervention
A need for technical assistance	Poor management of earned income is only one example of the problems associated with a lack of ongoing technical assistance. Help may be needed in a variety of areas, including planning; organizational management; legal and financial management; entrepreneurship/enterprise building; contract negotiation; resource monitoring; regulation of resource extraction (including wildlife), and enforcement. In many cases, one or more important type of assistance is not provided or not sustained. Social dysfunction may also undermine these efforts. In addition, community members who have been trained for the purpose of providing local capacity often move to more urban areas where their new skills can earn more and the quality of life is considered better.	Technical assistance is needed at almost every stage, from legal incorporation, to developing a business plan, to evaluating results. Presently, most of this assistance is provided by government agencies and international NGOs at levels that would not be sustainable if the programs were expanded beyond pilot areas. The most stable and potentially sustainable CBNRM programs are typically those that receive extensive ongoing technical assistance. Such assistance is very expensive and has for the most part been paid for by national governments or donor agencies. If continuing assistance is essential, then the economic viability of CBNRM must be reevaluated, a task which means including expenditures on technical assistance as direct program costs. Whether CBNRM will appear a reasonable longer-term investment in this light remains to be demonstrated. Certainly, donor agencies do not have sufficient capital to support expanding CBNRM activities to all theoretically viable locations. Will the income generated by programs eventually be sufficient to pay for the continuing need for technical assistance services? Will the financial return to the communities be large enough for communities to pursue CBNRM approaches after donor or government assistance ends? These questions deserve greater attention in program design.

Problem Area	Description	Suggested Intervention
Little genuine ecological monitoring	The only way to determine whether a CBNRM project is achieving its goals of sustainable exploitation/resource conservation is to periodically monitor the state of exploited resources and levels of exploitation. Ecological monitoring is almost invariably resource-intensive and requires some expertise to carry out. A significant amount of theoretical work has been done on the question of how best to measure ecosystem health and monitor specific natural resources, yet little genuine ecological monitoring is taking place. Although there are exceptions to this trend (e.g., Kakumbi Natural Resources Management Business), CBNRM program sponsors bear some responsibility for the lack of monitoring. National and regional governments are failing to establish and coordinate comprehensive national programs or to ensure that the necessary but capital-intensive and/or scientifically advanced types of monitoring are being employed. Remote sensing of vegetative cover with satellites or aircraft can be extremely useful, but must be matched by monitoring on the ground. Monitoring must track the rate at which exploitation is actually occurring—i.e., number and types of animals harvested and changes in biodiversity. Too little capital investment and inadequate institutional capacity contribute significantly to the poor ecological monitoring by both governments and CBNRM projects. Local residents can be trained to collect many types of data, but generally lack the expertise to design the program or analyze the collected information.	Provide a well-structured plan for the design and coordination of ecological and resource monitoring. Drawing on indigenous knowledge on sustainable yields and harvesting techniques may provide useful proxy measurements without necessarily incorporating more costly scientific monitoring.
Lack of power to control resource use by outsiders.	Monitoring data showing a decline in diversity and/or abundance of exploited animals or plants does not necessarily indicate that a project has set quota limits too high. It could also be an indication of unauthorized resource use. Communities in many cases lack the authority or means to prevent outsiders from poaching, illegally harvesting timber or carrying out similar activities. They may also have insufficient resources for policing purposes.	In some locations community members are provided with guns and trained in their use. This has deterred poaching, but may result in excessive emphasis on enforcement, and raises questions regarding the use of weapons by community groups for management purposes.

Guided questions

These questions are not all-inclusive, but can be helpful in CBNRM program design and implementation. Program designers and implementers are advised to systematically address each question that does not receive a “yes” answer.

Assessing enabling conditions

1. Do communities have ownership control over natural resources (e.g., wildlife and forest products) in the host country?
    a. Do they have, or can they gain, complete control over use and revenue from more than one resource?
    b. Is tenure secure? Is it permanent (or only for a limited time)?
2. Is there an official process for establishing CBNRM projects?
    a. Do all levels of government, donor agencies, NGOs, community-based organizations (CBOs) and the private sector have clearly defined roles in the process?
    b. Are the rights and responsibilities of each party clearly defined?
3. Is the CBO free to create a legally recognized entity?
    a. Can it define who is a member?
    b. Can it define its own boundaries? Is there a mechanism for resolving boundary disputes with neighboring communities?
    c. Is it empowered to exclude or license outsiders who might be attracted by the resource or potential income from it?
4. Will the community receive most of the income from project-related enterprises?
    a. Has a democratic mechanism for distributing income been established?
    b. Has a system been put in place to ensure the security of communal funds and provide for equitable distribution through community-led processes?
5. Has control over NRM been devolved from the national to the regional or local level?
    a. Has the community been given a large degree of control over natural resource planning and management?
    b. Do district representatives of the national natural resource agency have authority to make decisions if consulted?

6. Is the government's bureaucracy efficient?
    a. Does the natural resource agency have enough qualified staff?
    b. Can program be established and maintained without interference from corruption?
7. Has a national survey been conducted to identify the most valuable and ecologically viable areas?
8. Is the tourism industry working closely with the government at the national and district level to develop long-term plans for sustainable management of tourism assets?
9. Are policies and standards in place to encourage and ensure equitable joint ventures between communities and companies doing tourism and safaris?
10. For proposed enterprises, will the primary initial source of revenue generate enough income to support sustainable and profitable CBNRM without outside donor support? Will there be meaningful benefit to the community?
    a. Are market incentives sufficient? Are they stable?
    b. Are market reforms needed? If, so what are the prospects for adoption?
    c. Does the community have access to commercial credit for the initial enterprise or to finance any additional entrepreneurial activities?
    d. Are markets sufficiently accessible during the seasons the enterprise(s) will be operating?
    e. Have business plans been prepared to identify income, costs, potential market volatility, social and environmental impacts, etc.?
11. Are natural resource monitoring programs effectively tracking rates of natural resource use (e.g., for forests, wildlife, other flora and fauna)?
12. Does the government, donor agency, or international or local NGO have the resources to provide necessary technical assistance? Have long-term commitments been secured from sponsors to ensure that funding gaps do not jeopardize the project?

Initiating a program

12. Has the community established a representative organization whose authority is recognized?
    a. Does the organization rely on customary authority, such as a chief, or on the authority of democratically elected representatives?

b. Are women equal and active participants in the organization?

c. Is the community socially viable?

d. Is the community free of internal conflicts over resources or management? Free of conflicts with neighboring communities?

13. Do community members have a strong sense of project ownership?

a. Do they participate as equal partners in project development activities?

b. Is their traditional knowledge and advice sought out?

14. Do the community, NGO, donor and government have complementary objectives?

15. Have sponsors prepared a capacity-building plan in close collaboration with community members?

a. Will they be taught to read, write and calculate if they lack these skills?

b. Will they receive organizational skills training?

c. Will they receive program-related job training?

d. Will they be given entrepreneurial training?

e. Will they receive training in contract development and negotiation?

f. Will they receive training in bookkeeping?

g. Will they be taught how to access information and technology? Will they be provided with a means of doing so?

h. Will they be trained in impact assessment, environmentally sound design and "best practices?"

16. Has a capacity-building plan been prepared for local NGOs?

a. Will they be trained to "train trainers"?

b. Will they be given adequate budgets to support technical assistance services?

17. Do sponsors plan any capacity building with government agencies?

Project Implementation

18. Is a plan for ecological monitoring of resource use in place?

a. Has a baseline study assessing the distribution, abundance, and diversity of the natural resource base been conducted?

b. Will resource monitors receive training and equipment?

c. Are resources being used on a sustainable basis? Is effective ecological and resource use monitoring occurring? Are quotas and extraction rates for fauna and flora being tracked?

d. Are the responsibilities for monitoring clearly defined?

e. Will communities receive instruction in enforcement and be provided with necessary equipment?

19. Are communities and sponsors addressing population growth in the area?

    a. Is population growth being tracked? Birth rates? Death rates? In-migration rates and sources? Out-migration rates and reasons?

    b. Are primary education, health and family planning services closely linked to income-generating CBNRM initiatives?

    c. Is a community-based plan to establish "limits of acceptable use" or human carrying capacity in the CBNRM area in place?

    d. Does this plan include "zoning" for new infrastructure (roads, schools, health posts, water points, etc.) to reduce impacts on sites of exceptional value and to encourage community relocation to less sensitive areas?

    e. Are cumulative environmental impacts being tracked?

    f. Is there community commitment to implementing the plan?

    g. Is a system of permits, licenses or fees in place to limit in-migration?

    h. Are incentives in place to encourage limitations on family size?

Monitoring project or activity results

2. Has a satisfactory CBNRM plan been developed?

    a. Did the community participate fully in development of the plan?

    b. Does the plan cover more than one resource?

    c. Has the national natural resource agency reviewed the plan (if necessary)?

    d. Has the plan been reviewed by independent academic, donor, or NGO experts?

    e. Is the community satisfied with the plan? Do they regard it as their plan?

f. Are mechanisms in place to ensure annual independent review of the plan's effectiveness, and for systematic follow-up?

g. Have targets and indicators to track progress been developed?

h. Is a system in place to track progress?

i. Has an analysis of historical baseline conditions been conducted? Have alternatives, including the no-action alternative, and their consequences 20 years hence been analyzed?

j. Are responsibilities for plan implementation and monitoring clearly defined?

ENVIRONMENTAL SCREENING:

Links Between Proposed Activities and the Environmental and Cultural Resources of Activity/Enterprise Area[4]

This environmental screening form is intended to address community-based NRM and ecotourism environmental issues more directly. It is to be used in conjunction with the Environmental Screening Form/Report promulgated by USAID's Africa Bureau ENCAP program. The form is oriented around major resource/issue clusters and asks "leading questions" to help guide a systematic review of potential environmental impacts affecting CBNRM and ecotourism interventions. *Suggestions and input are requested to help develop this form further. It is intended to be a "living" document subject to adaptation.*

Review the questions that follow. If a question could justify a "yes" then an environmental review report (3-5 pages, typically) is needed to explain and describe the intended activity, as well as the mitigation steps that are planned.

Chapter 3. Will the activities…	**YES**	**NO**
Natural Resources		
accelerate erosion by water or wind?		
reduce soil fertility and/or permeability?		
alter existing stream flow or reduce seasonal availability of water resources?		
potentially contaminate surface water and groundwater supplies?		
involve the extraction of renewable natural resources?		
involve the extraction of non-renewable natural resources?		
restrict customary access to natural resources?		
reduce local air quality through dust generation, burning of wastes, or use of fossil fuels and other materials in improperly ventilated areas?		
affect dry-season grazing areas and/or lead to restricted access to a common resource?		
Ecosystems and Biodiversity		
drain wetlands, or be sited on flood plains?		
harvest wetland plant materials or use sediments from bodies of water?		
lead to the clearing of forestlands for agriculture or to the over-harvesting of valuable forest species?		
Promote in-forest beekeeping?		

[4] *This form is inspired by the format used by the COMPASS Grants Manual, USAID/Malawi CBNRM program.*

lead to increased hunting, or the collection of animals or plant materials?		
increase risks to endangered or threatened species?		
introduce new exotic species of plants or animals to the area?		
lead to road construction or rehabilitation, or otherwise facilitate access to fragile areas (natural woodlands, wetlands, erosion-prone areas)?		
alter relatively undegraded tropical forest?		
Agricultural and Forestry Production		
have an impact on existing or traditional agricultural production systems by reducing seed availability or reallocating land for other purposes?		
lead to a reduction in fallow periods, the burning of pastureland, or the harvest of forest plantations without replanting?		
affect normal levels of food storage by reducing food inventories or encouraging the incidence of pests?		
affect domestic livestock by reducing grazing areas, or creating conditions that could exacerbate livestock disease problems?		
involve the use of pesticides?		
Community and Social Issues		
have an adverse impact on potable water supplies?		
encourage domestic animals to migrate through natural areas?		
change the existing land tenure system?		
have an adverse impact on culturally important sites in the community?		
disturb or reduce the value of archeologic or historic sites?		
adversely affect scenic values or viewsheds?		
increase in-migration to the area, placing a potential strain on the existing natural resource base?		
lead to the generation of non-biodegradable waste?		
create conditions harmful to community health?		
contribute to the spread of HIV/AIDs?		

COMPARATIVE FRAMEWORK FOR COMMUNITY-BASED NATURAL RESOURCES MANAGEMENT

Key Parameters for Wildlife and Tourism-Based CBNRM

prepared by Candace Buzzard for GTZ September 2001[5]

	COUNTRY & STATUS						
1. NATURAL RESOURCES							
1.1 LAND USE CONSIDERATIONS FOR WILDLIFE AND TOURISM-BASED CBNRM							
PARAMETER	**Uganda**	**Botswana**	**Namibia**	**Kenya**	**Tanzania**	**Zimbabwe**	**Malawi**
Land area *	Total: 236,040 sq km Land: 199,710 sq km Water: 36,330 sq km	Total: 600,370 sq km Land: 585,370 sq km Water: 15,000 sq km	Total: 825,418 sq km Land: 825,418 sq km Water: 0 sq km	Total: 582,650 sq km Land: 569,250 sq km Water: 13,400 sq km	Total: 945,087 sq km Land: 886,037 sq km Water: 59,050 sq km	Total: 390,580 sq km Land: 386,670 sq km Water: 3,910 sq km	Total: 118,480 sq km Land: 94,080 sq km Water: 24,400 sq km
People-to-land ratio*(excludes water)	116 people/sq km	2.6 people/sq km	2.2 people/sq km	53.3 people/sq km	39.8 people/sq km	29.3 people/sq km	110.4 people/sq km
Land use *	Arable land: 25% Permanent crops: 9% Permanent pastures: 9% Forests and woodland: 28% Other: 29% (1993 est.)	Arable land: 1% Permanent crops: 0% Permanent pastures: 46% Forests and woodland: 47% Other: 6% (1993 est.)	Arable land: 1% Permanent crops: 0% Permanent pastures: 46% Forests and woodland: 22% Other: 31% (1993 est.)	Arable land: 7% Permanent crops: 1% Permanent pastures: 37% Forests and woodland: 30% Other: 25% (1993 est.)	Arable land: 3% Permanent crops: 1% Permanent pastures: 40% Forests and woodland: 38% Other: 18%	Arable land: 7% Permanent crops: 0% Permanent pastures: 13% Forests and woodland: 23% Other: 57%	Arable land: 34% Permanent crops: 0% Permanent pastures: 20% Forests and woodland: 39% Other: 7% (1993 est.)
Wildlife considerations	Wildlife suffered major decline during Amin/Obote era and numbers still very low Restricted mainly to National Parks and Reserves	Large populations of wildlife both in and outside protected areas (PAs) Many big mammals and predators Wildlife present on	Large populations of wildlife both in and outside PAs Many big mammals and predators Wildlife present on community lands	Large populations of wildlife both in and outside PAs Many big mammals and predators Wildlife present on community lands	Large populations of wildlife both in and outside PAs Many big mammals and predators Wildlife is migratory	Large populations of wildlife both in and outside PAs Many big mammals and predators Wildlife is migratory	Wildlife restricted mainly to national parks and reserves Wildlife numbers low compared to historical numbers Poaching

[5] Buzzard, Candace. *Community-Based Natural Resources Management (CBNRM) in Uganda: A Review of the National Enabling Framework and Comparison with Other African Countries*. Published by GTZ/UWA, Kampala, Uganda. September 2001.

	Half the world's population of mountain gorillas; chimpanzees and other primates in forests; savannah areas with wildlife Indigenous fish in lakes and rivers; tremendous variety and numbers of birds Habitat destruction is major threat; poaching rampant	community lands Large elephant population (over 100,000) Indigenous fish in Okavango delta and rivers Livestock disease fences restrict wildlife migrations	Many desert adapted species Birds	Famous wildlife migrations Poaching	Selous area has reportedly the highest concentrations of elephants in the world Destruction of coral reefs affecting marine life	Reportedly 16,000 elephants on community lands Birds Black rhino significantly reduced by poaching	Lake Malawi–39% of all the freshwater species of fish in the world Birds
Agricultural considerations	Agriculture 44% GDP: Tropical climate with two rainy seasons Some highly productive lands for crops; increasing use of marginal agricultural lands Soil fertility declining Deforestation; conversion of forest and wildlife habitat to agricultural lands	Agriculture 4% GDP: Semi-arid and marginal land for crop agriculture in most of the country Low rainfall Livestock diseases and pests present challenges Recurring droughts Overgrazing; desertification	Agriculture 12% GDP: Desert, hot, dry Rainfall sparse and erratic Marginal land for crop agriculture Large livestock ranches Increasing game ranching Very limited fresh water; desertification occurring	Agriculture 26% GDP: Climate varies from tropical on coast to arid inland Degradation of water quality from increased use of pesticides and fertilizers Deforestation Soil erosion Deesertification	Agriculture 49% GDP: Country heavily dependent on agriculture— it provides 85% of exports 4% of country has suitable topography and climate for cultivated crops Climate varies from tropical on coast to arid inland Many areas suited to wildlife/livestock Soil degradation, deforestation, desertification Recent droughts have affected marginal agriculture	Agriculture 28% GDP: Agricultural products: corn, cotton, tobacco, wheat, coffee, sugarcane, livestock; game Soil erosion, land degradation, deforestation occurring Some livestock ranches being converted to game farms	Agriculture 37% GDP: (1998 est. for Malawi) Some very productive agricultural lands Water pollution from agricultural runoff and sewage Conversion of forests to agricultural land Soil erosion and decreasing fertility Deforestation occurring at a rapid pace
Natural features/scenic attractions **(tourism basis)**	Many scenic and cultural attractions: Great Lakes; Albertine Rift Valley; Rwenzori Mountains; Mt. Elgon; Lake Victoria; Nile River Murchison Falls	Many natural features and attractions: Okavango inland delta Chobe River; thousands of elephants during the dry season Kalahari Desert is home to the Bushman	Many natural features and attractions: Namib desert and sand dunes Etosha and other wilderness areas Coast	Many scenic and cultural attractions: Masai Mara, Serengeti; famous wildlife migrations Lake Victoria Mt. Kenya	Many scenic and cultural attractions: Serengeti; world-famous wildlife migrations: Ngorogoro Crater Kilimanjaro	Many scenic and cultural attractions: Victoria Falls; wildlife viewing in parks Zambezi River and Lake Kariba Great Zimbabwe ruins	Scenic and cultural attractions: Lake Malawi is major attraction Wildlife Mountains

	Bwindi Impenetrable Forest (gorillas) Mgahinga National Park (gorillas) Variety of landscapes	home to the Bushman True wilderness opportunities		Rift Valley Coast	Selous - highest density of elephants in the world Coastal attractions Island of Zanzibar		

1.2 NATURAL RESOURCES MONITORING & MANAGEMENT

PARAMETER	Uganda	Botswana	Namibia	Kenya	Tanzania	Zimbabwe	Malawi
Monitoring and management of wildlife by communities	Community monitoring systems not in place M&E plan for districts/ sub-districts is in planning stage	In some areas Resource monitors are employed by CBOs to monitor hunting and ecotourism activities More comprehensive pilot community wildlife monitoring and veld monitoring systems are in place in only a few areas	In some areas Community game guards hired by conservancies to monitor and protect wildlife and gather info on poaching Community Resources Monitors monitor natural resources utilization and use of thatch, basket grass, etc., for crafts and other conservancy uses	In very few areas Community monitoring employed on individual project basis	In very few areas Village game scouts undertake patrol activities, report on natural resource utilization encountered in patrols, apprehend poachers, hunt for meat for village, accompany tourist hunters, prevent or control bush fires	In some areas Community involved in monitoring and quota setting under CAMPFIRE Zimtrust facilitates POMS (Process Oriented Monitoring System) by communities Communities trained in quota setting, monitoring, etc. and facilitated by World Wildlife Fund (WWF)	In some areas Community monitoring activities outlined in individual management agreements

Monitoring and management of wildlife by government and NGOs	Government monitors and surveys some natural resources (NR) Uganda Wildlife Authority (UWA) ranger-based monitoring system; UWA Management Information System (MIST) Forestry	Wildlife surveys, including aerial surveys by Department of Wildlife and Natural Parks (DWNP); BRIMP integrated database DWNP does not allow community input into wildlife quota setting at this point DWNP and Agricultural Resources Board (ARB) assist in initiating and analyzing pilot wildlife/veld monitoring systems Several NGOs and private sector monitor wildlife, esp. predators and trophy animals	Government monitors and surveys some NR NGOs	Government monitors and surveys some NR NGOs, African Wildlife Foundation, WWF, IUCN, others	Government monitors and surveys some NR Tanzania National Parks Authority (TANAPA) – wildlife inside national parks Wildlife Division wildlife outside of parks NGOs, WWF, AWF World Resources Institute	Zimtrust facilitates the POMS WWF support to CAMPFIRE, producing manuals and toolkits for communities, e.g., *Quota Setting, Counting Wild Animals, Managing Safari Hunting*, etc. WWF provides ecological, wildlife (aerial censuses) and economic information to communities and organizations	Government monitors and surveys wildlife NATURE program Southern African Development Community technical coordinating units headquartered in Malawi for Fisheries, Forestry and Wildlife - undertake monitoring
Research on natural resources	Ongoing	Ongoing	Ongoing	Ongoing	Ongoing	Ongoing	Ongoing
Environmental impact of CBNRM activities assessed	Not yet	In some cases	In some cases	In some cases	In some cases	In some cases	In some cases

2. POLICY AND LEGAL BASIS FOR CBNRM

PARAMETER	Uganda	Botswana	Namibia	Kenya	Tanzania	Zimbabwe	Malawi
Policies and legislation important to CBNRM	National Environment Policy 1994 National Environment Statute 1995 Local Governments Act 1997 Land Act 1998 Wildlife Statutes 1996 Wildlife Policy 1995 Wildlife Policy 1999 Forestry Policy 2000	Constitution 1966 Forest Act 1968 Tribal Land Act 1970 (amended 1993) Herbage Preservation (Prevention of Fires) Act 1977 Wildlife Conservation Policy 1986 National Conservation Strategy 1990	Nature Conservation Amendment Act 1996 Amendment of 1975 Regulations relating to Nature Conservation Wildlife Management, Utilization and Tourism in Communal Areas 1995 Promotion of Community-Based Tourism 1995		National Wildlife Policy 1997 Land and Villages Act 1999 Wildlife Conservation Act 1974 Wildlife Division maintains ownership of wildlife Legislation and guidelines still lacking	1975 Wild Life Act amended in 1992 to grant Appropriate Authority (AA) over wildlife to Rural District Councils (RDCs)(formerly accorded only to private farmers on their land)	National Parks and Wildlife Act 1992 National Parks and Wildlife (Amendment) Bill 1998 Wildlife Policy 2000 Forest Policy 1996 Forestry Act 1997 Environment Management 1996 Fisheries Conservation

	Wetlands Policy 2000	Tourism Policy 1990 Wildlife Conservation and National Parks Act 1992 Tourism Act 1992 Community-Based Strategy for Rural Development Community Wildlife Offtake Policy (DWNP)					and Management Act 1997
Basis for community ownership or control over wildlife	Wildlife Statute 1996	Wildlife Conservation Policy 1986 Wildlife Conservation and National Parks Act 1992	Nature Conservation Amendment Act 1996 (makes provision for communal area conservancies)		The Wildlife Policy 1997 authorizes communities to establish Wildlife Management Areas (WMAs) and to develop plans to govern management and use of wildlife in those areas	1982 Wildlife Act	1998 NP and Wildlife Bill (amendment of 1992) authorizes the director to enter into management agreements with CBOs Wildlife Policy 2000 establishes community role
Basis for CBOs to earn income/benefits from resource use; to enter partnerships with private sector for resources use	Wildlife Statute 1996	Wildlife policies; Joint Venture Guidelines (Note: New attempts by government to reverse earlier policies away from community empowerment)	Wildlife Management, Utilization and Tourism in Communal Areas Policy 1995 Promotion of Community-Based Tourism 1995		Wildlife Policy 1997	1982 Wildlife Act 1991 Guidelines for the Use and Allocation of Wildlife Revenues by districts 1991 Guidelines paid 50% to producer communities, up to 35% to be used for wildlife mgmt, up to 15% to RDC 1992 Guidelines increased community percentage to 80% 1996 Joint statement from Ministry of Environment and Tourism (MET) and Ministry of Local Government, Rural and Urban Development (MLGRUD) said Rural District Councils	Revenue sharing provided by Wildlife Policy 2000

						(RDCs) not held to any specific distribution plan	
Security of community resource tenure (e.g., wildlife)	Must be negotiated on a case-by-case basis.	15 years; for joint venture partnership arrangements, 1 yr., 1 yr., 3 yr., then 5 years	Variable	Variable	Variable	Fairly secure	Variable; depends on agreements
Important pending policies/legislation **Policy/legislative gaps and problems**	Forestry Act pending Tourism policy needed; updated wildlife policies and guidelines needed	CBNRM policy pending Botswana National Forest Policy Game ranching policy and Regulations National Park and CBNRM policy stalled with Cabinet	Land Act Land Tenure		WMA guidelines Government has not yet provided guidelines to facilitate and legalize WMAs[—urgently needed	Communal Lands Forest Act 1928 (amended 1984) and the Forest Act 1948 (amended 1982)—does not recognize rights of rural communities—needs update	Wildlife Act needs revision—currently in process Policy implementation difficult and slow

3. INSTITUTIONAL FRAMEWORK FOR CBNRM

3.1 COMMUNITY INSTITUTIONS

PARAMETER	Uganda	Botswana	Namibia	Kenya	Tanzania	Zimbabwe	Malawi
Community awareness of wildlife- and tourism-based CBNRM	Low	High	High	Medium	Medium	High	Medium
Capacity at community level	Poor	Limited	Limited	Limited	Limited	Limited	Poor
Community-based organizations (CBOs) are in place	Few CBOs involved in CBNRM Mainly specialty CBOs: women's groups, burial societies, farmers groups, some crafts	12 CBOs formally awarded wildlife rights Over 30 CBOs/trusts involved in CBNRM Community organizations legally recognized with power to sign contracts with joint venture or other private sector partners	14 conservancies formally recognized 35 more in process		CBOs organized and in place, awaiting WMA guidelines Village natural resources committee formulates by-laws, keeps record, supervises hunting activities, prepares village land-use guidelines, coordinates between village and district; supervises and coordinates patrol activities	37 wards involved in CAMFIRE; 37 RDAs awarded Appropriate Authority (AA) (out of a total 57)	Many CBOs with varying levels or organizational and institutional capacity

					Village Forest Committees lead community forest management		
CBOs have acquired wildlife resource rights over a legally defined and demarcated community area, recognized by government	No	Yes: Approx. 12 CBOs have been awarded wildlife quotas on their lands Others are utilizing and marketing veld products, i.e. phane caterpillars, devil's claw, marula fruit, etc.	Yes: Conservancies have wildlife rights and tourism rights		Yes: WMAs mobilized and awaiting legislation to finalize establishment Village Natural Resources Committees recognized 6 villages ready to seek WMA approval under Partnership Options for Resources Use Innovations Project (PORI)	Yes: Legal wildlife rights remain with the RDCs—not yet devolved to communities	Few in wildlife
Capacity at community level for tourism, wildlife-based enterprise	Low Need for training and awareness building	Limited Many CBOs trained in leadership, organization, financial record-keeping, empowerment, tender guidelines, ecological monitoring techniques	Limited Many conservancy members trained in conservancy concept, project implementation training, environmental education, small enterprise	Limited Some communities trained	Limited Training planned by govt. in development of Community Natural Resources Management Plans and for development of WMA plans Training in Natural Resources-based enterprise development; school and community outreach; and environmental awareness	Limited Much training has taken place; need for more general accounting, quota setting and enterprise development skills	Limited Training under donor projects and NGOs is underway
CBOs involved in CBNRM represent population within defined geographic areas	Few CBOs involved in CBNRM; generally population subset	Yes, in most cases	Yes Register of names that defines members of a conservancy	Variable	Yes, in many cases	Yes	In some cases, but generally subset

3.2 GOVERNMENT SUPPORT TO CBNRM							
PARAMETER	**Uganda**	**Botswana**	**Namibia**	**Kenya**	**Tanzania**	**Zimbabwe**	**Malawi**
Decentralization/ Devolution of powers	Yes, some powers to District and Local Govt	Yes, some powers	Yes, some powers	In process	In process	Yes, some powers	In process
Local government understands role in CBNRM and is a supportive partner	Learning new roles; local government prepared to assist CBNRM	Local government members are trained and supportive of wildlife-based CBNRM in certain areas	Role of local govt well understood in certain areas; Involved and supportive	In process; community-govt relationships being developed	In process; Community- Based Conservation (CBC) at early stage of development, communities are keen to get involved	Role of local government generally well understood in CAMPFIRE areas	In process; learning new roles
National-level support to CBNRM	Lack of coordinated CBNRM support at national level; UWA works with communities on PA issues; districts assuming new role in CBNRM; no national strategy	National CBNRM forum: Ministries of Agriculture, Wildlife, and Tourism; others participate; DWNP staff take CBNRM course at wildlife training college; familiar with and supportive of CBNRM Government-funded community Conservation Fund provides grants to CBOs for CBNRM activities; Agricultural Resources Board (ARB) active in CBNRM for veld products.	Ministry of Environment and Tourism responsible for CBNRM; contains Directorates of Environmental Affairs (DEA), Resources Mgmt (DRM), Forestry (DoF) and Tourism (DoT) DoT employs a community-based tourism officer who liaises w/ communities;	Kenya Wildlife Service Wildlife Forum	TANAPA created Community Conservation Services Program Wildlife Division CBC program	Active Collaborative Group DWNP within MET MET provides AA to communities under CAMPFIRE District Environmental Action Planning (DEAP) initiated that works w/ communities to tackle most pressing environmental problems DWNP participates in the Collaborative Group	Proposed National Coordinating Body for CBNRM Forestry Dept w/in Min of Natural Resources and Env. Affairs has forest extension agents and forest guards at community level DNPW under policy amendment, can assist communities, encourage local govt to provide extension, enter wildlife mgmt agreements
Local/District government services that support CBNRM accessible to communities	New local govt services are being developed	Yes; CBOs have access to technical expertise of DWNP, Land Board, local government and other govt institutions DWNP assists communities to organize and to obtain quota	Yes DEA publicizes CBNRM at local levels and provides the "Toolbox" with information and instructions on how to form a conservancy DRM awards wildlife	Yes	Yes Conservation Services Program within TANAPA provides services and training to communities Wildlife Division implements Community-Based	Yes District and Wards are primary players RDCs and Ministry negotiate joint venture contracts with safari operators; communities have limited input	Yes Local govt encouraged to provide wildlife extension under new policy Forestry extension workers in place

		quota District Land Board awards leases DWNP awards quotas and provides problem animal control Community Conservation Fund (DWNP), about $4 million from 1997 to 2001, can fund mobilization, CBO formation, CBO activities, etc.	quotas, provides Problem Animal Control		Conservation CBC District Steering Committee (chairperson is District Executive Director plus various stakeholders) recommends quota. Coordinate CBNRM activities in district, establish arbitration panel for conflicts		

3.3 NGO SUPPORT TO CBNRM

PARAMETER	Uganda	Botswana	Namibia	Kenya	Tanzania	Zimbabwe	Malawi
NGOs provide support, advocacy, training, services to CBOs	Few Uganda NGOs work at community level: Advocates Coalition for Development and Environment (ACODE) provides advocacy and legal advice Uganda Community Tourism Association (UCOTA) Promotion of Rural Initiatives and Development Enterprises (PRIDE) Heritage Trails Uganda Wildlife Society Some international NGOs: CARE, IUCN, AWF, International Gorilla Conservation Project (IGCP), Wildlife Conservation Society (WCS)	Several NGOs provide technical, financial, legal and mobilization support to CBOs: BOCOBONET—national NGO w/ CBO members, CBNRM advocacy and training, started 1998 People and Nature Trust Thusano Lefatseng Botswana Craft Kalahari Conservation Society Hotel and Tourist Association of Botswana (HATAB) Conservation International Chobe Wildlife Trust others IUCN/SNV CBNRM Support Program	Several strong NGO support providers: CBNRM Assoc. of Namibia (CAN) Namibia NGO forum (NANGOF) manages the Secretariat of the national CBNRM association Namibia Nature Foundation (NNF) Integrated Rural Development & Nature Conservation (IRDNC) provides capacity—building, services, networking visits to communities, and advanced services Nyae Nyae Development. Foundation supports CBO in NE Namibia assists w/ tender negotiations and investment strategies	Several NGOs provide support: AWF facilitates services to communities: training, financial management, small enterprise development, etc.	Several NGOs provide support: AWF Africare GreenCom Sokoine University of Agriculture/ Tuskegee University (SUA/TU) Inyuat e Maa (IeM) (local NGO in Tarangire/Manyara area) Mazingira Bora Karatu	Several strong NGOs provide support: CAMPFIRE Association represents producer communities of RDCs with AA, and chairs CAMPFIRE Collaborative group Zimbabwe Trust, Institutional Development Unit, promotes CBNRM through mobilization and establishment of community institutions SAFIRE—promotes diversification and integration of CBNRM (DANIDA) African Resources Trust (ART) Center for Applied Social Sciences (CASS)	CURE is NGO umbrella organization, with 50 NGOs; approx. 12 member NGOs use CBNRM approach**

	Society (WCS)	Support Program	NACOBTA provides business marketing and training to CB tourism operators, over 40 members pay for services Rossing Foundation—training & education for small farmers & crafts producers				
NGOs provide marketing or other linkages for CBO products, services	Some UCOTA provides marketing for tourism establishments and crafts	Some Thusano Lefatseng assists veld product marketing BOCOBONET assists linkages for all member CBOs Botswana Craft markets crafts/curios locally and internationally	Some Rossing Foundation—provides product development marketing and institutional support to crafts producers NACOBTA provides tourism linkages Others	Some AWF assists with community–private sector linkages for butterfly farming, tourism, etc.	Some AWF assists with community–private sector linkages WWF	Several NGOs assist	Some CURE assists linkages of member organizations

3.4 PRIVATE SECTOR LINKAGES TO COMMUNITIES

PARAMETER	Uganda	Botswana	Namibia	Kenya	Tanzania	Zimbabwe	Malawi
Economic opportunity & marketing linkages between CBOs and private sector	Few linkages	Partnerships present for wildlife/tourism	Partnerships present for wildlife/tourism	Partnerships present for wildlife/tourism	Partnerships pending or present for wildlife/tourism	Partnerships present for wildlife/tourism Joint venture partnerships undertaken by RDCs on behalf of communities	Few partnerships
CBOs use private sector services (financial, auditing, marketing, design, etc.)	Very little	Some	Some	Some	Some	Some	Some

3.5 DONOR SUPPORT TO CBNRM

PARAMETER	Uganda	Botswana	Namibia	Kenya	Tanzania	Zimbabwe	Malawi
Current donor	Yes	Yes	Yes	Yes	Yes	Yes	Yes

programs related to CBNRM underway							
3.6 RESEARCH							
CBNRM-related research undertaken	Yes, by various institutions: IGAD, MUIENR, ACODE, university, projects, others	Yes, by various institutions: IUCN, SNV, University of Botswana, Government	Yes, by various institutions	Yes, by various institutions	Yes, by various institutions: AWF,WWF	Yes, by various institutions: CASS, UZ, ART, Zimtrust, IUCN, Government	Yes, starting to undertake CBNRM research by various institutions
3.7 CBNRM COORDINATION MECHANISM							
CBNRM national frum or body in place	No	Yes	Yes	No	No	Yes	Yes, very new
Clearly defined roles of players in CBNRM process	Not yet worked out; in process	Yes, but still working on best mechanisms	Yes, but still working on best mechanisms	In process	Somewhat; awaiting guidelines	Yes, but still working on best mechanisms	In process
4. ECONOMIC CONSIDERATIONS							
PARAMETER	**Uganda**	**Botswana**	**Namibia**	**Kenya**	**Tanzania**	**Zimbabwe**	**Malawi**
Options for wildlife or tourism enterprises identified locally	Yes, in some areas; but viability and feasibility of enterprises needs work	Yes, in some areas	Yes, in some areas	Yes, in some areas	Yes, in some areas	Yes, in some areas	Yes, in some areas
Cost-benefit analysis and/or business/marketing plans prepared for CBNRM enterprises	Very few ; mostly on pilot basis	Mostly though private sector partnerships; increasingly through CB enterprises	Mostly though private sector partnerships; increasingly through CB enterprises	In some cases	Mostly though private sector partnerships; increasingly through CB enterprises	Mostly though private sector partnerships; increasingly through CB enterprises	In some cases, mainly with donor assistance
CBOs/communities receive major share of income from wildlife/tourism community-private sector partnerships	Few private sector partnerships in place; communities do not receive a major share	Yes, from formal partnerships	Yes, from conservancy partnerships	Variable	Variable	Yes, from CAMPFIRE partnerships	Variable
CBOs have access to credit and/or grants	In some cases Through donor projects, trusts, ECOTRUST Uganda	Some access Community Conservation Fund (Government Of Botswana); others	Some access	Some access	Some access	Some access	Some access Community Partnerships for Sustainable Resource Management (COMPASS)
Wildlife-based tourism status	Low level of wildlife-based tourism	High level of wildlife-based tourism	High level of wildlife-based tourism	High level of wildlife-based tourism	High level of wildlife-based tourism	High level of wildlife-based tourism underway	Limited wildlife-based tourism; Limited wildlife areas/parks;

	Economic feasibility affected by poor security situation and scarcity of international tourists						new initiatives being started
Hunting activities undertaken	No; feasibility being explored in select areas, but wildlife numbers low Uganda Wildlife Authority (UWA) moving forward with pilot hunting permit in Lake Mburo Area; need to carefully assess sustainability to avoid further drops in wildlife populations	Yes	Yes	Yes	Yes	Yes	No; possibility in very restricted areas
Products and services provided by communities	Some guide services, community campgrounds, boat trips, bird walks, curios, etc. Tourism very low in Uganda at present; bargaining position not firm Some crafts/curios marketed internationally by Uganda Community Tourism Association (UCOTA) Charcoal Thriving illegal bush meat market exists	Joint venture partners hire negotiated number of community members Guides and service workers employed by tourism and recreation industries CB enterprises provide services and products in some areas Botswana baskets and other crafts marketed locally and through NGOs Veld products collected and marketed (phane caterpillars, marula, devil's claw, etc.)	Private sector partners hire community members Employment by tourism and recreational industries CB enterprises provide services and products in some areas Crafts marketed locally and through NGOs Veld products and traditional medicines collected and marketed	Some	Some	Private sector partners hire community members Products and services offered by communities to tourists, others	Many products including: Firewood and Charcoal (even though illegal) Fish Bushmeat (even though illegal) Wooden and other Crafts and Curios; Non-timber forest products Labor for Service Industry
5. SOCIO-CULTURAL CONSIDERATIONS							
PARAMETER	**Uganda**	**Botswana**	**Namibia**	**Kenya**	**Tanzania**	**Zimbabwe**	**Malawi**
Demographics	Population: 23,317,560 Population growth rate:	Population:1,576,470 Population growth	Population: 1,771,327 Population growth	Population: 30,339,770 Population growth rate	Population 35,306,126 Population growth rate	Population: 11,342,521 Population growth	Population: 10,385,849 Population growth

	2.72% (2000 est.)	rate: 0.76% (2000 est.)	rate: 1.57% (2000 est.)	1.53% (2000 est.)	2.57%0 (2000 est.)	rate: 0.26% (2000 est.)	rate: 1.61% (2000 est.)
Literacy* **(age 15 and over can read and write)**	61.8% total 73.7% male 50.2% female (1995 est.)	69.8% total 80.5% male 59.9% female (1995 est.)	38% total 45% male 31% female (1960 est.)	78.1% Total 86.3% male 70% female (1995 est.)	67.8% total 79.4% male 56.8% female (1995 est.)	85% total 90% male 80% female (1995 est.)	58% total 72.8% male 43.4% female (1999 est.)
Gender Issues	Women's groups are motivated but have difficulties getting access to resources; women less educated than men	Women and men involved on CBO boards, but chairmen are generally men	Women active in CBNRM; educational gender issues	Women less educated, less access to resources	Women less educated than men; less access to financial resources	Both women and men involved in deciding use of CAMPFIRE funds	Women's groups are motivated and involved
Poverty Level*	55% below poverty line (1993 est.)	47% (1999 est.)	NA%	42% below poverty line (1992 est.)	51.1% below poverty line (1991 est.)	60% population below poverty line (1999 est.)	54% population below poverty line (1991 est.)
GDP per capita **(purchasing power parity)***	$1,060 (1999 est.)	$3,900 (1999 est.)	$4,300 (1999 est.)	$1,600 (1999 est.)	$550 (1999 est.)	$2400 (1999 est.)	$940 (1999 est.)
Social Issues	82% of labor force engaged in agriculture Conflict, rebel activities, insecurity in some areas; migration of locals within Uganda to escape conflict Refugees from surrounding countries settling in Uganda Lack of capacity at local level Many ethnic groups, languages HIV/AIDS, malaria, schistosomiasis	80% engaged in agriculture, mostly livestock raising Communities with sudden high income levels from CBNRM adjusting to changes HIV/AIDS, malaria	Educational level Lack of capacity at local level Remoteness of communities Recovering from conflict and apartheid Many ethnic groups, languages HIV/AIDS, malaria	Many ethnic groups with history of conflict; 75–80% labor force engaged in agriculture HIV/AIDS	HIV/AIDS 90% labor force engaged in agriculture Varying lifestyles	Land tenure issues HIV/AIDS Current instability in country affecting peoples livelihoods Education/capacity at local level low	86% labor force engaged in agriculture Lack of capacity at local level Many ethnic groups, languages Lack of clear role for traditional authorities in CBNRM HIV/AIDS, malaria
Level of Corruption: Transparency International Corruption score 2001**** 10=highly clean	1.9	6.0	5.4	2.0	2.2	2.9	3.2

0=highly corrupt							

* Based on CIA World Factbook (2000) Figures

** Simons (2000)

*** Trick (2000)

**** Transparency International 2001 Corruption Perception Index (2001)

Resources and References

Resources

- Borrini-Feyerabend, G., ed. (1997). *Beyond Fences: Seeking Social Sustainability in Conservation*. IUCN, Gland (Switzerland). http://www.iucn.org/themes/spg/Files/beyond_fences/beyond_fences.html.

  Beyond Fences is an extensive resource designed to help professionals involved in conservation initiatives to identify social concerns relevant to their work, assess options for action and implement them. Volume 1 is a companion to a process of planning, evaluating or re-designing a conservation initiative. It uses a "learning by doing" approach, involving meetings and field-based activities. Volume 2 is a reference book containing an extensive set of resource pieces on subjects ranging form ecotourism to conflict resolution. This material is to be consulted as needed.

- Buzzard, Candace (2001). *Community-Based Natural Resources Management (CBNRM) in Uganda: A Review of the National Enabling Framework and Comparison with Other African Countries*. Published by GTZ/UWA, Kampala, Uganda. September.

- Buzzard, Candace (2001). *Policy Environment Governing the Great Limpopo Transfrontier Park and Conservation Area: A Review of Relevant International Agreements, SADC Protocols, and National Policies*. Prepared by Development Alternatives Inc. for USAID. November.

- The CBNRM Support Programme in Botswana http://www.cbnrm.bw/) makes available many reports released by several different agencies. A set of practical tools and models is particularly useful. The following are a subset of these reports, produced by Chemonics International for the Botswana Department of Wildlife and Natural Parks (DWNP). These were funded by USAID and can be obtained by sending a request to information@cbnrm.bw.

  - *Practitioners Guide—Community Based Natural Resources Management* (1999). Easy-reference manual for extension staff of DWNP and local NGOs. The guide is divided in three sections: Botswana's CBNRM Programme overview, a guide to CBNRM activities, a brief overview of different stages of development and options available, a CBNRM tool kit and a bibliography.
  - *Joint Venture Guidelines: A Guide to Developing Natural Resource Based Ventures in Community Areas* (1999). Used by communities, safari companies and Government of Botswana extension staff to guide the process of facilitating joint venture agreements or partnerships between a community and the private sector. This booklet explains the roles and responsibilities of the different stakeholders involved and the procedures to be followed.
  - *Community Management of Hunting Quotas: Discussion Draft* (1996). Botswana Department of Wildlife and Natural Parks.
  - *Enterprise Development Tool Kit* (n.d.). Botswana Department of Wildlife and National Parks. The tool kit gives suggestions on how to establish a CBNRM enterprise. Discusses assistance that might be required (by an accountant, lawyer, bank manager, consultant) as well as how to prepare a business plan, market the product and manage the business. In addition, an overview is provided on legislation regarding business licenses in Botswana.

- *Problem Animal Control Manual* (1995). Instructions and technical guidance in problem animal control for DWNP staff.
- *Community Escort Guide Manual* (1999). Instructions and technical guidance for community escort guides on how to escort hunting clients. DWNP.
- *Developing a Methodology for a Community Natural Resource Inventory and Monitoring System* (1999). A methodology developed for Sankuyo (NG33/34 in Ngamiland) and Ukhwi area (KD1 in Kgalagadi district) that covers both comprehensive records on and monitoring methodologies of veld products and vegetation in the study areas.
- *Procedures for Establishing and Implementing Community-Based Wildlife Monitoring Programs* (1999). A methodology for communities to monitor wildlife density and distribution in their areas.
- DWNP's Monitoring and Evaluation Experience with the Natural Resources Management Project: Lessons Learnt and Priorities for the Future (1997). Four case studies on work in Zutshwa, D'Kar, Sankuyo and the Chobe Enclave.
- *Nqwaa Khobee Xeya Trust Constitution*. Nqwaa Khobee Xeya Trust. http://www.cbnrm.bw/nkxtconsti.pdf. Legal constitution of a CBO, the Nqwaa Khobee Xeya Trust, registered on 10 June 1998.
- *Integrating the Socio-economic and Biophysical Data for Monitoring and Evaluating CBNRM: Conceptual Design Report* (1999).

The FRAME Web site offers a collection of resources about CBNRM at http://www.frameweb.org/ev.php?ID=1122_201&ID2=DO_TOPIC. This Web site supports strategic analysis of environmental issues in Africa, including the environmental investments of USAID and others. Contents range from the African Conservation Centre (ACC) Database of Community -Based Conservation Projects, to the report on Community Based Conservation Experience in Tanzania: An Assessment of Lessons Learned.

The Natural Resource Management Tracker Tool is found at http://www.frameweb.org/ev.php?ID=11394_201&ID2=DO_TOPIC.

Sponsored by the USAID Africa Bureau's Office of Sustainable Development, the Tracker Web site has been developed to facilitate information capture and sharing among those interested in improving resource management through work with local communities. The Web site exists to capture local experiences and sharing through the mediums of e-mail, Web, and CD-ROM. The Tracker database allows users to enter their own experiences from local resource management or learn about best practices and key lessons from the experiences of others. Tracker thus:

- helps field offices and local partner organizations capture and organize information about their own activities in local-level conservation and natural resources management (useful for reporting to the home office and sharing lessons between country programs);
- helps home offices put their partner organizations and country program offices in touch with one another; keeps track of experiences being gained by multiple projects;
- consolidates material for ready use in developing reports to donors; and
- disseminates experiences among other conservation and sustainable development organizations for potential partnerships, mutual learning, and other collaborative opportunities.

A small sample of organizations with information in Tracker about their activities in African conservation and NRM include: USAID/Africa Bureau/Office of Sustainable Development; Conservation International (Madagascar); Cooperative League of the USA (CLUSA); International Resources Group, Ltd.; Development Alternatives, Inc.; Savanna Conservation Nigeria; Appui-Recherche-Cooperation (Burkina Faso); Ministère de l'environnement et du tourisme (MET—Burkina Faso), Association de Développement de l'Elevage et de la Faune Africaine (ADEFA—Burkina Faso)**;** University of Dschang Department of Rural Education (Cameroon); United Nations Development Program (UNDP—numerous countries); Christian Relief and Development Association (Ethiopia); Kenya Agricultural Research Institute (KARI); WWF—Madagascar; and numerous independent African consultants in the environmental field.

Information about CBNRM in Malawi can be found at http://www.compass-malawi.com.

A set of model documents and tools produced by SNV/Netherlands are available by sending a request to information@cbnrm.bw:

- *KD1 Land Use and Management Plan* (1999). This document describes how the inhabitants of KD 1, organised under the Nqwaa Khobee Xeya Trust, intend to manage the natural resources in their Controlled Hunting Area (CHA)**.**
- *NG 4 Management Plan*, Cgaecgae Tlhabololo. The NG 4 Management Plan describes how the inhabitants of NG 4, now organised in the Cgaecgae Tlhabololo Community Trust, intend to manage the natural resources in their controlled hunting area (CHA).
- *NG 4 Tender Guidelines*, Cgaecgae Tlhabololo Community Trust. These guidelines indicate the community trust's conditions for joint ventures to interested private sector companies for tender of the communities' hunting quota or non-consumptive tourism potential.

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  This assessment involved an evaluation of program activities and field examination of community-managed projects supported by USAID through the Botswana NRMP. Many challenges facing Phase II CBNRM implementation were identified during this exercise.

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  The report gives a brief review of the extent and progress of community wildlife management (CWM) in the seven countries of southern Africa—Botswana, Malawi, Mozambique, Namibia, South Africa, Zambia and Zimbabwe. It includes a summary of supporting legislation for CWM projects and the extent of project establishment. Key emerging issues are discussed. These range from land tenure and conservation/biodiversity impacts, to participation and vertical/horizontal integration, along with many others. In addition, strengths and weaknesses in existing knowledge are indicated.

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  A brief history of CBNRM activities in Botswana and Namibia covering socio-economic and environmental aspects, together with the policy and legal framework for CBNRM; national level activities; major implementing organizations; and short project profiles detailing the location, activities, and implementing partners of individual local projects.

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  This paper examines the development and implementation of a policy to promote the sustainable management of wildlife and wild habitats by rural communities occupying communal land in Namibia, the most arid country south of the Sahara.

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  This publication covers 19 examples of small-scale CBNRM best practices. These practices mainly include integrated natural resources management (NRM), communal reforestation, permaculture, and other sustainable agricultural practices. There are also cases where community-based organizations (CBOs) gradually evolved to become local NGOs. COMPASS will keep up with the developments at these model sites to monitor changes and record new lessons that can be shared with partners.

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  A contribution to a comparative study dealing with institutional issues in community-based natural resources management CBNRM) in the Southern Africa Development Community (SADC) region (funded by WWF and coordinated by Bruce Campbell and Sheona Shackleton)

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  This report presents an overview of CBNRM policy in Malawi and documents the outcomes of the policy analysis training and CBNRM policy dialogue conducted in April/May 2002. This report presents three legal analyses (on fisheries, wildlife and land reform) conducted by the trainers/facilitators to update understanding of these important sectors and support future CBNRM efforts. It also records the consensus, processes and outcomes of the collaborative group analyses conducted over the course of the workshop.

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  The Botswana NRMP component aims to make rural households more prosperous by encouraging local communities to have more direct involvement in managing wildlife and products produced from the country's dry woodland savannah ("veld"). This project promotes sustainable, conservation-based development of marginal lands that previously were used only for crop production and domestic livestock.

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  Building on lessons learned from more than 20 years of natural resource–based development in rural

Africa, this discussion paper presents principles and action steps that can serve as a guide to investment. It was prepared by the Environment and Natural Resource Team of the Sustainable Development Office in USAID's Africa Bureau (AFR/SD). The paper is intended as an opening statement in a dialogue on rural Africa. Comments are welcome and can be sent to Jon Anderson, Natural Resource Policy Advisor, Economic Growth, Agriculture and Trade Bureau (USAID/EGAT) janderson@usaid.gov.

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Chapter 3
Small-Scale Construction

Contents

Brief Description of the Sector	3-1
Potential Environmental Impacts	3-1
Sector Program Design	3-4
Environmental Mitigation and Monitoring Issues	3-8
Resources and References	3-18

When planning a construction project, in order to properly evaluate their options, project developers must examine all the classes of impacts — direct, indirect, ancillary, cumulative and socio-cultural.

The magnitude of impacts is likely to be proportional to the size of the project.

Brief Description of the Sector

Virtually all small-scale development activities—housing, sanitation, water supply, roads, healthcare, energy, etc.—involve some amount of construction. Construction is one or more of a set of diverse activities: demolition; site-clearing; grading, leveling, and compacting soil; excavating; laying pipe; installing equipment; or erecting structures. The development benefits of construction come not from the construction itself, but from the buildings and infrastructure which are its result.

The details of the construction carried out in support of any particular development activity or site will have a number of unique aspects. Construction activities in general, however, share a set of common features and potential adverse environmental impacts.

This sector briefing addresses a number of these common elements. It is intended to apply to the types of projects mentioned above, as well as the construction of schools, health posts, storage silos, market or community centers, fire observation towers, and any similar small-scale construction projects. It is only intended to identify key issues and illustrate potential mitigation measures associated with the construction process. Detailed guidelines for the specific type of project should also be consulted (e.g., the “Housing” or “Water Supply and Sanitation” sections of the Guidelines).

USAID uses a working definition of small-scale construction as “Construction or repair of facilities where total surface area to be disturbed is under 10,000 sq. ft.” While this "rule of thumb" is not strictly compliant with Regulation 216, it functions as a reasonable and practicable threshold value. Projects which involve construction of larger surface areas are generally subject to a higher degree of oversight with required application of environmental soundness checklists.

Potential Environmental Impacts of Construction and Their Causes

Construction projects may cause both direct and indirect potential adverse environmental impacts. An example of a direct impact is the filling of a wetland to use as a project site. Indirect impacts are induced changes in the environment, population, and use of land and environmental resources. Examples of indirect impacts include:

- in-migration of population to take advantage of schools, health posts or other infrastructure;
- effects on fish spawning associated with siltation of streams from soil erosion at a construction site; or

- the spread of disease from insect vectors breeding in flooded and abandoned quarries and borrow pits (areas from which construction materials were excavated, or "borrowed").

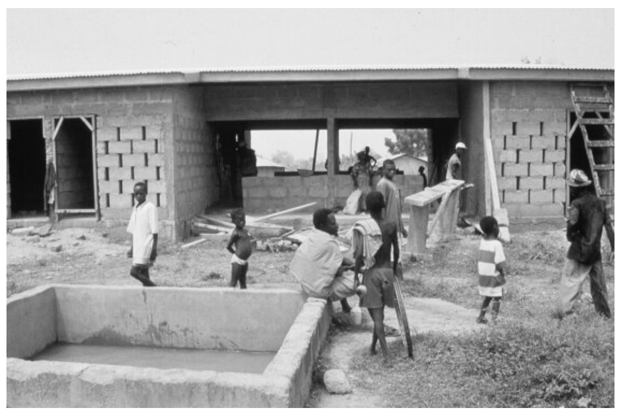
Another example could be a construction project's use of unsustainably extracted timber, which may contribute to the degradation of a forest some distance away. Direct impacts often receive more attention, but indirect effects can be just as significant.

Adverse Impacts of Construction Projects

- Damage to ecosystems
- Sedimentation of streams and surface water
- Contamination of water supplies
- Social impacts
- Spread of disease
- Damage to aesthetics of area

Direct and indirect impacts of *associated* or *ancillary* activities also need to be considered. For example, construction of a small-scale irrigation system may require construction of a new road or improvement of an existing road so that materials and equipment can reach the project site. The road is an associated or ancillary activity, with its own set of environmental impacts. The size and scope of both indirect and ancillary effects may be magnified over time, or through the cumulative effects of building many small facilities.

Construction can also have significant effects on public health—for



This market near Tamale, Ghana, will provide permanent stalls for butcheries and restaurants. But the market lacks a solid waste disposal system.

example, the spread of HIV/AIDS and other communicable diseases is often associated with workers and construction camps. Standing water in quarries and borrow pits may become sources of contaminated water and disease-bearing insects.

All potential impacts should be considered and mitigated to the extent possible, but the most significant impacts should be addressed first. As with any project, the best way to accomplish this is by careful planning and incorporation of mitigation measures into project design.

Environmental impacts of special concern include:

- **Damage to sensitive or valuable ecosystems.** Construction in wetlands, estuaries or other sensitive ecosystems may destroy or significantly damage exceptional natural resources and the benefits they provide. This damage may reduce economic productivity, impair essential ecosystem services (such as flood control or breeding habitat for food fish), or degrade the recreational value of these resources.

Compaction of the soil and grading of the site may alter drainage patterns and water tables, changing access to water by animals, people and vegetation, and may degrade water resources as well (see below). Improper extraction of construction materials such as wood, stone, gravel, or clay may damage terrestrial ecosystems (e.g., wood may come from relatively undegraded forests).

- **Sedimentation of surface waters.** Removal of natural land cover, excavation, extraction of construction materials and other construction-related activities can result in soil erosion. Erosion can, in turn, lead to sedimentation in receiving waters. Sedimentation may reduce capacity of ponds and reservoirs, increasing flood potential, or substantially alter aquatic ecosystems by changing streambed, lakebed and estuary conditions.
- **Contamination of ground and surface water supplies.** Toxic materials are often used in construction. Examples include solvents, paints, vehicle maintenance fluids (oil, coolant), and diesel fuel. If these are dumped on the ground or wash into streams they may contaminate ground or surface water supplies. This may harm the health of the local community, as well as populations living down gradient and downstream. Aquatic and terrestrial ecosystems may also be damaged. Where sanitary facilities for construction crews are inadequate, human waste may contaminate water resources.
- **Adverse social impacts.** Construction may displace local inhabitants, or reduce their access to environmental resources. (For example, farmers' income or subsistence may be reduced.) Construction on or near culturally important sites (cemeteries, worshipping areas, meeting places) may generate conflict with the local community. If the new facility provides a valuable service not available elsewhere, it may cause migration to the area. Noise and dirt from the site may disturb neighbors. If local labor is not used, this may also generate resentment.
- **Spread of disease.** An influx of construction workers from other regions or construction of a new road may introduce new diseases to the local population or increase the incidence of local infection. This is a particular concern with sexually transmitted diseases, such as HIV/AIDS.

  Specific types of facilities such as those for healthcare, sanitation, and solid waste can also increase the spread of a variety of diseases unless they follow proper waste-handling procedures (see Section 3-13).
- **Damage to aesthetics of site/area.** If the structure is too large, the architectural style is not consistent with local architectural customs, or it is sited without adequate attention to existing aesthetic and scenic characteristics, the facility may harm the visual quality of the area.

Sector Program Design—Key Questions for Construction Projects[1]

Apply best practices. All best practices discussed in Chapter 1 of this volume ("An Introduction to Environmentally Sound Design") apply to the construction dimension of projects.

Consider the full range of impacts. When planning a construction project, in order to properly evaluate their options, project developers must examine

A dusty road passes in front of the Tamale market's new buildings, but no provision was made for cleaning the facilities. This is one of the considerations to take into account in project design and site selection.

all the classes of impacts described above—direct, indirect, ancillary, cumulative and socio-cultural. Assessment of indirect effects is especially important for large infrastructure development projects, but must also be considered for small-scale activities. Ancillary, cumulative, and socio-cultural effects can occur with any size project. The magnitude of impacts is likely to be proportional to the size of the project.

The following questions, categorized by project phase, are intended to stimulate consideration of the full range of impacts. Consult the mitigation and monitoring tables for measures to address these impacts. Please note: not all apply to all projects, nor are all possible mitigation measures incorporated in these tables.

Project Design Consideration

- Apply best practices
- Consider full range of impacts, both direct and indirect, for three main project areas:
  - site selection
  - planning and design
  - construction

Site Selection

- What are the current uses and activities at the proposed project site? Who will be displaced?
- How close are neighboring residences?
- What types of environment, landscape, flora and fauna are present in the area? Are any species of particular biological, medicinal,

[1] Incorporates material from "Checklist #2 / Building Construction" (1997), *Handbook on Environmental Assessment of Non-Governmental Organizations and Institutions Programs and Practices,* Canadian International Development Agency.

cultural, historical, social or commercial value—and, if so, could the project damage them?

- Is the site itself of cultural, archeological, historical, or social value?
- Are there any bodies of water, wooded areas, slopes, wetlands or other vulnerable sites nearby?
- Is the area and/or site prone to landslides, flooding, heavy rainfall, earthquakes and other disasters?
- Is the site steeply sloped? Is the soil sufficiently stable? What is its thickness, texture, drainage and topographical features?
- How distant is the site from the intended users?
- Would use of the site require construction or improvement of a road?
- Are water and sanitary facilities readily available or would they need to be provided?
- Are historical data available on precipitation, surface water flows and climatic conditions?
- Can the extent and quality of groundwater supplies be determined? Are historical and seasonal data available?

These new public latrines are too far from the market and have no cleaning system in place. Ease of maintenance and impact on the local environment are critical elements for proper planning of small-scale construction projects.

Planning and Design

- What are the local zoning, building, and permit requirements?
- Is the proposed design constructed of materials appropriate to the climate and site?
- Are erosion and flood protection measures incorporated?
- Is this a small, isolated project, or one of many similar projects?

- Will ancillary or associated infrastructure development be necessary?
- What indirect effects are possible? For example, if a new facility is to be built in a forest, will the road servicing the facility encourage illegal logging and poaching?
- What are the types, quantities and source of construction materials? Where does the material come from, e.g., quarries, borrow pits, relatively undegraded forest?
- Where will workers sleep? What types of water supply, sanitation and solid waste disposal will be provided for workers? Have steps been taken to ensure that these services are provided in an environmentally sound manner?
- If water supply and sanitation facilities are to be constructed, will they be designed according to the "Water Supply and Sanitation" sector briefing in this volume?
- If healthcare facilities are to be constructed, will their waste streams be handled as described in the "Healthcare Waste: Generation, Handling, Treatment and Disposal" sector briefing in this volume?

  For example, is there a waste storage room, an incinerator (if rural), a space for encapsulation and a plastic/clay-lined pit for safe burial? How will graywater from bathing and washing of bedding, etc., be disposed of? What system of human waste disposal will be provided to prevent undue health risks? Will water be provided to the facility in a manner that minimizes risk of contamination for patients and nearby communities?
- If the facility will generate solid waste, does the design include space and features for source separation of recyclables and organic waste, as described in "Management of Solid Waste from Residential, Commercial and Industrial Facilities" in this volume?
- If hazardous chemicals, radioactive waste or other types of hazardous materials will be produced, does the design include proper storage, handling and disposal facilities, as described for some sectors in "Activities with Micro and Small Enterprises (MSEs)" in this volume? (These materials could include heavy metals, oil, lubricants, batteries, dyes, glue, solvents, acids, etc.)
- If cooling waters, soaking waters, or water containing suspended matter, mercury, lead, soaps or other previously mentioned products are likely to be generated, does the design include elements for treatment, storage and discharge, as described for some sectors in "Activities with Micro and Small Enterprises (MSEs)" in this volume?
- What kind of public health education will construction workers receive? Will it include information about HIV/AIDS?

Construction Phase

- Where will the construction crew come from? Will the construction schedule compete with local crop harvesting?

- What site preparation and construction activities will be carried out? Will there be demolition, excavation, leveling, clearing, filling, backfilling or wetland reclamation?
- How will any construction and demolition debris be disposed of?
- How will the materials be conveyed to the site and stored?
- What toxic materials will be used during construction? Are non-toxic substitutes available? Are measures in place to ensure that toxic materials are properly disposed of?
- What measures are in place for monitoring environmental impacts and ensuring adherence to environmental guidelines?

Environmental Mitigation and Monitoring Issues

Table 1: Environmental Mitigation and Monitoring Issues for Construction-Related Aspects of Development Projects

Issue or aspect of activity	**Impact** *The activity may. . .*	**Mitigation** *Note: Mitigations apply to specified project phase: Site Selection (SS); Planning and Design (P&D), Construction (C), or Operation and Maintenance (O&M)*
Site Selection (SS)		
Site occupied or used by local residents	Displace untenured residents or reduce farmers' or pastoralists' lands	• Find alternative location (SS). If that is not possible: • Provide equivalent land and/or accommodations or fair monetary compensation, provided these are accepted voluntarily and without coercion (SS)
Dwellings located close by	Facility and/or construction disturbs neighbors, creating noise and dust	• Build as far as practical from neighbors (SS) • Concentrate noisiest types of work into as short a period as possible, and during least disruptive times of the day. Take measures to keep dust to a minimum (P&D)(C) • Screen facility with trees or fencing to control noise (P&D) • Wet ground if water is abundant and/or leave natural cover intact as long as possible (C)
Site has historic, cultural, or social importance	Offend local population; damage local social fabric	• Find alternative site (SS)
Site would require road improvement or new road construction (Also consult "Rural Roads" section of the Guidelines)	Cause one or more of a set of adverse environmental impacts typical of roads, including erosion, changing water tables, or providing access for illegal landclearing, logging or poaching	• Find alternative site. Evaluate "minimum tool" alternatives (e.g. consider whether a foot or bicycle path might suffice (SS) (O&M) • Follow guidance on design, construction, and operation and maintenance described in "Rural Roads" and resources listed there

Issue or aspect of activity	**Impact** *The activity may. . .*	**Mitigation** *Note: Mitigations apply to specified project phase: Site Selection (SS); Planning and Design (P&D), Construction (C), or Operation and Maintenance (O&M)*
Site contains habitat for important ecosystems, animals or plants	Destroy or harm plants or animals of ecological, cultural, and/or economic importance	Find alternative location (SS). If that is not possible: • Limit access to the site • Design any infrastructure (if unavoidable) to create least impact (P&D) • Minimize disturbance of native flora during construction (P&D) (C) • Remove, without destroying, large plants and ground cover where possible (C) • Replant recovered plants and other flora from local ecosystem after construction (C)
Site has important scenic, archeological or cultural/historical features	Destroy or harm these sites	Find alternative location (SS). If that is not possible: • Limit access to site • Design any infrastructure (if unavoidable) to create least impact (P&D) • Minimize disturbance of site during construction (P&D) (C) • Remove important artifacts where possible (C) • Provide worker incentives for discovery and safe removal of archeological or paleontological material. (SS) (C)
Site is wetland or abuts body of water	Destroy or harm valuable and sensitive ecosystems and organisms	Find alternative site. Wetlands and *riparian* ecosystems (those sited next to a body of water) are extremely sensitive. Wetlands provide important environmental services such as water storage, bird and animal habitat, flood control, and filtering toxins and nutrients from runoff (SS). If no alternative is available: • Set back any infrastructure as far as possible from the water body/wetland and minimize the amount of wetland destroyed by infrastructure footprint or construction (SS) (P&D) • Revegetate as soon as possible (C) *If facility will include sanitation facility, find alternative site* (SS)

Issue or aspect of activity	**Impact** *The activity may. . .*	**Mitigation** *Note: Mitigations apply to specified project phase: Site Selection (SS); Planning and Design (P&D), Construction (C), or Operation and Maintenance (O&M)*
Site is steeply sloped	Cause erosion and damage to terrestrial and aquatic ecosystems during construction or use	Find alternative site (SS). If that is not possible: • Design facility and apply construction practices that minimize risk, e.g., use hay bales to control erosion during construction. Pay particular attention to potential erosion and redirection of water flows during design and construction (SS) (P&D) (C) • Revegetate as soon as possible (C) • Maintain design features (O&M)
Area is heavily wooded	Degrade forest, contributing to flooding potential	Find alternative location if area is old growth or relatively undegraded forest (SS). If that is not possible: • Design so as to minimize clearing or disturbance (P&D) • Avoid destroying rare or unique species. Consult with local populations about current use of forest and preferences for preservation (SS) (P&D) (C)
Site prone to flooding	Be destroyed and/or subject workers or inhabitants to risk of injury or death Cause environmental damage from accidental release of toxic, infectious or otherwise harmful material during flooding Contaminate drinking water	Find alternative site or design infrastructure so it is raised above flood plain, if possible (SS) Design infrastructure to minimize risk, e.g., design with proper grading and drainage (P&D) Maintain design features such as drainage structures (O&M) Avoid constructing sanitation or other facilities that will use and store harmful materials at flood-prone sites (SS). If that is not possible: • Design storage area so that hazardous materials are above ground and/or in waterproof containers with locking lids that are kept closed. Ensure that facility operators follow these practices (P&D)(O&M) • Chose dry sanitation options or closed disposal systems, instead of wet ones such as septic tanks or detention ponds (P&D)

Issue or aspect of activity	**Impact** *The activity may. . .*	**Mitigation** *Note: Mitigations apply to specified project phase: Site Selection (SS); Planning and Design (P&D), Construction (C), or Operation and Maintenance (O&M)*
Area and/site prone to landslides	Be destroyed and/or expose workers or inhabitants to risk of injury or death Cause environmental damage from accidental release of toxic, infectious or otherwise harmful material Contaminate water supplies	Find alternative site on stable ground (SS). If that is not possible: • Design infrastructure to minimize risk, e.g., plant trees all around facility ((P&D) • Maintain protective design features (O&M) Avoid constructing sanitation or other facilities that will use and store hazardous or biohazardous materials at landslide-prone sites (SS). If that is not possible: • Design storage area so that hazardous materials are stored in durable leak-proof containers with locking lids, and that these are kept closed (P&D)(O&M) • Chose dry sanitation options or closed disposal systems, instead of wet ones such as septic tanks or detention ponds (P&D)

• **Planning and Design**		
Area experiences heavy rainfall, earthquakes	Be destroyed and/or expose workers or inhabitants to risk of injury or death Cause environmental damage and/or contaminate water supplies via accidental release of toxic, infectious or otherwise harmful material	• Design infrastructure to minimize risk, e.g., in earthquake-prone areas, build structures with wood frames instead of concrete or brick (P&D) • Maintain protective design features (e.g., drainage structures and vegetation on slopes). (O&M) • Use material appropriate to the climate (e. g., stucco instead of adobe in areas with heavy rainfall) (P&D) (C) • Design storage area so that hazardous materials are above the ground and/or in waterproof containers. Ensure that facility operators follow these practices (P&D)(O&M) • Chose dry sanitation options or closed disposal systems, instead of wet ones such as septic tanks or detention ponds (P&D)
Facility is or will include a water supply improvement (Also consult "Water Supply and Sanitation" section of the Guidelines)	Deplete ground and/or surface water resources and damage local ecosystems or downstream/down-gradient communities Poison users with natural or man-made chemical contaminants such as arsenic Spread disease with pathogenic contaminants Cause groundwater contamination	• Determine safe and sustainable yield. Establish system for regulating use (P&D) (O&M) • Test seasonal water quality and examine historical water quality and quantity data before building facility (SS) (P&D) • Incorporate siting, design and operation and maintenance practices that minimize environmental impacts as described in "Water Supply and Sanitation" secction of these *Guidelines* (e.g., community participation, fee-for-service pricing, preventing livestock grazing near water supply, etc.) (SS) (P&D) (C) (O&M)
Facility is or will include a sanitation improvement (Also consult "Water Supply and Sanitation" section of the *Guidelines*)	Discharge untreated or insufficiently treated sewage that: • Contaminates drinking water (ground and surface) • Spreads diseases • Degrades aquatic ecosystems	• Do not site in wetland or next to stream, river, lake or well (SS) • Do not site up-gradient from potable water sources such as wells, if possible (SS) • Do not site where water table is high or underlying geology makes contamination of groundwater likely. Alternately, choose dry sanitation options or closed disposal systems, instead of wet ones such as septic tanks or detention ponds (SS) (P&D) • Incorporate design features, education/social marketing programs, construction and operation and maintenance practices described in the "Water Supply and Sanitation" section of these *Guidelines* and resources listed there; e.g. community participation, sanitation promotion focusing on women and children,

		use of appropriate natural treatment systems, etc. (SS) (P&D) (C) (O&M)

Facility will provide healthcare services
(Also consult the "Healthcare Waste: Generation, Handling, Treatment and Disposal" section of the *Guidelines*)
	Spread disease via failure to (1) sterilize infectious waste and/or (2) prevent access to waste by waste pickers or disease vectors
	Expose local community to health risks via unsafe disposal of toxic, carcinogenic and teratogenic[2] materials
	Contaminate water supplies (ground and/or surface) via improper land disposal. (May also damage local ecosystems, animals or plants.)
		• Do not site in wetland or next to stream, river, lake or well (SS)
		• Incorporate design features and O&M procedures, described in the "Healthcare waste: Generation, Handling, Treatment and Disposal" section of the *Guidelines*, including, but not limited to, hand-washing facilities, waste storage rooms, incinerators (if rural), spaces for encapsulation, and a plastic/clay-lined pit for safe burial (SS) (P&D) (C) (O&M). Among the most important guidelines from this section:
		  • If waste will be buried on site, avoid wherever possible siting the burial pit up-gradient from a drinking water source such as a well. Pit must be lined with impermeable material such as clay or polyethylene (SS) (P&D) (C)
		  • If waste will be buried on site, avoid wherever possible sites where water table is high or underlying geology makes contamination of groundwater likely. If no alternative site is available, ensure that pit is lined with impermeable material such as clay or polyethylene (SS) (P&D) (C)
		  • Provide for safe disposal of graywater from bathing and washing of bedding, etc. (P&D; O&M)
		  • Ensure that the system of human waste disposal provided minimizes health risks (P&D; O&M)
		  • Ensure that water is provided to the facility in a manner that minimizes risk of contamination for patients and nearby communities (P&D; O&M)

Facility will generate solid waste (Also consult the "Management of Solid Waste from Residential, Commercial and Industrial Facilities" section of the *Guidelines*)	Spread disease Contaminate drinking water (ground and surface) Degrade aquatic ecosystems Generate greenhouse gases	• Include space and features for source separation of recyclables and organic waste. Consider including space and/or constructing a compost bin or worm box if facility will produce organic waste (P&D) (C) (O&M)

[2] Teratogenic means causing birth defects.

Facility will house automotive, laboratory or other industrial activities (Also consult the "Activities with Micro and Small Enterprises (MSEs)" section of the *Guidelines*)	Expose workers or local population to toxic, carcinogenic and teratogenic materials such as heavy metals, oil, lubricants, batteries, dyes, glue, solvents, acids, etc. Contaminate drinking water (ground and surface) Damage local ecosystems, animals or plants	• Do not site near wetlands or bodies of water (SS) • Design with proper storage, handling and treatment facilities (SS) (P&D) (C) (O&M)
Facility will generate cooling waters, soaking waters, or water containing suspended organic mater, mercury, lead, soaps, etc. (Also consult the "Activities with Micro and Small Enterprises (MSEs)" section of the *Guidelines*)	Expose workers or local population to toxic, carcinogenic and teratogenic materials Contaminate drinking water (ground and surface) Damage local ecosystems, animals or plants	• Incorporate cleaner production technologies into design, operation and maintenance as described in the "Activities with Micro and Small Enterprises (MSEs)" section of these *Guidelines* and resources listed there (SS) (P&D) (C) (O&M) • Design with elements for storage, treatment and discharge of wastewater (P&D) (O&M)
Indirect effects on local populations	Damage or destroy natural resources Increase in-migration Damage local social and cultural integrity Facilitate spread of disease to both people and animals	• Research indirect effects that may be associated with the particular type of facility being built and evaluate other possible impacts of this type. If the project falls into one of the sectors covered in the *Guidelines*, the relevant sector briefing and the resources listed therein are starting points for this research (SS) (P&D) (C) (O&M)
Cumulative effects of one development project over time or many small developments built within a short time period	Cause excessive extraction of building materials, multiply impacts associated with logging undegraded forest, quarrying and obtaining sand, gravel and fill ("borrowing"). (see below for more detail)	• Develop logging, quarrying and borrowing plans that take into account cumulative effects and include reclamation plans (P&D) • Monitor adherence to plans and impacts of extraction practices. Modify as necessary (C) (O&M)

Issue or aspect of activity	**Impact** *The activity may. . .*	**Mitigation** *Note: Mitigations apply to specified project phase: Site Selection (SS); Planning and Design (P&D), Construction (C),* *or Operation and Maintenance (O&M)*
Construction		
Construction crews and camps	Damage local habitat, compact soil and create erosion via building and occupation of construction camps Contaminate surface water and spread disease via solid waste and feces generated by camps Spread communicable diseases including malaria, tuberculosis, and HIV/AIDS via construction crews who come from outside the region Introduce alcohol or other socially destructive substances via construction crews Deplete local fauna and flora (especially game and fuelwood) via poaching and collection by construction crews	• Explore off-site accommodation for crew (P&D) (C) • Keep camp size to a minimum. Require that crew preserve as much vegetation as possible, e.g., by creating defined footpaths (P&D) (C) • Provide temporary sanitation on site, e.g., pit latrine (assuming the water table is low enough, with soil and geology of appropriate composition) (P&D) (C) • Use local or regional labor, if possible. Screen potential crew members for HIV/AIDS and tuberculosis. Provide education and strict guidelines regarding contact with local residents, and enforce guidelines (P&D) (C) • Set guidelines prohibiting poaching and collection of plants/wood with meaningful consequences for violation such as termination of employment. Provide adequate quantities of food and cooking fuel; both should be of good quality (C)
Use of heavy equipment	Cause erosion due to machinery tracks, damage to roads, stream banks, etc Compact soil, changing surface and groundwater flows and damaging future use for agriculture Contaminate ground or surface water when machinery repairs result in spills or dumping of hydraulic oil, motor oil or other harmful mechanical fluids.	• Minimize use of heavy machinery (P&D) (C) • Set protocols for vehicle maintenance such as requiring that repairs and fueling occur elsewhere or over impervious surface such as plastic sheeting. Prevent dumping of hazardous materials. Burn waste materials that are not reusable/readily recyclable, do not contain heavy metals and are flammable (P&D) (C) •
Use of hazardous materials	Contaminate ground or surface water when hazardous construction materials are spilled or dumped Put workers at risk from exposure to hazardous materials	• Prevent dumping of hazardous materials. Burn waste materials that are not reusable/readily recyclable, do not contain heavy metals and are flammable (P&D) (C) • Investigate and use less toxic alternative products (P&D) (C)

Issue or aspect of activity	**Impact** *The activity may. . .*	**Mitigation** *Note: Mitigations apply to specified project phase: Site Selection (SS); Planning and Design (P&D), Construction (C),* *or Operation and Maintenance (O&M)*
Demolition of existing structures	Bother or endanger neighbors via noise, dust, and debris from demolition Contaminate soil, groundwater or surface water from demolition waste containing residual amounts of toxic materials (e.g., leaded paint)	• Recover all reusable material (this may be standard practice in many developing countries) (P&D) (C) • Determine whether toxic materials are present. If possible, dispose of waste in lined landfill. Otherwise, explore options for reuse in areas where potential for contamination of surface and groundwater are small (e.g., consider the feasibility of use as roadbed material, if non-hazardous.). (See the “Management of Solid Waste from Residential, Commercial and Industrial Facilities” section of the Guidelines and references listed there for a more information) (P&D) (C)
Site clearing and/or leveling	Damage or destroy sensitive terrestrial ecosystems in the course of site clearing/preparation Produce areas of bare soil which cause erosion, siltation, changes in natural water flow, and/or damage to aquatic ecosystems	• Design infrastructure so that it will create least impact (P&D) • Minimize disturbance of native flora during construction (P&D) (C) • Remove, without destroying, large plants and ground cover where possible (P&D) (C) • Use erosion control measures such as hay bales (C) • Replant recovered plants and local flora as soon as possible (C)
Excavation	Cause erosion, siltation, changes in natural water flow, and/or damage to aquatic ecosystems when excavated soil is piled inappropriately Expose inhabitants and crew to risk of falls and injuries in excavation pits Deprive down-gradient populations and ecosystems of water if higher regions of aquifer are blocked	Cover pile with plastic sheeting, prevent runoff with hay bales, or similar measures (P&D) (C) • Place fence around excavation (P&D) (C) • Investigate alternatives allowing shallower or no excavation (P&D)
Filling	Block water courses when fill is inappropriately placed Destroy valuable ecosystems when fill is inappropriately placed Result in land subsidence or landslides later if fill is inappropriately placed, causing injuries or damage	• Do not fill the flow-line of a watershed • Be aware that in arid areas, occasional rains may create strong water flows in channels. A culvert may not supply adequate capacity for rare high volume events such as flash floods. (SS) (P&D) • Design so that filling will not be necessary. Transplant as much vegetation and groundcover as possible (SS) (P&D) (C) • Use good engineering practices (e.g., do not use soil alone. First lay a bed of rock and gravel) (P&D) (C)

Issue or aspect of activity	**Impact** *The activity may. . .*	**Mitigation** *Note: Mitigations apply to specified project phase: Site Selection (SS); Planning and Design (P&D), Construction (C),* *or Operation and Maintenance (O&M)*
Road improvement/new road construction (Consult the "Rural Roads" section of the *Guidelines* and resources listed there)	Erosion and changes to water quality and natural water flows via poor road construction practices and maintenance Provide access for clearing agricultural land, logging, poaching, mining, settlement or other development that destroys natural resources and/or harms local populations Lead to the spread of human or livestock disease	• Find alternative site. Evaluate whether an alternative mode of transport would suffice (e.g., rail, water, or footpath). (SS) (P&D) • Adhere to specifications for road design and maintenance that keep water off road surfaces (P&D) (C) (O&M) • Follow best practices for design, construction, and operation and maintenance described in the "Rural Roads" section of the Guidelines and resources listed there. These include practices such as developing quarry and borrow pit plans, following the contour line, using camber and turnout drains, training operations and maintenance personnel, etc. (SS)(P&D) (C) (O&M)
Source of building materials	Damage aquatic ecosystems through erosion and siltation Harm terrestrial ecosystems via harvesting of timber or other natural products Spread vector-borne diseases when stagnant water accumulates in active or abandoned quarries or borrow pits and breeds insect vectors	• Identify the most environmentally sound source of materials within budget (P&D) • Develop logging, quarrying and borrowing plans that take into account cumulative effects (P&D) • Monitor adherence to plans and impacts of extraction practices. Modify as necessary (C) (O&M) • Fill in quarries and pits before abandoning (C) • Control runoff into pit (C)
Decommissioning		
Hazardous abandoned structures	Buildings with collapsing roofs and walls, open latrines or septic systems, accumulation of rubble	• Remove or bury all abandoned construction materials and rubble • Fill in and close all latrines and septic systems
Eroded soils in the vicinity of abandoned infrastructure	Gulleying and siltation. Damage to aesthetics	• Restore the site through replanting, reseeding and use of soil erosion control measures (hay bales, etc.)

Resources and References

CIDA "Checklist #2 / Building Construction" (1997). *Handbook on Environmental Assessment of Non-Governmental Organizations and Institutions: Programs and Practices.* Canadian International Development Agency. http://www.acdi-cida.gc.ca/search-e.htm

Tsunokawa, Koji and Christopher Hoban (Eds.) (1997) Roads and the Environment: A Handbook. Wold Bank Technical Paper No. 376. World Bank, Washington, D.C. http://www.worldbank.org/transport/publicat/reh/toc.htm

Chapter 4

Ecotourism

Contents

Brief Description of the Sector	4-1
Potential Environmental Impacts	4-1
Sector Program Design	4-2
Mitigation and Monitoring Issues	4-7
Resources and References	4-14

Ecotourism can help fuel economic development and conserve protected areas by creating local jobs, providing a sense of community ownership, and bringing in revenue that can be used to manage protected areas in a sustainable way.

Brief Description of the Sector

Since these guidelines first appeared in 1996, ecotourism has become a significant component of the tourist industry. Tourists increasingly seek out relatively undisturbed natural areas to study and admire. They are drawn by the prospect of seeing unusual or spectacular scenery and unique plants and animals in their native habitats, as well as any cultural and historical features found in these areas.

Ecotourism can contribute to economic development and the conservation of protected areas by generating revenues that can be used to sustainably manage protected areas, and by providing local employment and a sense of community ownership. However, without careful planning and management that balances ecological, social, and economic objectives, ecotourism can easily cause environmental damage.

Ideally, ecotourism should be used as a way to promote community-based natural resources management (discussed elsewhere in these *Guidelines*). If local communities directly benefit from the use of their land, water, forests and other natural resources, they can be expected to support and participate in efforts to conserve and sustain them. Thus ecotourism projects should aim to:

- increase socioeconomic benefits to communities and landowners;
- sustainably manage the environment;
- raise awareness of and support for conservation, and
- increase a community's capacity to conserve and manage natural resources outside protected areas.

Ecotourism projects should:

- provide socioeconomic benefits to local communities
- sustainably manage the environment
- raise awareness of and support for conservation
- increase communities' capacity to manage their natural resources

Potential Environmental Impacts of Development Programs in the Sector and Their Causes

Ecotourism impacts are similar to those for small-scale construction, water and sanitation, roads, etc., but with added concern for sensitive environments.

Potential adverse impacts include:

- soil erosion and/or soil compaction from (a) poorly designed roads and trails that do not follow natural contours; (b) people walking, riding or driving off-road or off-trail to avoid wet, rutted or gullied areas; (c) visitors walking, riding or driving off-road or off-trail to view unique wildlife or resource features; (d) poorly planned or overused infrastructure (e.g., camping areas, tour routes);
- deterioration of water resources and water quality due to inappropriate design and siting of latrines, septic tanks and solid waste pits;
- deforestation from firewood harvesting, camping and construction;
- destruction of unique flora;
- changes in animal behavior due to human interference; and
- pollution (e.g., litter, vehicle and boat exhaust, oil residues).

Potential Environmental Impacts of Ecotourism Projects

- Soil erosion, from poorly designed or managed roads and trails
- Water quality deterioration
- Deforestation
- Loss of unique flora
- Changes in animal behavior
- Increased pollution
- Undermining the cultural and economic integrity of the local community
- Uncontrolled population growth and in-migration

In addition to physical impacts, ecotourism can harm the users of local resources living near protected areas. Tourists can undermine a community's cultural and economic integrity. For example, tourism's peak-season demands can conflict with a community's need for labor during planting or harvesting of crops. Enhanced protection of an already safeguarded area can also conflict with a community's traditional use of the area for non-timber products (e.g., fuelwood, medicinal plants or game meat).

Even the potential local benefits of ecotourism can lead to environmental damage to a protected area. For example, an increase in employment opportunities, road improvement, technical assistance, or health care can stimulate migration of people into the vicinity of the protected area. Improved economic conditions may also result in increased production of solid waste.

Sector Program Design—Some Specific Guidance

Adverse environmental impacts often result from poor planning and coordination. Conversely, establishing a national tourism plan can lead to environmentally sound design of ecotourism programs. NGOs can play an important role in developing the plan, if one does not already exist. The plan can be used to establish policies, regulations and responsibilities for tour operators and other resource users. In addition, management plans should be developed for specific protected areas before beginning tourism activities. Standards for the environmentally sound design and operation of camps and lodges also need to be written, and their adoption must be made a legal requirement for all potential tourism developers and operators.

Protected-area staff need training in the management of resources, materials, equipment, personnel and budgets. In addition to enhancing the enjoyment and educational experience of the visitors, properly trained staff can ensure that tourists stay within designated areas and use facilities and resources (e.g., water resources, fuelwood and camping sites) in a sustainable way.

Management Plans

Develop Protected Area Management Plans. Plans should be based on appropriate ecological and social field assessments and the incorporation of **limits of acceptable use** (LAUs) for specific protected zones. LAUs define the maximum level of use an area can sustain without sacrificing visitor experiences or ecological, aesthetic or natural resource values.

LAUs can be based on the number of visitors per day, number of beds allowed in the zone, number of vehicles per kilometer, or other measurements. Whatever measures are selected, they must be easy for protected area staff to track and to act upon if LAUs are exceeded.

Protected area management plans should also establish criteria governing access to sensitive ecological, scenic or cultural sites, including minimum distances that roads must be kept from specific sites and the degree of access allowed to foot traffic. They should designate the areas to be specifically reserved for research, wilderness, non-foot access only, social preservation zones, visitor facilities, overnight posts, roads and trails. The ecological assessment should identify both sites to be avoided and those to be developed, as well as the type and amount of potential infrastructure considered permissible, e.g., lodges, camps, visitor centers, administrative offices, housing for staff, roads, etc.

The heaviest environmental damage may be associated with roads that provide visitor access. Existing plans should be revisited to determine whether roads can be relocated or replaced by trails. Managers and developers increasingly recognize that experiencing natural environments on foot, rather than from vehicles, enhances a visitor's experience.

Plans should also draw on social assessments that provide information on local communities' use of protected areas. Many communities in Africa receive substantial income and materials from protected area resources in the form of fuelwood, construction materials, game meat, fish, birds and insects, fruits and berries, ornamental plants and medicine. Social assessments identify the people who use the protected area and how their activities affect ecosystems and visitors' experience, both present and future. Social surveys can be used to determine the potential for establishing sustainable partnerships between tourism managers and local communities.

Once the ecological and social assessments are completed, a tourism plan can be developed which sets parameters for infrastructure development (e.g., roads, trails and campsites); the number, location, and intensity of tourist visits; and responsibilities for implementing and monitoring the plan. Consider the following when establishing management plans and guidelines:

- Decide on the primary audience for the guidelines (e.g., general visitors, tour operators or user groups).

Management Plans

Management plans based on "limits of acceptable use" for the region must be developed to ensure the sustainable use and conservation of local natural resources. In creating such a plan, it is important to:

- Focus on the primary users
- Develop a key theme for the project—e.g, environmental or cultural awareness
- Set rules for visitor behavior and protected area use
- Consult local guides and drivers
- Use technical assistance from scientists and scholars
- Organize meetings with stakeholders to collect their input into the plan
- Form an oversight committee with stakeholders (residents, resource managers, guides, commercial operators, lodge owners, service persons, etc.)
- Use lessons learned from other countries and regions
- Establish objectives and goals to evaluate the project
- Have experts review draft plan
- Set up a distribution list for the plan
- Make the plan and guidelines the basis of official regulations for use of the area

- Clearly identify the theme or key thrust of the guidelines (e.g., environmental protection or increased cultural awareness).
- Include guidance on visitor behavior and protected area use (e.g., campgrounds, hiking and boating).
- Consult with guides and drivers who lead tourists into target areas.

Many communities in Africa get substantial goods and income from protected area resources, including game animals, fuelwood, construction materials, and edible and medicinal plants. Ecotourism can help a local community preserve resources as well as provide socioeconomic benefits to the inhabitants.

- Get technical assistance from scientists and other experts who have studied tourism impacts.
- Organize meetings or workshops with the stakeholders concerned with tourism development. Form an oversight committee of residents, resource managers, guides, commercial operators, lodge owners, service personnel, tour drivers and local vendors.
- Use applicable guidelines from other countries as a model.
- Set objectives and formulate a way to evaluate whether the objectives have been met or not (e.g., decreased levels of soil erosion from trails and roads, improved scenic vistas).
- Develop a draft document to be reviewed by technical specialists.
- Create a distribution plan for the guidelines.
- Establish official regulations based on the guidelines. (This requires sufficient numbers of motivated enforcement and research personnel, supported by data regarding visitor impacts on soils, water, and endangered species and habitat.)

Develop Tourism Concession Plans. Plans for tourism concessions can be prepared to regulate development on protected area lands. If a protected area has a concession system, the requirements can be built into the contract before a tourism business is allowed to operate in the area. Without a concession system plan, damage from operating tours, lodges and all other private enterprises surrounding the area may be difficult to prevent.

Tourism concession plans can require that concession proposals and agreements incorporate and follow specific guidelines for environmentally sound design and management. Working within established LAUs,

To ensure the protection of sensitive areas or resources, tourist, concessionaires and private developers must be aware of the rules for sustainably using an ecosystem and preventing changes in animal behavior or damage to local flora.

management plans determine the nature of visitor activities and the type and amount of camping and lodging facilities allowed. They may also lay out the terms and conditions of commercial leases. A well-structured tourism concession plan offers:

- a fair and stable administrative environment for concessionaires, of sufficient duration to make private sector investment worthwhile,
- reimbursement for all costs necessary to provide an attractive ecotourism environment and sustainable protected-area management services, and
- quality visitor facilities and services for the public.

Concession agreement leases are normally for a limited number of years and monitored through periodic inspections. The information obtained from monitoring is used by protected area managers to determine whether to continue or terminate a concession. The information can also be used to determine whether a concessionaire should be allowed to build or operate additional facilities within established LAUs.

A concession application should include specific provisions regarding the implementation and monitoring of the concession activity. The government, private sector, tour guides/interpretive workers, NGOs, donors, and local communities should agree on the information and restrictions to be included in a concession contract.

Tourist Concession Plan

If an area is operating under a concession, then a concession plan to regulate tours, lodges and other private development is necessary. It should include:

- Requirements for environmentally sound development and operation of the concession
- Assurances of a fair and stable administrative environment for concessionaires, to encourage long-term investment
- Reimbursement for costs to community and government of managing and conserving the ecosystem
- Standards for quality visitor facilities and services
- Provisions for monitoring and evaluating the concessionaire's performance

In addition to guidelines for private-sector concessions, guidelines should be developed for *tourists*, who need, and usually appreciate, information on how to use and conserve protected-area resources. Much of the environmental and cultural damage that tourists cause results from lack of information and understanding.

Partnerships and shared commitments should be forged among communities, government and the private sector to:

- strengthen ecotourism ventures;
- plan the sustainable management and use of resources;
- strengthen business and community marketing, and
- build financial management and organizational skills.

These partnerships must provide equitable tourism benefits to both communities and the private sector to ensure their sense of responsibility for sustainable management of protected areas. Establishing these relationships can be a long-term process, but the potential rewards make it a worthwhile effort.

Environmental Mitigation and Monitoring Issues

Issue or aspect of activity	Impact *The activity may. . .*	Mitigation Note: Mitigations apply to specified project phase: *Planning and Design (P&D), Construction (C), or Operation and Maintenance (O&M)*
Planning and Design in General		
Define use limits	Exceed limits of acceptable use (LAUs) for the protected area	• Develop management zone plans to set LAUs and the processes that will be employed to ensure they are not exceeded. Use the technology with the least impact on the environment, for example, use motorcycles or bicycles to deliver supplies to sensitive locations needed to provide emergency access to sensitive or wilderness areas. (P&D) (C) (O&M)
Select site for infrastructure Identify nature and location of proposed infrastructure	Cause loss of tropical forest Result in loss of habitat necessary for maintenance of biodiversity Adversely affect threatened or endangered species Result in poor siting of infrastructure, roads, etc. Damage viewsheds and general visual appeal	• Carry out environmental assessments (EAs) or detailed mitigation strategies to avoid or mitigate adverse impacts on tropical forest, biodiversity and/or threatened and endangered species • Use a multidisciplinary team—e.g., hydrologist, geotechnical engineer, soil scientist, ecologist, tourism specialist—to determine the nature of proposed infrastructure and potential site locations (e.g., buildings roads, camp sites, observation points, etc.). (See the “Small-Scale Construction” section of the *Guidelines.*) (P&D) (C) (O&M)
Develop road and trail networks to provide access to protected area	Result in unnecessary alteration of natural setting and viewsheds; damage aesthetics Site roads and trails too close to wetlands, rivers and other water bodies, tropical forests, or sensitive areas	• Develop integrated road and trail network plans. Emphasize the use of trails instead of roads near sensitive or exceptional resources (e.g., habitat for rare, threatened or endangered species; tropical forest; cultural, archeological, scenic, historical or paleontological sites). Place lodges and camps out of view of protected-area visitors. • Conduct careful analysis of soils and subsurface geology. Incorporate correct siting and design within design specifications. (See “Rural Roads” section of the *Guidelines.*) (P&D)

Issue or aspect of activity	**Impact** *The activity may. . .*	**Mitigation** Note: Mitigations apply to specified project phase: *Planning and Design (P&D), Construction (C), or Operation and Maintenance (O&M)*
Quarry materials for road surface maintenance and construction	Damage viewsheds and general visual appeal	• Develop a quarry and borrow pit management plan for extraction of materials for road and building construction. Plans should include assessments of quantity and quality of material available from potential sites, in sufficient detail to choose a site that is ecologically sound, yet practical, and should include a plan for restoration. (See the "Small-Scale Construction" and "Rural Roads" sections of the *Guidelines.*) (P&D) (C) (O&M)
Select construction materials	Cause dependence on imported construction materials	• Design to use local materials as much as possible, without depleting available resources or harming the environment. To avoid negative impacts from using local materials, may plan to replant trees, carefully restore local quarries or borrow pits, etc. (See the "Small-Scale Construction" section of the *Guidelines.*) (P&D) (C) (O&M)
Supplying long-term water requirements	Cause excessive water consumption, competing with needs of fauna and flora in protected areas, especially in semi-arid and arid climates	• Estimate water demands for all future uses in protected areas. Develop surface and groundwater budgets based on historical meteorological and precipitation records and assessments of groundwater flows. Select water-conserving and water-purifying technologies. (See the "Water Supply and Sanitation" section of the *Guidelines.*) (P&D) (O&M)
Determine site locations for human waste disposal and select human waste disposal system	Cause placement of latrines and septic systems too close to wells and water supplies Create human waste disposal problems (causing spread of disease, odor, loss of potential soil nutrients, etc.)	• Conduct careful analysis of soils and subsurface geology. Incorporate correct placement and leach field design into planning and construction specifications. • Establish a comprehensive plan for disposal and reuse of accumulated human waste. For latrines, require Ventilated Improved Pit (VIP) latrine designs; for campers, provide instruction in soil mining (digging a pit for human waste and covering immediately after use) where pit latrines are not feasible. Establish a long-term plan for the removal and reuse of sludge. (See the "Water Supply and Sanitation" section of the *Guidelines.*) (P&D) (O&M)

Issue or aspect of activity	**Impact** *The activity may. . .*	**Mitigation** Note: Mitigations apply to specified project phase: *Planning and Design (P&D), Construction (C), or Operation and Maintenance (O&M)*
Select energy sources	Increase dependence on non-renewable energy resources	• Employ solar water heating in regions with low cloud cover; employ photovoltaics for lighting, radio, and cold chain storage in areas without access to the electric grid. Incorporate passive solar cooling and heating into building designs. Investigate wind energy and microhydro power and employ where cost-effective. Develop and implement energy conservation plans. (See the "Biomass and Renewable Energy" section of the *Guidelines.*) (P&D) (O&M)
Choose solid waste disposal alternatives	Cause solid waste accumulation at disposal sites	• Develop management plans for disposal of solid waste and recycling of wet wastes (organics), paper, metal, plastics and waste oil. Require all visitors, concessionaires and tour operators to "bag and remove" all solid waste from the protected area. Where feasible, employ a "check-in, check-out" system for all food consumed by visitors. Minimize incineration, and locate incinerators outside the protected area, where feasible, or at least away from visitors and animal populations. • Include design specifications that reduce exposure of solid waste to potential disease vectors, e.g., insects, birds, rodents and other mammals, by requiring screening or regular covering. (See the "Management of Solid Waste" section of the *Guidelines.*) (P&D) (O&M)
Operate equipment Fuel and service vehicles and equipment	Create a variety of problems: hearing loss for equipment users; unpleasant sounds, sights and smells for visitors; alteration in animal behavior Contaminate soil and water	• Place generators and pumps below ground or in sound-buffered earth mounds or sheds. Require earplugs or other hearing protection for workers. • Design fueling and equipment maintenance areas to minimize fuel spillage and prevent gasoline and waste oil from contaminating soil or water. (See the "Rural Roads" section of the *Guidelines.*) (P&D) (O&M)
Develop financial management plan	Fail to generate enough revenues for sustainable operation	• Emphasize high-value, low-impact tourism with fee and lodging cost structures set to provide for sustainable management. (P&D) (O&M)
Offer local economic and social gains	Fail to provide enough benefits to local communities	• Establish local employment requirements in concession agreements. • Place clauses that require sharing revenues and benefits with local communities in concessions or trust agreements. (P&D) (O&M)

Construction		
Creation of roads and trails	Lead to excessive road and trail networks Contribute to soil erosion	• Ensure that protected area management follows the long-term comprehensive plan for the road and trail network. (See the "Rural Roads" section of the *Guidelines.*) (P&D) (C) (O&M)
Construction of hotels and lodges	Contribute to unsustainable use of local materials Cause overuse of imported materials Contribute to soil erosion and siltation of riparian systems	(See earlier entry on construction materials under "Planning and Design in General" as well as the "Small-Scale Construction" section of the *Guidelines.*) (C)
Quarrying materials for road surface maintenance and construction	Harm viewsheds and general visual appeal	• Ensure that extraction follows the long-term quarry and borrow pit management plans for road and building construction. Carry out phased and systematic restoration/reclamation. (See the "Small-Scale Construction" and "Rural Roads" sections of the *Guidelines.*) (P&D) (C) (O&M)
Excavation related to road or building construction	Cause damage to, or removal of, paleontological, archeological or cultural artifacts	• Periodically inspect site. Enforce severe penalties for damage or theft of artifacts, etc. Provide education and incentives to encourage preservation. (C) (O&M)
Construction camps	Spread HIV/AIDS	• Provide initial instruction and periodic educational follow-up with construction workers, communities and protected area staff. (O&M)
Construction and operational safety	Create potential hazards to workers and communities (falls, disease, human/animal encounters) Create potential hazards to visitors	• Prepare a health and safety plan for the protected area and environs, including appropriate safety measures and equipment for workers (masks for dust, gloves for exposure to waste oil, earplugs for high-decibel equipment use, etc.). Provide health and safety training, as needed. (P&D) (C) (O&M) • Develop mitigation plan to reduce speeding. (See the "Rural Roads" section of the *Guidelines.*) (P&D) (O&M) • Mitigate to minimize or prevent human/animal interactions. (P&D) (O&M)
Operation		
Tourists visiting protected areas	Exceed visitor LAUs	• Enforce LAUs for protected areas. Conduct annual reviews for compliance with LAUs and the need for additional action, if any. (P&D) (O&M)

Visitors walking or driving within protected area	Result in visitors walking or driving off-road or off-trail, which may: • Result in creation of multiple tracks • Change animal behavior • Interfere with reproductive patterns of threatened or endangered species • Damage aesthetics • Introduce exotic species	• Schedule regular field inspections by designated road inspectors. • Keep water off existing roads and trails. (P&D) (O&M) • Impose and enforce substantial penalties for moving off roads or trails. • Determine acceptable visitor movement levels that do not alter animal behavior. (P&D) (O&M) • Use park staff or volunteers to remove non-indigenous species before extensive ecological impacts occur. (See the "Rural Roads" section of the *Guidelines.*)
Visitor use	Cause loss of tropical forest Cause loss of habitat necessary for maintenance of biodiversity Adversely affect threatened or endangered species	• Schedule regular field inspection by designated ecologist/inspector. • Revise workplans, management plans and strategies annually. (O&M)
Visitor and community natural resource extraction	Result in illegal removal/extraction of fauna and flora beyond established limits for sustainable use or quotas Damage archeological, paleontological, historical or cultural sites Contribute to removal of artifacts, fossils, etc.	• Provide budget and training for local community residents and/or local staff as protected-area resource monitors for fauna and flora to ensure observance of extraction/quota limits. • Provide budget and training for local community residents and/or local staff as protected area resource monitors for archeological, paleontological, historical or cultural sites. • Provide awards/incentives for exemplary performance of resource monitors and concessionaires. Use major disincentives (loss of concessions or employment, visitor or tour operator fines) for illegal extraction of or damage to resources of special significance, sensitive areas, flora or fauna. • Schedule regular field inspection by designated inspectors/resource monitors. (P&D) (O&M)
Provision of potable water for ecotourism activities	Result in excessive water consumption that competes with needs of fauna and flora in protected areas, especially in semi-arid and arid climates.	• Schedule site inspections to ensure that water supply and water use rates are as predicted and that water supply technologies are being used effectively. Monitor water supply to ensure that proper health practices are observed. (See the "Water Supply and Sanitation" section of the *Guidelines.*) (O&M)

Visitor and staff human waste disposal	Contaminate water and soil with human waste	• Maintain latrines and septic tanks; recycle or dispose of sludge. • Test water and soil periodically. Schedule regular field observations. (See the "Water Supply and Sanitation" section of the *Guidelines.*) (P&D) (O&M)
Visitor and staff solid waste disposal	Contaminate water and soil with solid waste	• Dispose of solid waste and recycle wet wastes (organics), paper, metal, plastics and waste oil. Require all visitors, concessionaires and tour operators to "bag and remove" all solid waste from the protected area. Where feasible, employ a "check-in, check-out" system for all food consumed by visitors. Minimize incineration, and locate incinerators outside the protected area, where feasible, or at least away from visitors and animal populations. • Schedule regular field observations. (See the "Management of Solid Waste" section of the *Guidelines.*) (P&D) (O&M)
Visitor interactions with local communities	Alter local cultural values	• Provide initial instruction and follow-up educational sessions and materials for tour concessionaires, tour operators and visitors. (P&D) (O&M)
Sex worker and local community interactions with laborers, truck drivers, tourists, etc.	Spread HIV/AIDS	• Provide initial instruction and periodic educational follow-up with laborers, hotel staff, communities and protected area staff. (P&D) (O&M)
Operation of equipment	Create excessive noise affecting equipment operators, other staff, visitors, wildlife and local communities Harm staff and the environment, and damage equipment (see "Staff training: maintenance and operation staff" below)	• Schedule field observations.
Staff training: maintenance and operations staff	Inadequate training of staff in equipment operation and maintenance may: • Lead to accidents and injuries from unsafe operations • Increase equipment breakdown and shortened equipment life • Increase pollution from used oil and other fluids from poor maintenance	• Carry out health and safety plan described under "Construction and operational safety" above. • Budget for and conduct periodic retraining of staff in maintenance and operation of equipment. Also, emphasize the importance of keeping accurate operation and maintenance logs on equipment. (P&D) (O&M)

Administrative and financial management	Inadequate training of staff in administrative and financial management leading to • Inaccurate books and unclear cost picture that make budgeting and economizing difficult • Difficulties or lateness paying bills or wages or collecting money owed due to unexpected cash shortfalls • Opportunities for embezzlement	• Hire qualified staff. (P&D) • Train staff before they begin working. (P&D) • Budget for and conduct periodic retraining. (O&M) • Have books audited annually. (O&M)
Successful ecotourism program	Infringe on traditional land use by local communities Create in-migration to ecotourism sites or protected areas Contribute to natural population increase in the area over time	• Design and implement a community support service program employing protected area staff. Work with district governments, villages and NGOs to develop regional assessments of land use outside the protected areas and develop both regional environmental assessments and regional plans for reducing population pressures. Carefully assess cumulative impacts. (P&D) (O&M) • Develop and help institute companion health and family planning services and off-farm employment initiatives. (P&D) (O&M) • Ensure establishment of a licensing, permit or quota system for residence in or near the area. (P&D) (O&M)
Decommissioning		
Closing infrastructure or facilities in protected area	Cause erosion of abandoned roads and trails Allow abandoned infrastructure to become unsightly Create hazards from abandoned infrastructure Create hazards from abandoned quarries and borrow pits	• Include plans and budget for decommissioning in original planning and design and incorporate in design and construction specifications. (P&D) (O&M) • Carry out site inspections at time of decommissioning to ensure abandoned infrastructure does not harm aesthetics or pose safety or health hazards. (P&D) (O&M) • See the “Small-Scale Construction” and “Rural Roads” sections of the *Guidelines.*

Resources and References

Campbell, Lisa M. (1999). “Articles: Ecotourism in Rural Developing Communities.” *Annals of Tourism Research* 26 (3): 534. (20 pages)

Eagles, Paul F. J. (1997). *International Ecotourism Management: Using Australia and Africa as Case Studies*. IUCN World Commission on Protected Areas, Protected Areas in the 21st Century: From Islands to Networks. Albany, Australia, Nov. 23–29, 1997. http://www.ahs.uwaterloo.ca/rec/ecotour.htm

Honey, Martha S. (June 1999). “Treading Lightly? Ecotourism's Impact on the Environment.” *Environment* 41 (5): 4–9.

Lea, John P. (2000). “Ecotourism in the Less Developed Countries.” *Annals of Tourism Research* 27 (1): 248. (2 pages)

Nsanjama, Henri (1997). “People and Animals Vie for Africa's Ecosystems.” *Forum for Applied Research and Public Policy* 12: 136–8.

Obua, Joseph (1997). “The Potential, Development and Ecological Impact of Ecotourism in Kibale National Park, Uganda.” *Journal of Environmental Management* 50 (1): 27. (12 pages)

Richardson, Julie (1998). “Wildlife Utilization and Biodiversity Conservation in Namibia: Conflicting or Complementary Objectives?” *Biodiversity and Conservation* 7 (4): 549. (11 pages)

Roe, D., Leader-Williams, N. and Barry, Dalal-Clayton (1997). *Take Only Photographs , Leave Only Footprints: The Environmental Impacts of Wildlife Tourism.* Environmental Planning Group, International Institute for Environment and Development. IIED Wildlife and Development Series No. 10, October 1997. http://www.ecotourism.org/textfiles/roe.pdf.

Young, Emily H. (1999). “Balancing Conservation with Development in Small-Scale Fisheries: Is Ecotourism an Empty Promise?” *Human Ecology* 27 (4): 581. (40 pages)

Tanzania National Parks (July 1995). *Development/Action/Lease Procedures (DALP).* An excellent set of required procedures and checklists to be used by prospective lodge, camp and infrastructure developers submitting development proposals to Tanzania National Parks. Applicable to protected area management worldwide. (55 pages)

The International Society for Eco-Tourism (TIES). (Offers a number of valuable resources for eco-tourism professionals, including links to the staff’s selection of the best recent research articles.) http://www.ecotourism.org/

World Commission on Protected Areas Publications

All publications produced by the World Commission on Protected Areas (WCPA) of the World Conservation Union (IUNC) are available for download via http://wcpa.iucn.org/pubs/publications.html. PARKS Magazine is a publication of the IUNC-WCPA.

Beltrán, Javier and Phillips, A. (ed.) (2000). *Indigenous and Traditional Peoples and Protected Areas: Principles, Guidelines and Case Studies.* IUCN-WCPA. Best Practice Protected Areas Guidelines Series No. 4.

It is sometimes assumed that protected areas must be in conflict with the rights and traditions of indigenous and other traditional peoples. This document suggests processes to avoid conflicts between those peoples' rights and protected area objectives.

Davey, Adrian G. and Phillips, A. (eds.) (1998). *National System Planning for Protected Areas.* IUCN-WCPA. Best Practice Protected Areas Guidelines Series No. 1.

A system plan is the design of a total protected area system covering the full range of ecosystems and communities found in a particular country. These guidelines identify links between system planning, *in situ* conservation, protected area management categories and the importance of carrying out activities within a broad national framework. This publication provides good guidance to national governments in implementing Article 8 of the Convention on Biological Diversity.

Hockings, Marc, Stolton, S., Dudley, N., and Phillips, A. (ed.) (2000). *Evaluating Effectiveness—A Framework for Assessing the Management of Protected Areas.* IUNC-WCPA Best Practice Protected Areas Guidelines Series No. 6.

> This report proposes a framework for assessing management effectiveness. The framework also includes suggested tools which can be used as the basis for developing an assessment methodology..

IUCN (1998). *Population and Parks. PARKS Magazine* 8 (1).

> A selection of case studies acknowledging the need to establish partnerships and encourage cooperation with neighbors and other stakeholders, promote stewardship, and other instruments which support protected areas objectives.

IUCN (1998). *Marine Protected Areas. PARKS Magazine* 8 (2).

> A volume of "lessons learned" case studies from MPAs around the world. The case studies focus on: the application in practice of IUCN-WCPA protected area categories to MPAs and an evaluation of the contributions which MPAs can make to sustainable fishing and biological diversity.

IUCN (1998). *Grassland Protected Areas*. *PARKS Magazine* 8 (3).

> A volume of case studies advancing the discussion on the lack of protected temperate grassland biomes—and the vital need for them. Case studies represent each realm on the planet in which temperate grasslands are found.

IUCN (1999). *Reserve Design and Selection*. *PARKS Magazine* 9 (1).

> Special issue with articles illustrating the real-world applicability of recent approaches to systematic conservation planning.

IUCN-WCPA (2000). *Protected Areas: Benefits beyond Boundaries—WCPA in Action.* In English, French and Spanish. *The International Society for Eco-Tourism (TIES).*

> Offers a number of valuable resources for eco-tourism professionals, including links to the staff's selection of the best recent research articles. http://www.ecotourism.org/

IUCN-WCPA and World Conservation Monitoring Centre (1994). *Guidelines for Protected Areas Management Categories.*

> The guidelines attempt to establish greater understanding among all concerned about the different categories of protected areas. A central principle upon which the guidelines are based is that categories should be defined by the objectives of management, rather than the title of the area, or the effectiveness of management in meeting those objectives. English and French versions.

Kelleher, Graeme (1998). *Guidelines for Marine Protected Areas*. *PARKS Magazine* 8 (2). (Guidelines for creating and managing MPAs as a component of integrated coastal management and sustainable development.)

This guideline is aimed at providing protected areas managers with information about financing their protected areas and where to look for finance beyond existing sources.

Phillips, Adrian (ed.) (1998). *Economic Values of Protected Areas: Guidelines for Protected Areas Managers.* Task Force on Economic Benefits of Protected Areas of the WCPA, with the Economics Service Unit of IUCN. IUNC-WCPA Best Practice Protected Areas Guidelines Series No. 2.

Part I provides an overview of how the economic values of protected areas can be assessed, providing new insights and informing the debate. The case studies in Part II identify those sites where protecting the environment made significant economic contributions.

The World Commission on Protected Areas (WPCA). WCPA promotes the establishment and effective management of a worldwide representative network of terrestrial and marine protected areas. As is evident from the preceding long list of publications, they provide a wealth of resources; see their Web site at http://wcpa.iucn.org/

Chapter 5

Energy Sources for Small-Scale Development

Contents

Biomass Energy Sources	**5-1**
Brief Description of the Sector	5-1
Potential Environmental Impacts	5-3
Sector Program Design	5-4
Environmental Mitigation and Monitoring Issues	5-5
Alternative Energy Development	**5-7**
Micro-Hydro Power Projects	**5-11**
Brief Description of the Sector	5-11
Potential Environmental Impacts	5-11
Sector Program Design	5-14
Environmental Mitigation and Monitoring Issues	5-14
Resources and References	**5-16**

The majority of Africans can neither access nor pay for "modern" forms of energy, including electricity, bottled gas and kerosene. They must rely on wood and charcoal.

5.1 Biomass Energy Sources

Brief Description of the Sector

Africa's poor use energy primarily for cooking, with other uses including transportation, heating, lighting and power for appliances. Biomass, in the form of wood or charcoal used for cooking, is the main source of energy in sub-Saharan Africa. It accounted for 71.5 percent of total primary energy used on the continent in 1995, and in many African countries it accounts for up to 90 percent of the total national energy supply.

Although biomass can be an environmentally sound source of energy, the current methods of harvesting wood and producing charcoal in most African countries are unsustainable. These practices are doing serious harm to Africa's natural resource base and environmental well-being.

Biomass dependence in Africa reflects several factors. One is poverty: "modern" forms of energy, including electricity, bottled gas and kerosene, are still beyond most people's economic reach in many African countries. Moreover, many areas have no access to non-biomass energy or lack the infrastructure to distribute it. There are two principal reasons for this situation:

- Although Africa possesses substantial and diverse non-biomass energy resources, the sources and demand for these resources are

Project Benefits

Small energy projects can:

- Improve public health
- Protect the environment
- Better the quality of life for the poor, especially women
- Generate business opportunities
- Make it easier to carry on business or education

During this century, Africa's forest area has been cut in half. Deforestation drives down farm production and biodiversity, raises prices of fuel and other forest products, and boosts the greenhouse effect.

not distributed evenly throughout the continent. For example, 96 percent of oil reserves are located in North Africa, Nigeria, and Angola, while 95 percent of the workable coalfields are in southern Africa.

- The infrastructure needed to produce and distribute non-biomass energy is often capital-intensive. Thus, even where natural resources are available, production and distribution facilities are often absent or inadequate. For example, hydroelectric resources are found in both East and West Africa—but as of the early 1990s, sub-Saharan Africa had exploited only 4 percent of its hydroelectric resources for energy purposes. In general, electrification rates are low. Kerosene and gasoline are the only "modern" forms of energy with near-universal availability.

Biomass dependence is not expected to lessen in the foreseeable future. It is true that per-capita consumption of "modern" energy has been declining over the past 20 years in sub-Saharan Africa. The downward trend is expected to continue as production and distribution infrastructures fail to keep pace with Africa's projected growth in population. However, the population increase will almost certainly lead to an increase in *total* consumption of both biomass and modern energy. Over the next decade, estimates of annual growth range from 2.7 percent to 4.5 percent, compared to 0.9–1.6 percent for the industrialized countries. This increase will be amplified by urbanization; Africa's urban populations are forecast to increase substantially over the next 50 years, and urban dwellers consume higher energy per capita.

Africa's primary energy use is for cooking. Using biomass energy sources contributes to the degradation of African forests and severely affects the health, and quality of life, of the African people.

This increased pressure on already overstressed biomass energy sources makes energy projects all the more important. Small-scale energy development projects are generally designed to improve public health, protect the environment, and better the quality of life for poor populations, especially women. They may also have ancillary benefits, such as generating entrepreneurial opportunities. They do so by supplying energy where it was not previously available or by substituting perpetual or self-renewing locally available sources of energy for those that are in limited or exhaustible supply and that, in some cases, must be imported.

Mitigation and Monitoring:

This section discusses ways to address the environmental impacts of initiatives in:

- Fuelwood
- Solar energy
- Biogas
- Ethanol
- Hydropower
- Wind power

Development projects often focus on improving the efficiency of cooking with wood or wood-derived fuel—e.g., by promoting improved cookstoves—or by replacing biomass with an alternative energy source, such as biogas or solar energy, for biomass energy. Other projects focus on providing alternative sources of electricity—solar, micro-hydro or biogas—to power modern lighting, appliances, and remote telecommunication, especially for rural communities that lack access to electrical grids. The availability of dependable electricity can let householders, especially adult women, develop additional income by working at home after dark. Lighting also facilitates education, and it is a valued convenience, making activities such as cooking and bathing easier at night. Photovoltaic systems are used to provide electricity to rural health posts for small cold-chain refrigeration systems used to store vaccines. They also provide power for health post's radio communication and night lighting.

This module discusses various approaches to the problem of fuelwood-driven deforestation. It also addresses possible environmental damage from other energy projects, such as those involving solar dryers and ovens as well as photovoltaic, biogas, micro-hydro and wind power. Social impacts are treated to a lesser extent. Micro-hydro power is discussed in a special sub-section.

Potential Environmental Impacts and Their Causes

Deforestation. During this century, Africa's forest area has been cut in half. Between 1990 and 1995 alone, Africa lost over 18.5 million hectares of forest—3.5 percent of its total forest cover. This is equivalent to an annual deforestation rate of 0.7 percent, the highest of any continent in the world.

Potential Impacts of Biomass Energy

- Deforestation
- Lost economic productivity
- Damage to health from smoke inhalation

Trees cut for charcoal production in Zambia. Indiscriminate cutting can quickly lead to deforestation.

The vast majority of this loss occurred in tropical Africa, though rates varied considerably from country to country. Niger lost no forest, while Kenya's forest cover declined at a rate of 0.3 percent a year, Tanzania lost 1 percent per year, and Sierra Leone lost a shocking 3 percent per year. While such factors as agricultural expansion and increases in human population are the major underlying causes of deforestation in Africa, consumption of wood for fuel is also a significant factor. As noted above, population increases will raise the pressure on biomass resources.

Fuelwood and charcoal production in Africa has increased significantly during the last two decades and is projected to continue growing. In 1994, 84 percent of wood from trees was used as fuel. In the mid-1990s, it was estimated that 32 percent of the total African population lived in areas where biomass resources cannot be sustained under present use practices. The demand for charcoal and fuelwood by urban populations is a major contributor to deforestation, particularly in arid and semi-arid regions. The deforestation in turn is driving down agricultural productivity (e.g., loss of soil from increased erosion, destruction of watersheds) and biodiversity (e.g., loss of wildlife habitat and species diversity). Unsustainable extraction of fuelwood also contributes to the greenhouse effect by releasing stored carbon and reducing the region's capacity to sequester carbon.

In Africa, great distances often separate the location of biomass energy and consumers. As forests fall, the distance widens, raising the price of charcoal and fuelwood. Also, as householders, especially women and children, walk longer distance to find fuelwood, they lose time for other productive activities, including school.

Land tenure complicates the problem further. In many African countries, ownership of resources, including tenure over trees and forest lands, remains vested in the state, a holdover from centralized colonial control over resources. In others, individual farmers and communities may be unaware of recent laws devolving ownership to them. These conditions can discourage the planting of trees and the sustainable use of fuelwood.

Health impacts. In addition to environmental impacts, the burning of wood, charcoal and other biomass in poorly ventilated houses or areas exposes users to high levels of smoke. Continuous exposure of this type can seriously damage human health, particularly that of women and children, who often spend much time indoors and are therefore exposed for longer periods.

Sector Design Elements

- Find or complete local energy analysis
- Survey existing public incentive programs
- Get local input
- Assess community's long-term energy aspirations
- List beneficiaries
- Figure costs to transport fuel
- Examine socioeconomic incentives and obstacles

Sector Program Design—Some Specific Guidance

If your organization is planning new activities to develop renewable energy development activities, it may be helpful to ask the following questions before you start designing them.

- Has the World Bank or another international organization completed an energy-sector or biomass analysis for the country? What are the current patterns of energy use in the immediate project area?
- Could existing tax or incentive programs be used, publicized or modified to increase the use of renewable resources and decrease dependence on petroleum-based fuels and wood energy?
- Have local communities been consulted? (Their suggestions and needs may be of critical importance in developing the project.)
- What are the long-term aspirations of rural communities regarding energy? Will fuelwood alone accommodate these aspirations? If a community is interested in developing small industry/enterprises (such as agroprocessing), could it consider other forms of energy?

- Who will be the project's customers? Will the project benefit local households or other sectors?
- If it is a fuelwood project, how accessible will the fuelwood be to the area where it is to be consumed? What transportation costs are related to the project?
- What are the socioeconomic incentives and constraints associated with the project (e.g., tree-tenure systems, community ownership, credit availability, etc.)?

Environmental Mitigation and Monitoring—Issues and Guidance

Potential adverse environmental impacts, along with guidance on mitigation and monitoring issues, are considered below for fuelwood, solar energy, biogas, ethanol, and windpower. Micro-hydro is treated in the section that follows.

Fuelwood Initiatives

- *Assess biomass (including the availability of, and demand for, fuelwood)*. Establish baseline conditions and identify patterns of deforestation over time. Provide information on promising energy initiatives in the area. Where available, remote-sensing Global Positioning Systems (GPS) and Geographic Information Systems (GIS) mapping techniques can be used for this purpose.
- *Develop a biomass strategy based on the assessment*. The strategy should identify areas requiring technical assistance, policy reforms, and practical incentive and disincentive systems, and indicate where conditions support the use of economical energy sources other than fuelwood.
- *Develop action plans*. Action plans, at both the local and national levels, should combine measures aimed at increasing production (e.g., agroforestry), reducing consumption (e.g., improved cooking stoves), and enhancing protection of remaining forest resources (e.g., developing tree nurseries). Include incentives for tree planting and disincentives for use of fossil fuels. Foster multisector planning to manage fuelwood resources.
- *Ensure community participation*. Ensure that the local community has early input into project design and implementation. (Insufficient farmer, family and community participation is a common weakness of fuelwood projects that makes them much harder to sustain.)
- *Reflect economic value*. Adjust fuelwood and charcoal prices to reflect the true value of forest resources by applying natural resource and environmental accounting. Often the biological, economic and social values of forest resources are not incorporated into the total price of fuelwood.

- *Protect resources*. Protect existing sources of fuelwood in natural forests by involving neighboring communities in sustainable forest management and sharing of forest resources.
- *Provide for ownership of fuelwood resources*. Where needed, participate in a policy dialogue to establish legislation that provides for private or communal ownership and management of fuelwood resources.
- *Select tree species*. If trees are to be planted for fuelwood, select the most appropriate ones, drawing on local and national-level expertise. The short rotation required for fast-growing, exotic tree species allows increased production of fuelwood; however, their rapid growth can also accelerate the depletion of soil nutrients or water resources. Consider using fertilizer for plantations of rapidly growing species. Match species to local soil and climatic conditions. In areas of low or sporadic rainfall, avoid species that require much water.
- *Assess potential for improved cookstoves*. Commercializing of improved charcoal cookstoves is another means of encouraging people to conserve fuelwood. Typically built of metal with an insulating clay lining, these stoves trap heat, causing charcoal to burn more efficiently, thereby significantly reducing charcoal consumption.

Action Plans for Fuelwood Initiatives

These should include:

- Raise fuelwood production
- Lower fuelwood consumption
- Better protect remaining forest resources
- Create incentives for tree planting
- Discourage use of fossil fuels

Many tree species serve multiple wood and non-wood purposes, with fuelwood being a secondary product. For example, pruned branches from some *Prosopis* species can be used for firewood, while the trees themselves can be used as living fences.

5.2 Alternative Energy Development

Renewable energy technologies must satisfy several criteria. These should be simple, affordable systems adaptable to small-industry/private-enterprise development at the community level. While the installed cost of an alternative energy technology may be a constraint, operating costs tend to be much lower than with conventional energy systems. Credit schemes can, in some cases, help address the capital cost barrier, and thus allow long-term cost advantages to be realized. This section will consider solar, biogas, ethanol and wind power. Hydropower is another important alternative energy source, but since its potential impacts are fairly complex, it will be discussed separately in the next section of the chapter.

Solar ponds can be a source of energy or can be used to dry food for storage. They need strong safeguards, however, to prevent leaks, prevent drowning and protect water from evaporation.

Solar Energy. The sun is an important source of clean and abundant energy in many parts of Africa. But the use of solar energy is not yet widespread, for both technical and economic reasons.

Adverse environmental impacts associated with solar energy include pollution caused during the manufacture of solar devices, acid battery spillage and improper disposal of batteries. These impacts, which are usually manageable, should be weighed against solar power's potential to reduce deforestation and improve air quality for women and children.

Some examples of solar energy devices and the potential environmental impacts associated with them include:

- *Solar food dryer*. A solar food dryer is a box with at least one transparent side through which solar energy enters, raising the inside temperature and setting up a convection current of air. Fruit, grain, vegetables and fish can be dried inside. Food dries rapidly, compared to direct sunlight, allowing greater vitamin retention.
- *Solar ponds*. A solar pond operates on the same principle as the solar food dryer. Instead of trapping heat rays under a transparent window, heat is trapped under several layers of fresh and salt water. The heat generated may be used for low-temperature industrial and agricultural processes; pre-heating for higher-temperature industrial processes; and electricity generation. Unlike solar food dryers, however, solar ponds can create serious environmental damage. Because large amounts of salt are used, a leak in the bottom of the pond could seriously contaminate groundwater supplies. The steeply sloped sides of the pond may also present a hazard. Without adequate fencing, animals or small children may fall in and become trapped or drown. Because of the high temperatures, objects sinking to the bottom of the pond cannot be easily

Criteria for Renewable Energy Technologies

A proposed system must be:

- Simple
- Affordable
- Adaptable as a small, private, community-level industry

Credit schemes can address a high initial cost if the system offers long-term cost advantages.

Solar Power Issues

Solar energy can combat deforestation, air pollution and the greenhouse effect. But problems may include:

- High initial cost
- Pollution from manufacturing solar devices
- Acid battery spillage
- Improper disposal of batteries

Solar ponds may have other serious impacts:

- Salt leaks that contaminate groundwater and soil
- Drowning hazards
- Metal corrosion from hot brine
- High water loss from evaporation

retrieved without special equipment. The hot brine of a solar pond corrodes many metals. Finally, water evaporated from the pond surface must be replaced by water from other sources.

- *Solar cooking*. Solar ovens trap and/or reflect solar energy that is converted to heat when it strikes the surface of a black pot. A substantial increase in use of solar cooking apparatus took place over the last several years, but use is still not widespread, for several reasons. Designed for slow baking or simmering, they cannot be used for traditional foods that require frying or stirring. Solar stoves that use parabolic reflectors must be constantly refocused as the sun moves. Other deterrents include their initial cost, restriction of cooking time to bright daylight hours, incompatibility with local cuisine and people's unfamiliarity with the devices. Solar cookers are frequently used in camps for refugees and internally displaced-persons. While costly, they help reduce the high rates of deforestation that often occur around these camps.
- *Solar water heating*. Increasingly, governments, utilities and the private sector are promoting residential solar water heating systems in areas with low cloud cover. Under these conditions they are now economically competitive over the longer term (10–20 years) with water heating using electricity or gas, though up-front installation costs may be significantly higher.
- *Photovoltaic cells*. While the cost of converting solar energy into electricity continues to fall, it is still high enough to discourage widespread application in Africa. Nevertheless, in remote locations away from power grids, where the costs of electrical generation from diesel engines are high, photovoltaics can be competitive for certain applications such as lighting, cold-chain vaccine refrigeration, and radio and microwave communication. To maintain a photovoltaic system, people need only clean the panel surface regularly. However, trained individuals must do the cleaning to avoid damage to the cells. Systems must also be protected against theft and vandalism.

Biogas Issues

Biogas has many possible uses in cooking, lighting, power generation and repairing environmental damage.

Potential problems include:

- High initial costs
- Difficulty getting communities and organizations to participate in larger, community-size installations
- Lack of training in construction and maintenance
- Side effects of "bioenergy crops" for biogas—may displace food crops, add to deforestation, or become invasive
- Disease carried in fecal wastes used as fuel
- Offensive liquid overflow
- Biogas leaks and losses that can cause asphyxiation and explosions
- Conflicts over the right to use "communal" manure

Biogas. Technologies, such as anaerobic digestion, used for the conversion of organic materials to biogas are far from new. However, their application is not widespread. Biogas production involves the biological fermentation of organic materials (e.g., agricultural wastes, manures or industrial effluents) in an oxygen-deficient environment to produce methane, carbon dioxide and traces of hydrogen sulfide. The gas can be used either directly to be burned for cooking or lighting, or indirectly to fuel combustion engines delivering electrical or motive power (Bokalders and Kristoferson, 1991). The slow diffusion of this technology is related to (a) the initial cost of construction; (b) the lack of organizational and community involvement, particularly for larger, community-level digesters; or (c) insufficient training opportunities in construction and maintenance.

Recently, more bioenergy is being produced using crops raised specifically for this purpose, by contrast with the use of agricultural wastes. This practice may both help and harm the environment. Bioenergy crops can be used to revegetate barren land, reclaim waterlogged or salinated soils, and stabilize erosion-prone areas. They can provide habitat and increase biodiversity, if properly managed. However, their use may also displace agricultural production, contribute to deforestation, and even introduce invasive, and potentially harmful, non-native species.

The operation of a biogas digester presents several potential environmental problems, but these problems can be minimized with proper planning and operation. For example, if the digester is built close to a lavatory or livestock shed, the excrement may be deposited directly without unnecessary handling. However, special precautions are required if human or hog wastes are used in digesters. For example, humans and some animals share similar feces-borne parasites and pathogens. For this reason, some authorities feel that even treated fecal waste is extremely dangerous and do not recommend applying sludge to soil where root and vegetable crops are cultivated.

The disposal of liquid overflow (supernatant) from the digester may occasionally have adverse effects. Normally this liquid is clear and odorless and has some value as a dissolved fertilizer. If water is scarce, the supernatant may be recycled into the digester with new organic feedstock. Otherwise, it can be used to water plants or moisten compost materials. However, with an improperly working digester, the supernatant may be dark and offensive. If it is not recycled, this liquid should be buried or mixed with soil in an isolated spot.

As with natural gas, biogas composition should be tested and precautions taken to prevent leaks and losses. Surveillance is also important, since biogas is usually odorless and difficult to detect. In closed rooms, leaking gas can lead to asphyxiation or explosion.

In areas where manure or dung is considered a free community resource, the installation of biogas digesters can cause unwanted changes in local economics. For example, if manure suddenly becomes more valuable than usual, it can become a marketable commodity that is no longer available to the poor. In the initial planning stages, the question of who stands to lose or gain from an energy project is one that deserves attention. Thus, community input is important.

Ethanol Issues

Fermenting farm by-products can produce a useful liquid fuel, plus solid residues for animal feed. Problems are:

- High volumes of water must be used in production
- Production generates large amounts of liquid residue that can damage soil and contaminate lakes and streams

Ethanol. Liquid fuel in the form of ethanol can be produced through the fermentation of biomass (e.g., sugar cane leaves or bagasse). The production of ethanol involves the washing, fermentation and distillation of biomass. Again, the long-term economic costs and benefits need to be weighed carefully before developing these systems.

Solid residues from ethanol production can be disposed of easily as a high-protein dietary supplement for livestock; however, the disposal of liquid residues, which may amount to 12 to 13 times the volume of the final product, is more difficult. This “thin stillage” has a strong odor and high acid content and contains many organic solutes. Land application of thin stillage could be harmful to many types of soils, especially those with high clay content. Stillage should not be disposed of in areas where it can flow into and contaminate lakes and streams.

Ethanol from maize yields 50 percent more energy than the total amount required to farm the maize and make the ethanol. This is not bad, but other ethanol crops (e.g., grasses, trees) are more efficient, yielding four to five times as much energy as the amount needed to farm the crops and make the ethanol.

Significant amounts of water are used in the production of ethanol. For every unit volume of ethanol produced, approximately 16 volumes of water are needed to generate steam. This demand for water must be evaluated against its available supply and the merits of alternate uses.

- Ethanol has environmental advantages over fossil fuels such as coal and oil, but like any liquid fuel it may cause damage through leaks and spills. There are also potential indirect impacts associated with the methods used to grow ethanol-producing crops, including pest management.

Wind Power. If properly designed and well placed, wind machines can provide a reliable source of energy. A wind-powered water pump can be used for irrigation and supplying potable water. Larger wind machines may compete favorably with other forms of electrical generation.

Wind Power Issues

Wind can be a reliable energy source, pumping water for irrigation and home use. Possible problems:

- Historical data on wind strength/constancy are hard to find
- High winds may damage the machines, endangering people and animals
- Standing water around pumps

Economic cost-benefit analysis against other energy sources is needed before selecting wind power as an energy source. The strength and constancy of the wind is especially important in this calculation, as is the proven ability of the wind machine to withstand high wind events. Since historical meteorological data are often absent in many African countries, wind power needs to be approached cautiously.

One potential adverse effect associated with wind-driven water pumps is that standing water from spillage around the pump can become a health risk. An automatic shut-off mechanism can potentially solve the problem. As with any water system, overgrazing near the water supply can be a serious

Wind power can be a reliable source of energy. Be sure to assess all the environmental impacts of wind generators, from possible standing water, to the affect on birds and aesthetic values.

problem, especially in arid and semi-arid environments.

As with the other technologies mentioned earlier, the discussion of this technology does not cover all possible wind-related environmental issues such as noise, and effects on birds, land use and visual aesthetics.

5.3 Small-hydro Power Projects

Brief Description of the Sub-Sector[1]

Sub-Saharan Africa has exploited only 4 percent of its potential hydrological energy resources. If developed in an environmentally sound way, the remaining reserves of hydroelectric energy could meet significant portions of the region's energy needs (UNDP 1992) particularly in remote rural areas.

Micro-hydro installations range in size from a few kilowatts to 100 kilowatts. They are of two general types:

- **Run-of-the-river** micro-hydro installations involve no reservoir. They rely instead on the natural flow of the river or stream to provide motive power to the turbine(s). They typically involve diverting a portion of river flow through a spillway, side channel, or pipeline. The diverted water is returned to the river downstream from the turbine.

- **Impoundment** micro-hydro installations use a dam to create a reservoir either to stabilize electricity supply against variations in flow; to provide greater head, or pressure, to power the turbine(s); or both. The reservoir may also be used for irrigation.

Micro-hydro Projects:

This special subsection on micro-hydro power projects discusses:

- Run-of-the-river projects
- Impoundment projects

Potential Environmental Impacts and Their Causes

The single most important factor in determining the extent of environmental impacts from micro-hydro projects is whether or not an impoundment needs to be created.

Dams on the scale considered for funding through PVO/NGO programs should be constructed only with the assistance of skilled professionals. Even with assistance, not all the problems associated with dams may be immediately apparent.

Run-of-the-river

For run-of-the-river operations, the greatest impacts occur during the construction phase. The primary concerns are the impacts on the stretch of river from which water is diverted to support the micro-hydro operation; the method of returning the water back to the stream; and effects on downstream users. Impacts are generally on-site and relatively easy to assess. Potentially adverse impacts are summarized in table 6.1

[1] The micro-hydro material presented here is in large part adapted from "Environmental Guidelines for Micro-hydroelectric Projects," developed in support of USAID/Dominican Republic's PVO Co-Financing Project No. 517-0247 and Electrical Energy Sector Restructuring Project 517-0270. Preparers of the original text were Odalís Pérez, Energy & Environment Team, USAID/DR and Karen Menczer, USAID Bureau for Latin America and the Caribbean Office of Regional Sustainable Development/Environment (USAID/LAC/RSD/ENV).

Table 5.1: Environmental impacts of run-of-the-river micro-hydro

Activity phase	Impact
Construction	• Movement of soil may increase erosion, which may increase sedimentation of the waterway affecting downstream users (humans, fisheries and wildlife). • Increased activity along the stream and transmission line route may disrupt wildlife. • Construction and placement of pipeline may block waterway temporarily or permanently. • Construction and placement of pipeline and construction of transmission line routes may disturb wetland, floodplains or agricultural land. • Increased activity along the stream and transmission route may disrupt recreational/cultural/subsistence activities there. • Power transmission lines/pathway may result in destruction of wetlands or other sensitive habitat. • Decrease in downstream water flow may affect downstream users (humans, fisheries, and wildlife).
Operation	• Decrease in stream flow between point of diversion and water return point may affect fisheries and wildlife. • Decreased stream flow between point of diversion and water return point may change the flooding pattern (regime), harming wetlands. • Re-entry pipe may cause increased scouring of stream bank where water is returned to the stream. • Power lines may harm viewsheds and aesthetic values.

Impoundment micro-hydropower

If the project requires the creation of an impoundment, potential environmental impacts may be greater than for run-of-the-river systems. As with run-of-the-river installations, environmental impacts may result during both construction and operation. Primary concerns are the stretch of the river from which water is removed; the area that is being flooded; and downstream users, including humans, fish, and wildlife.

Note that impoundment micro-hydro typically triggers an environmental assessment (EA) under USAID's environmental procedures. Potential environmental impacts are summarized in Table 6.2.

Table 5.2: Environmental impacts of impoundment micro-hydro

Activity phase	Impact
Construction and operation	All the impacts caused by construction of run-of-the-river hydro, plus:
Construction	• Movement of soil at the impoundment location may increase erosion. • Increased activity at the impoundment location may disrupt wildlife. • Impoundment construction may result in disturbing wetlands, floodplains, or agricultural land. • Increased activity at the impoundment location may disrupt recreational and cultural activities, or disrupt the local resident's way of life.
Operation	• Change in water temperature in the impoundment may affect water quality in the impoundment and discharge from the impoundment. • Submersion of land covered by the impoundment destroys existing habitats and ecosystems and creates new (aquatic) habitats and ecosystems; it may reduce the amount of land available for growing crops. • The impoundment may create a breeding ground for pests and disease. • The impoundment may change the overall water flow pattern (regime), which may alter water flow in the stream. • The impoundment may change general hydrology of the area, altering habitat along stream banks. • Altering normal stream flow reduces the availability of nutrients and sediment downstream for crops and fish. A dam can also threaten fish migrations. • Insufficient attention to an area's geology and topography may result in designing a dam that is too weak. Failure of the impoundment may cause flooding, erosion and downstream destruction.

Sector Program Design—Some Specific Guidance

The local community must be involved in designing, implementing and monitoring all small-scale projects. However, since the proper operation and maintenance of micro-hydro facilities are essential to minimizing environmental damage, community involvement is particularly critical for these projects.

Given that impoundment micro-hydro projects are likely to require an EA, the basic axiom of environmental impact assessment should be underlined: *Consider the full range of alternatives to achieving project results*. For micro-hydro ask these questions:

- Are there other options available for producing needed power?
- Are there other locations where the project might be constructed?
- Would any other feasible options result in fewer environmental impacts than the proposed activity?

Micro-Hydro Sector Design Issues

- Consider all alternatives first.
- To assess benefits vs. costs of impoundment, examine:
    - Present use of land
    - Effects of transmission system on area
    - Downstream activities

Environmental costs of the project should be weighed against its economic benefits. To estimate the costs and benefits, a number of questions should be considered, including:

- What benefits does the stream provide in its natural state? (Examples include water supply, fisheries habitat, wildlife habitat, commercial/recreational fishing, attenuation of floods, tourism, cultural values, etc.) Will any of these benefits be affected by the activity?
- How is land currently used in the impoundment location? What benefits are offered at the location? (Examples include crop production, wildlife habitat, residential dwellings, cultural activities, etc.) Will constructing and operating the dam affect these benefits/land uses?
- How might the land area be affected by routing of powerlines across the land? (Or if batteries are used, transportation of batteries to and from the microhydro site?)
- What are the present downstream activities and land uses that may be affected by the activity? Will the micro-hydroelectric project affect any of these adversely?

Environmental mitigation and monitoring

Mitigation

The mitigation and monitoring issues and measures which apply to small-scale construction also apply to construction of microhyrdro installations. Please see the chapter on Small-Scale Construction in these *Guidelines*.

General guidelines for mitigating micro-hydropower impacts include:

- Avoid stockpiling soil in wetlands or floodplains. Stockpile soil in already disturbed areas.
- Do not block stream flow during construction. For temporary stream diversion, use concrete forms rather than soil. (Using concrete forms will result in less stream sedimentation).
- Following construction, return topsoil to its original location, and restore land contours to match the original topography.

- Avoid construction during wildlife breeding seasons.
- Ensure that construction does not harm the habitats of endangered or threatened species.

Mitigation of operations-phase impacts depends on both careful design and proper operation and maintenance (O&M) of the system. In the case of impoundment structures, proper O&M is especially vital to:

- maintaining critical downstream flows
- safeguarding the integrity of the impoundment structure—the water level in the reservoir must not be allowed to exceed the rated level, and required maintenance must be performed promptly.

Monitoring

Both types of micro-hydro installations require monitoring for the operations-phase impacts outlined above. In addition, impoundment hydro requires a regime for testing quality of water in the impoundment, as well as regular monitoring of the quantity of downstream flows. Monitoring plans should detail:

- What criteria will be used in testing?
- How often will tests be conducted?
- What process will be used to correct problems in the system?

In addition, the integrity of the impoundment structure (dam) must be monitored on a regular basis.

Micro-hydro Mitigation and Monitoring Guidelines

- Avoid soil stockpiling
- Keep streams and water flow open
- Return topsoil to original site
- Restore land contours
- Avoid wildlife breeding seasons
- Protect habitats of endangered wildlife
- Maintain downstream flows
- Safeguard dam structures
- Develop testing criteria and schedule
- Specify process for correcting problems

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Micro hydro Web portal. http://microhydropower.net/index.php A Web site with extensive links, information, and case studies of micro-hydro projects.

Chapter 6

Fisheries

Contents

Brief Description of the Sector	6-1
Potential Environmental Impacts	6-3
Sector Program Design-Some Specific Guidance	6-8
Mitigation and Monitoring Issues	6-13
Resources and References	6-21

Brief Description of the Sector

Fisheries are an important source of food, employment and revenue worldwide. Of all the animal protein consumed in Africa in 1997, 17.2 percent was from fish (Taco 2001). The fisheries sector is divided into two major sub-sectors: capture fisheries and aquaculture. The term “capture fisheries” is applied to the practice of harvesting wild fish and other aquatic organisms. Both industrial and artisanal fishing practices fall under this category.

Aquaculture is the practice of raising and harvesting fish and aquatic organisms under controlled circumstances. Typically, aquaculture is used to grow finfish (salmon, milkfish, carp, tilapia), mollusks (mussels, oysters, clams), shrimp and seaweed. Aquaculture can be pursued in fresh, brackish and salt-water bodies.

Aquaculture was introduced into Africa in the 1950’s. During the 1960s, however, aquaculture development sharply regressed and most ponds were abandoned for a variety of reasons: lack of secure land tenure, farmers’ reluctance to adopt aquaculture technologies, shortages of labor and stocking material, drought, and political turmoil. With donor support, aquaculture is again taking root in Africa, although it is still practiced mainly by small farmers as a secondary or part-time activity in freshwater ponds in rural areas. According to FAO statistics, aquaculture (fresh, salt, and brackish) produced 2.56 percent as much fish in 1995 as inland capture fisheries (Aguilar-Manjarrez, FAO, 1998).

There are two basic modes of practicing aquaculture: intensive and extensive. **Intensive aquaculture** subjects an organism to hatchery-controlled conditions for most of the life cycle. This form is most commonly applied to finfish. In salmon aquaculture, for example, the fish are hatched, reared and fed in controlled ponds until they are big enough to harvest. **Extensive aquaculture** usually involves unsophisticated technology, relies on natural food and has a low input-to-output ratio. Typically, only part of the life cycle is controlled. Extensively operated fish ponds often rely on a supply of young fish from the wild, and use minimal feed and fertilizer inputs.

Small-Scale Fish Farming in Rwanda

Rwandan fish farmers were surveyed in 1998 to estimate the costs and returns of extensive aquaculture, sweet potato, Irish potato, cassava, taro, sorghum, maize, sweet peas, beans, soybeans, peanuts, rice and cabbage production. Fish farming—predominately Nile tilapia (*Oreochromis niloticus*), *Tilapia rendalli*, and common carp *(Cyprinus carpio)*—yielded the highest cash income per unit of land. Sweet potatoes produced the highest carbohydrate yield, while soybeans were the least expensive source of protein. Because of the high economic returns from aquaculture, farmers kept only 31 percent of their fish harvest for consumption; 61 percent was sold as a cash crop. Income from fish culture was used for a variety of purposes, including re-investment in fish farming or other agricultural activities; payment of children’s school fees and taxes; purchasing household goods, medicines, lands and livestock; and savings in bank accounts.

Source: Hishamunda et al., 1998.

Small-scale fisheries provide many benefits to both farmers and the environment. For poor farmers, they are both a major cash crop and an important source of protein. For local communities, aquaculture can create employment and diversify income-generating activities. In addition, aquaculture can serve as insurance against long-term shortfalls in capture fishery yields. It can prevent over-exploitation of finite stocks and minimize competition for land use. Moreover, aquaculture can provide active benefits to water bodies, such as improving productive capacity and water quality, converting polluting waste products into fish protein, controlling the spread of diseases such as malaria and schistosomiasis, and providing sewage treatment and low-cost weed clearance in irrigation systems. Finally, wastes from aquaculture can be used as fertilizer for agricultural production.

Fish Population Collapse in Malawi's Lake Malombe

Fish stocks on the Upper Shire River, the water body connecting Lake Malawi to Lake Malombe, are seriously depleted. Catch of chambo, the primary fish stock, collapsed from 570 tons in 1983 to 96 tons in 1991. In Lake Malombe, kumbuzi, a small fish making the bulk of the catch after chambo stocks plummeted, is also in decline. The value of the total catch on the lake fell nearly 70 percent from 1983 to 1991. This has prevented thousands of fishermen from earning a living and feeding their families.

The populations of both the river and the lake collapsed due to over-fishing by artisan fisherman. Because neither water body was managed, the fishermen went from using 3-inch nets to half- and quarter-inch nets to catch smaller and smaller fish. Seine fishing, introduced to catch the smaller fish, worsened the collapse by reducing aquatic vegetation, removing nutrient-rich sediment and destroying nursery areas.

Malawi’s fisheries department instituted rules to conserve stocks, including regulating net mesh sizes, controlling night fishing and closing fishing grounds for most of the year. These regulations were widely disregarded, however, and the department lacked funds to enforce them.

A community-based management project sponsored by FAO and the United Nations Development Programme (UNDP) was more successful at sustainably managing the water bodies. The project established beach village committees who created rules and then policed them in partnership with the authorities. New fishermen were obliged by local custom to report first to the local headman, making them easier to track. "There was one fisherman … using a tiny mesh," recalled Michael Sambakunfi, the committee's secretary. "When members saw it was actually a mosquito net, they grabbed it and burned it." FAO estimates that 90 to 95 percent of area fishermen observe the committee rules.

Many families combine fishing with part- or full-time agriculture, growing mainly maize and groundnuts. Poor people who only crew the boats, however, earn too little to afford land to farm. During the 1992–1995 drought, fish stocks on Lake Malombe dropped again, and many people fenced off gardens on the lakebed to grow dry-season vegetables and maize.

Experts believe the committees will have to further limit the number of boats allowed to fish in the waters to achieve sustainability. However, jobs are difficult to find outside the fishing industry, and one of the dangers facing the project is that people will fish illegally if they cannot secure extra money. GTZ, the World Bank, and FAO/UNDP have all been actively promoting new industries and small businesses to help replace the income lost from fishing. If adequate means of supporting and feeding the community are found, the committees hope to close Lake Malombe to fishing for two years to allow fish populations to return.

Source: Alyanak, Leyla. FAO, 1996.

Potential Environmental Impacts of Development Programs in the Sector and Their Causes

Many of the impacts summarized below can be avoided through careful resource management and through sound planning and design of small-scale fisheries. Significant adverse impacts may include:

For Capture Fisheries

Over-harvesting. Widespread, unsustainable fishing practices have left capture fisheries with a shrinking resource base. FAO estimates that 11 of the world's 15 major fishing areas and 69 percent of the world's major fish species are in decline and in urgent need of management. Over-fishing by foreign fleets, particularly in West Africa, has depleted local fish stocks, forcing small-scale fishermen to fish further out to sea—a safety hazard—or in protected areas such as marine national parks. As harvests of valuable fish stocks decrease, fisherman are forced to collect lower-value fish, resulting in less return on investment and continuing the cycle of over-harvesting. (See the box on facing page.)

By-catch. Some types of fishing equipment—such as nets with small mesh sizes, trawlers, and long lines—collect both the desired species (catch) and many non-target species (by-catch). For example, driftnets entangle and drown birds, sharks, whales and dolphins. Prompted by governments and conservation groups around the world, the United Nations banned large-scale driftnetting on the high seas in 1993. Smaller driftnets, however, are still being used in coastal waters.

By-catch includes unwanted or undersized animals. These animals are culled and returned to the sea, often dead or dying; the populations of many non-target species are dropping as a result. In many cases, the discarded animals are juveniles, which increases the rate of population collapse.

Toxic Substances. Toxic substances, such as cyanide, and techniques like dynamiting and electrocution are used to more easily harvest fish. But cyanide, which anesthetizes fish for harvesting, also poisons coral reefs and non-target organisms. Dynamite fishing, practiced in the coastal zone of Eastern Africa, damages coral reefs and has caused fisheries to decline in these areas.

Endangered Species. Nearly 150 fish species are threatened in Africa, due to a combination of over-harvesting, habitat destruction and the introduction of exotic animals that compete with native species. Loss of fish populations leads to economic hardship for artisan fishermen and reduces food security for the entire population.

For Aquaculture

Pollution. Aquaculture systems cause pollution in a variety of ways:

- Pond water discharged into coastal areas or streams can adversely affect sedimentation rates, the nutrient cycle, and dissolved oxygen (DO) levels, and can raise sedimentation rates, accelerate the nutrient cycle and lower dissolved oxygen levels. These changes can lead to eutrophication, a state where a water body is polluted with excess nutrients, which remove dissolved oxygen from the water and cause rapid plant growth, including toxic algal blooms. These toxins may concentrate in shellfish, creating a serious risk to human health. Degraded organic materials from pond bottoms release toxic sulfide compounds and ammonia into the water. The net result from these combined nutrient changes may be decreased water quality and increased stress on aquatic life, with damage to capture fisheries.

- Feeding regimes for bred species often cause excess food to accumulate below aquaculture pens. This excess food is consumed by benthic (bottom-dwelling) organisms or is left to decompose. Decomposition causes degradation of water quality and decreasing oxygen levels in the water body, which can be fatal to aquatic organisms. Consumption by benthic organisms, on the other hand, disrupts the balance of the entire ecosystem.

- Fish wastes from intensive aquaculture, in combination with decomposing excess food, also cause algal blooms.

- Anti-fouling agents are often used to prevent organism growth on cages and netting. Some anti-fouling agents, such as TBT, interfere with reproductive functions of both cultured and wild shellfish.

- Human activities associated with aquaculture also generate pollution. Human wastes generated from habitation near aquaculture cages can degrade water quality and create health hazards. For ease of access, fish processing facilities are often located near fishponds or enclosures. If wastes from fish-processing activities are disposed of in fishponds, this also damages water quality.

A Tilapia fishpond in Tanzania. The pond restricts water flow on a small stream. What will happen to downstream users if more ponds like this one are constructed?

Habitat Destruction. Because they are located in inter-tidal zones, mangrove forests are often cleared for replacement by aquaculture ponds. Mangroves, however, stabilize coastlines, reduce storm erosion, act as spawning and nursery areas for many fish and crustacea, and generally support a diverse population of grasses, birds, and other land-based and aquatic animals. Mangroves also serve as a renewable resource, providing firewood, timber, pulp, and charcoal for local communities. Destroying mangroves has disastrous effects on the environment, including destruction of shorelines and loss of fish breeding grounds. These habitat changes may cause fish populations to collapse.

Wetlands are often converted to freshwater aquaculture ponds. This results in flooding and loss of animal habitats, and adversely affects downstream water quality.

Impacts on freshwater sources. Intensive aquaculture requires large quantities of freshwater, usually obtained from groundwater or surface freshwater bodies. This leaves less water available for downstream uses, such as municipal water supply and agriculture. Pumping groundwater near coastal areas may cause saltwater to enter the aquifer and contaminate the underground reservoir. Groundwater extraction may also cause land subsidence (i.e., the land surface slumps or collapses). If aquaculture ponds are not designed properly, saltwater can seep into surface reservoirs, canals and rice paddies. As noted above, pond water is often discharged into freshwater bodies, adding excess nutrients and pollutants and increasing salinity. Salt can also seep into freshwater sources from poorly designed sediment disposal sites.

Disease. Intensive aquaculture uses a dense stocking rate with intentional overcrowding. Overcrowding may induce stress in aquatic organisms and increase their susceptibility to diseases. It also contributes to poor water quality and the rapid growth and transmission of parasites and pathogens, which may spread to wild populations and local capture fisheries. To treat and prevent disease, a variety of chemicals are used, including antibiotics, parasiticides (parasite-killing drugs), pesticides, hormones, anesthetics, pigments, minerals, and vitamins. These chemicals are generally used in finfish or hatchery aquaculture, and applied along with feed. They may disperse beyond the pens and affect non-target organisms. Application of antibiotics also leads to the creation and spread of antibiotic-resistant bacteria.

Adverse effects on other organisms. Organisms escaping from aquaculture systems may have adverse impacts on wild populations. Species bred or genetically engineered for aquaculture are selected for high growth rates and/or disease resistance, usually at the expense of other survival characteristics. If these animals compete and interbreed with wild populations, the net result can be populations which are less genetically diverse and possibly less resistant to environmental changes.

If the escaping organisms are exotic to the area or water body into which they escape, where they are used, they may interfere with the food, habitat and spawning areas of native species. Non-native species are also a source of new diseases and predators.

Nearly all marine and brackish water aquaculture requires inputs from natural fisheries. Wild organisms or larvae are generally used as seed stock for aquaculture operations. Collecting larvae or young animals, if not done carefully, may depress the world population of the species to dangerously low levels.

Aquaculture based on carnivorous organisms (such as salmon and shrimp) requires large quantities of fishmeal. Fishmeal is manufactured from harvests of "trash fish," fish not otherwise consumed by people. Growing a pound of salmon may require 3–5 pounds of wild fish, and between 1985 and 1995 the world's shrimp farmers used 36 million tons of wild fish to produce just 7.2 million tons of shrimp (Emerson 1999). Expanding aquaculture by harvesting more trash fish may lead their populations to collapse, not only making the aquaculture unsustainable but endangering other aquatic animals that feed on trash fish.

Clustering and poor siting of aquaculture facilities can obstruct access to water resources by wild populations. Predators, often drawn to aquaculture sites, may become entangled in net pens and drown.

Adverse impacts on downstream users. As mentioned previously, intensive and semi-intensive aquaculture systems require large volumes of fresh water, often drawn from surface waters. This practice leaves less water available for downstream users. In rural areas, this results in less water available to irrigate crops and forces women to travel further to collect water for household use. Also, seepage and discharges from fishponds can degrade the quality of water available to downstream users, affecting drinking water, agriculture, capture fisheries and recreational uses of water bodies.

The site of a proposed fishpond near Kibwaya, Tanzania. Six families grow rice on this land. Will they receive any compensation? What is the effect of introducing alternative uses?

Possible Environmental Impacts of Aquaculture Listed by Production Type[1]

Culture System	Environmental Impact
Extensive	
1. Seaweed culture	May occupy formerly pristine reefs; rough weather losses; market competition; conflicts/failures, social disruption.
2. Coastal bivalve culture (mussels, oysters, clams, cockles)	Public health risks and consumer resistance; microbial diseases, red tides, industrial pollution; rough weather losses; seed shortages; market competition, especially for export produce; failures, social disruption.
3. Coastal fishponds (mullet, milkfish, shrimp, tilapias)	Destruction of ecosystems, especially mangroves; increasingly non-competitive with more intensive systems; nonsustainable with high population growth; conflicts/failures, social disruption.
4. Pen and cage culture in eutrophic waters and/or rich benthos (carp, catfish, milkfish, tilapias)	Exclusion of traditional fishermen; navigational hazards; conflicts, social disruption; management difficulties; wood consumption.
Semi-intensive	
1. Fresh- and brackish water pond (shrimp and prawns, carp, catfish, milkfish, mullet, tilapias)	Freshwater: health risks to farm workers from waterborne diseases. Brackish water: salinization/acidification of soils/aquifers. Both: market competition, especially for export produce; feed and fertilizer availability/prices; conflicts/failures, social disruption.
2. Integrated agriculture-aquaculture (rice-fish; livestock/poultry-fish; vegetables-fish and all combinations of these)	As for freshwater above, plus possible consumer resistance to excreta-fed produce; competition from other users of fishmeal inputs (livestock and cereal production); toxic substances in livestock feeds (e.g., heavy metals) may accumulate in pond sediments and fish; pesticides may accumulate in fish.
3. Sewage-fish culture (waste treatment ponds; latrine wastes and septage used as pond inputs; fish cages in wastewater channels)	Possible health risks to farm workers, fish processors and consumers; consumer resistance to produce.
4. Cage and pen culture, especially in eutrophic waters or on rich benthos (carp, catfish, milkfish, tilapias)	As with extensive cage and pen systems above.

[1] Source: Pullin, *Third World Aquaculture and the Environment* (1989), as cited by Baluyut (1989).

Intensive	
1. Freshwater, brackish water and marine ponds (shrimp; fish, especially carnivores—catfish, snakeheads, grouper, sea bass, etc.)	Effluents/drainage high in Biological Oxygen Demand (BOD) and suspended solids; market competition, especially for export product; conflicts/failures, social disruption.
2. Freshwater, brackish water and marine cage and pen culture (finfish, especially carnivores—grouper, sea bass, etc.—but also some omnivores such as common carp)	Accumulation of anoxic sediments below cages due to fecal and waste feed build-up; market competition, especially for export produce; conflicts/failures, social disruption; consumption of wood and other materials.
3. Other—raceways, silos, tanks, etc.	Effluents/drainage high in BOD and suspended solids; many location-specific problems.

Sector Program Design—Some Specific Guidance

As with other program and project development activities, potentially damaging environmental impacts need to be addressed early in the design process in order to avoid costly mistakes or project failure. Listed here are good management practices and design criteria that can help prevent adverse impacts.

Best Management Practices for Capture Fisheries

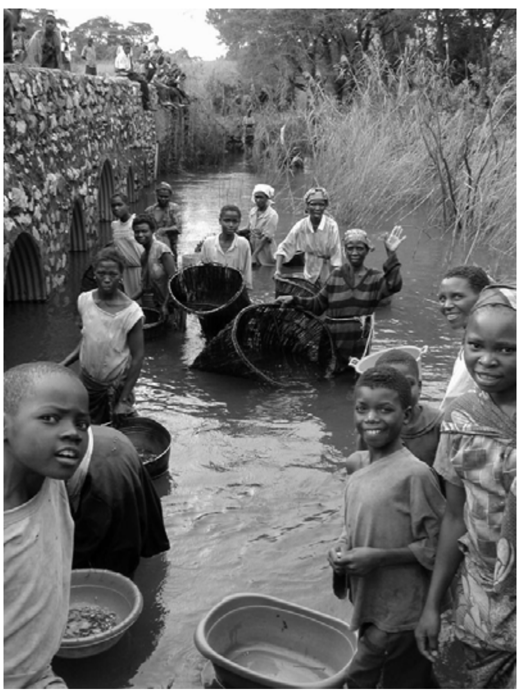
- Do not discharge toilets, washwater, non-oily bilge water, deck washwater, fish offal, or kitchen waste into coastal and sensitive waters.
- Exclude motorized vessels from areas that contain important shallow-water habitats.
- Establish no-wake zones for boats and ships to decrease erosion and turbidity.
- Use oil-absorbing materials in bilge areas of a boat's inboard engine; dispose of and replace them appropriately (see chapter on "Solid Waste Management" in these guidelines).
- Do not discharge bilge and ballast water with oil and grease concentration above 10 mg/liter.
- Clean boats in the water by hand. Use detergents and cleaning compounds that are phosphate-free and biodegradable: for example, no TSP (trisodium phosphate). Do not use detergents containing ammonia, sodium hypochlorite, chlorinated solvents, petroleum distillates or lye.

Best Management Practices for Aquaculture

General Guidelines for Site Selection for Aquaculture

Proper site selection is critical to successful aquaculture projects. A poor site will not only make an aquaculture project more difficult to manage, but it may also destroy critical natural habitats, spread disease and contaminate freshwater sources. Use the following general guidelines for selecting a suitable aquaculture site:

- Maintain adequate distance from other fish farming enterprises, natural spawning runs, restricted areas (national parks, world heritage areas, conservation areas) and sensitive ecosystems (including swamps, mangroves, mud flats, intertidal areas, bays, lakes, rivers, coral reefs, sea grass meadows, and shellfish beds).
- Choose sites with adequate wave, current, and tidal patterns. Areas of high currents will minimize waste accumulation through hydrodynamic dispersal. Lower levels of waste allow excess nutrients to be more easily assimilated into the local food web. Currents and tides also help replenish anoxic water with oxygen-rich water from surrounding areas. Rotting vegetation in a water body is an indicator of stagnant water and should be avoided. Remember to check for seasonal water variations.
- Do not use sites with incompatible users, such as riverbed sand extraction operations, harbors, sewage outfalls, oil platforms, shipping lanes, tanneries, sugar refineries and distilleries, or palm oil processing plants. Do not use sites polluted with chemicals, pesticides or heavy metals.



Women and children seining for fingerlings with traditional fishtraps, near Malambanyama, Chibombo District, Zambia.

- Choose sites that are near wild stock populations. Avoid introducing exotic fish species into a body of water. Remember to consider predator populations, existing ecosystem relationships and pathogen concentrations.

Other General Guidelines for Aquaculture

- Use hatchery stock where possible.
- Use non-native species only where escape is impossible or where survival and reproduction under local conditions is impossible.
- Use palatable feed with high utilization rates and low waste. Use feed of the appropriate size for the age of the stock. Feed often and at low levels to minimize waste. Distribute feed evenly.
- Use pathogen-free stock. If necessary, quarantine and provide treatment.
- Use drugs or pesticides only as needed during a disease outbreak, not on a routine preventive basis. Delay harvest of treated stock and delay discharge of treated water until the drug or pesticide has degraded fully.
- Apply Integrated Pest Management (IPM) to the aquaculture program. Aquaculture combined with rice production enables a farmer to grow two crops on the same land. The fish will consume algae and weeds, fertilize the water, and improve soil texture. Aquaculture in irrigation channels will control algae and weeds.

Specific Guidance for Pond Aquaculture

- *Siting Ponds*
    - Locate ponds where they do not cause a loss of habitats such as mangroves, wetlands, lagoons, rivers, inlets, bays, estuaries, swamps, marshes or high wildlife-use areas. Situate ponds away from tidal areas subject to flooding.
    - Choose sites with good soil, preferably clay-loam or sandy-clay, that will retain water and be suitable for building dikes. Soil should be alkaline (having a pH of 7 and above) to prevent problems that result from acid-sulphate soils (e.g., poor fertilizer response; low natural food production and slow growth of culture species; probable fish kills). Acidic and organic soils (e.g., high in humus or compost) are not suitable.
    - For saline brackish ponds, choose land with average elevation that can be watered by ordinary high tides and drained by ordinary low tides. Tidal fluctuation should be moderate, between two and three meters. Sites with tidal fluctuations above four meters require very large, expensive dikes to prevent flooding during high tide. Areas with slight tidal fluctuations, of one meter or less, cannot be properly drained or filled.
    - Provide a buffer zone for areas near riverbanks and coastal shores that are exposed to wave action.
    - Ensure that the area has a steady supply of water, in adequate quantities throughout the year. Water supply should be pollution-free and with a pH of 7.8–8.5.

- *Designing Ponds*
  - Design to prevent storm and flood damage that could cause overflow discharges.
  - Provide settling ponds for the effluent, and also for water intake, if the water supply has high sediment loads.
  - Ensure that pond depth is shallow enough to prevent *stratification* (potentially dangerous layering of the pond water into a warmer upper layer and a cooler, dense, oxygen-poor lower layer). If not, include a means of providing aeration or other destratifying mechanisms.
  - Include reservoirs for water storage and treatment.
  - Isolate supply and effluent canals as far as possible from each other, and from other farms.
  - Where possible, use a closed or re-circulating system with treatment; do not use more than small amounts of fresh water to top off the pond.
- *Constructing Ponds*
  - Line bottoms and sides of ponds, levees and canals with impervious material to prevent seepage into surrounding soils and groundwater.
  - Construct stormwater bypasses around the area of the ponds.
  - Dig ponds deep enough to control weed growth.
  - Minimize sediment erosion by:
    - using gradual slopes in construction;
    - planting vegetation on the surfaces of slopes;
    - compacting and lining the banks;
    - making discharge channels large enough to handle peak loads without scouring.
  - Construct wetlands to treat the settling pond water from freshwater ponds.
- *Operating Ponds*
  - Operate ponds so that they do not cause a loss of, or damage to, habitats, including mangroves, lagoons, rivers, inlets, bays, estuaries, swamps, marshes and other wetlands, high wildlife use areas, reefs, parks, ecological reserves, or fishing grounds.
  - Screen pond entrances and exits to keep fish stock in and other animals out.
  - Discharge saline ponds into deep water with high currents. Discharging saline water into intertidal zones is not acceptable.
  - Prevent erosion by leaving sediment, unless removal is absolutely necessary.
  - Keep freshwater use to a minimum in brackish or saline ponds.

- *Monitoring and Controlling Ponds*
    - Maintain water quality with aeration, sustainable stocking rates and controlled feeding rates, not with water exchange (replacing old pond water with clean water).
    - Treat effluent in settling ponds with filter feeders, and pass settling pond water from freshwater ponds through a constructed wetland before discharge.
    - Use the effluent as liquid fertilizer on crops, particularly forage crops where bare ground is minimal.
    - Monitor and control effluents before discharging to meet water quality standards for turbidity, suspended solids, BOD, pH, dissolved oxygen (DO), ammonia, nitrate, nitrite, disease organisms and pesticides. In freshwater ponds, monitor and control phosphorus.
    - Alternate freshwater ponds, where possible, and allow ponds to dry out, lie fallow, or grow a crop to reduce the need for sludge and nutrient removal.
    - Plow non-saline sludge into agricultural lands that are not susceptible to runoff and leaching.
    - Avoid discharge of saline ponds into freshwater habitats.

Specific Guidance for Net Pen Aquaculture

- *Siting Net Pens*
    - Locate all open-net pens in highly flushed, deep-water sites with no tidal reversals.
    - Site net pens at least one km from the mouths of streams or rivers when using fish that travel upstream to spawn.
    - Site net pens downcurrent of recreational areas, marine parks, fishing grounds, shellfish beds used for commercial or recreational harvest or other sensitive areas.
- *Constructing Net Pens*
    - Construct all net pens to prevent breakup of facilities and loss of stock, wastes, feed or supplies even in severe weather conditions.
    - Keep boats from discharging sewage into the water by:
        - constructing a shore facility with a proper septic system and drain field, tanks and pump-out or a small treatment plant, where conditions are suitable;
        - using holding tanks and a pump-out boat to empty the tanks at regular intervals.
- *Operating Net Pens*
    - Maintain sufficient storage capacity to handle even large, catastrophic fish kills caused by algal blooms or disease epidemics.

    - Provide adequate safe storage, with secondary containment, for drugs, fuels, solvents and toxic materials. Preferably, locate this storage on shore.

- *Monitoring and Controlling Net Pens*
    - Place a bag or other container around all net pens to isolate diseased fish. The bag should be impermeable and capture all fish wastes. Arrange to treat and neutralize bag water or wastewater before discharge.
    - Collect and dispose of waste feed and feces from bagged or contained pens as compost. Collect and dispose of waste floatables, scum and oils from bagged or contained pens with other compost in a suitable facility.
    - Collect and dispose of unmarketable fish, blood and guts:
        - with other compost in a suitable facility;
        - by sending it to a rendering plant, or
        - by sending it to a properly operated landfill.
    - Avoid discharges near or upcurrent of recreational areas, marine parks, fishing grounds, shellfish beds used for commercial or recreational harvest, or other sensitive areas.

Environmental Mitigation and Monitoring Issues

Field studies of small-scale fishponds in Zimbabwe and Zambia have shown a large number of project failures and pond abandonments. Reasons why the projects failed include:

Motivation. Many farmers choose to dig fishponds in anticipation of benefits or to associate themselves with a "culture of development," rather than a belief in the technology. Such farmers may be discouraged from continuing fish farming in the face of maintenance problems and/or lack of short-term economic returns. Moreover, development organizations and agencies often structure projects around false assumptions, including:

- Assuming members of fish farming households have equal authority in making decisions;
- Assuming farmers frequently make decisions by weighing costs, benefits, and risks; and
- Assuming fish production is the farmer's primary concern.

When these assumptions are not valid, the farmers may not be able to resolve management and operational problems and will discontinue fish farming.

Environmental Factors. Projects may fail due to uncontrollable environmental disasters, such as droughts and floods. Also, if water temperatures are too low, fish may not grow to adequate size in time for harvesting.

Biological Factors. Farmers may experience problems maintaining adequate stocking and survival rates.

Financial Factors. The project may not generate adequate or rapid enough financial return, especially in systems requiring inputs of fish feed. External factors like political unrest may disrupt access to distant markets. Also, competition from capture fisheries may decrease prices and prevent a project from reaching profitability.

Social Factors. Theft of tools and stocks can jeopardize project success and reduce individual and community enthusiasm for aquaculture.

Administrative Factors. Extensive bureaucracy and poor communications between farmers and project supporters may generate distrust or apathy and result in project failure. Poor information exchange, lack of extension services and lack of contingency planning can each be fatal blows to a fishpond project.

External Environmental Conditions Affecting Project Success

Even with good management and design, fisheries projects are still at risk from external environmental conditions which can prevent project success. Types of trauma include:

Exotic and Endangered Species. Alien species introduced into African water bodies have adversely affected native populations. The Nile perch (*Lates nilotica*), introduced into Lake Victoria 30 years ago to stimulate the fisheries of Uganda, Kenya and Tanzania, is now dominant in the lake and believed to be responsible for the decline or loss of more than 200 native fish species. Water hyacinth (*Eichornia crassipes*) has spread to freshwater bodies across Africa, including Lake Victoria and Lake Kariba, blocking water channels, altering hydrological regimes and leaving surrounding areas prone to increased flooding.

Tightening controls on importation of animals and plants will help prevent introduction of exotic species. This policy, however, requires allocating resources to police borders and entry points, and to enforce fines for breach of regulations; such resources may not be available.

Alien plants can be physically removed by hand, by machinery or by chemicals. Biological control can contain alien populations with fewer environmental impacts. The latter, however, is a more lengthy process, because control organisms must themselves be rigorously tested for adverse impacts before their release into the environment.

Pollution. Fish life cycles can be adversely affected by pollution from industries (including the fish processing industry), human wastewater, nutrient loading and pesticides from agricultural runoff, water body acidification from vehicle and power station emissions, dredging, reclamation, sedimentation, dams, river channel modifications, and alteration of freshwater drainage. Pollutants, including heavy metals, pesticides and radioactive wastes, will bioaccumulate in fish and mollusk populations.

Nutrient loading of a water body can best be mitigated at the source—for example, by treating human effluent and capturing agricultural runoff. Early-warning networks can monitor for toxic algal blooms caused by excessive nutrient enrichment of water bodies. Instead of closing water bodies during periods of seasonal contamination from metals or hazardous wastes, mollusks can be grown in polluted water and then purged in clean water sources before processing or sale. Encouraging vegetative ground cover to prevent runoff, along with active techniques like flushing and dredging the water body, can help mitigate pollution from sedimentation.

Habitat destruction. UNEP estimates that 38 percent of all coastal ecosystems in Africa, such as mangrove swamps and coral reefs, are under threat from development, including the growth of coastal settlements and their associated sewage discharges. According to the FAO, "Industrialization, urbanization, deforestation, mining, and agricultural land and water use often cause degradation of aquatic environments, the greatest threat to inland fish production" (FAO 1999). Fishery resources are damaged when:

- aquatic habitats are destroyed or fragmented;
- bodies of water are impounded (dammed) or channeled;
- too much water is drawn or diverted, or
- soil becomes eroded.

Manipulation of the hydrological characteristics of rivers, lakes and flood plains may also do significant harm.

Coral reefs are adversely affected by human activities such as sediment runoff from deforestation, eutrophication, bleaching, disease, dynamite and chemical fishing, anchor damage, dredging, and groundings from ship traffic.

Controlling damaging activities such as pollution, sedimentation, over-fishing, etc., can help mitigate habitat destruction. Replanting denuded areas can often restore mangrove habitats. Coral reefs are more difficult to restore and are highly sensitive to environmental stress. Thus, it is crucial to monitor coral ecosystems for changes in temperature, sedimentation, nutrient loading, storm damage and toxins.

Activity	Problem/Impact		Applicability	Mitigation Techniques
All Fisheries				
	Pollution		Mollusk	Mollusks are particularly vulnerable to biocides, leachates, metals and pesticides. Monitor water conditions closely for contaminants.
Capture Fisheries				
Design/ Operations	Over-harvesting		Capture fisheries	Set minimum size limit for harvested fish. Use bag limits. Use appropriate fishing gear. Choose the largest possible size of mesh in fishing nets. Close seasons during critical stages in fish life cycles.
	By-catch (catching fish and other aquatic animals that are too small or of the wrong species)		Capture fisheries	Use mesh sizes that allow small and juvenile fish to escape. Use a square mesh, or a mesh with square windows, instead of a diamond-shaped mesh. (Diamond-shaped mesh constricts during towing.) Use a by-catch reduction device to allow large animals to escape from nets.
	Use of hazardous substances and techniques		Capture fisheries	Educate fishermen about the long-term environmental and economic damage from using cyanide or dynamite on ecosystems.
Aquaculture				
Design				
	Site selection	Mangrove habitats	General	Always leave the most productive mangrove stands intact. Use already cleared land whenever possible. Reuse existing ponds before creating new ones. Site ponds on the landward side of the mangroves; leave the seaward side undisturbed. Ponds should have a small surface area (footprint) relative to total mangrove area. Ponds should be spaced well apart. Mangroves should be retained and replanted in the middle, or on the banks, of ponds.
		Adequate water supply and circulation	Finfish	Avoid shallow areas and areas with aquatic vegetation. Place units in an area with a good current flowing through it. The action of the current helps water move through the cage system, removing metabolites and replenishing oxygen.

Activity	Problem/Impact	Applicability	Mitigation Techniques
			Depending on the direction of prevailing winds and currents, orient the cages to prevent debris from collecting between them.
	Control of nutrient loading	General	Filter feeders—organisms that strain their food out of the water—improve water quality by consuming plankton and preventing eutrophication. Consider growing mollusks or seaweeds in conjunction with other species, to reduce nutrient loading.
	Control of seepage into ground and surface waters	General	Build ponds on soils with adequate clay content.
	Impacts to pond floor	Mollusk Culture	Use off-bottom systems such as rafts and lines.
	Erosion of ponds	General	Plan for seasonal constraints. Use settling ponds or other control structures.
	Disease prevention	Finfish	Locate cages where disturbances from people and animals can be minimized.
Construction			
	Erosion	General	Minimize disturbance of soil and vegetation.
	Control of dissolved oxygen supply	Mollusk	Do not seed mollusks too closely together or they will generate anoxic conditions (i.e., remove all oxygen from the water).
Operations			
	Overfeeding	General	Use high-quality feed. Feed the right amounts at the right time. Use feed pellets designed to float longer in the water column. Instead of fishmeal, use meals made from terrestrial animal byproducts, plant oilseeds and grain legumes; from yeast; or from cereal byproducts.
		Finfish	Consider culturing herbivorous fish that do not require feed inputs.
	Overcrowding	General	Use lower stocking densities.

Activity	Problem/Impact	Applicability	Mitigation Techniques
	Disease prevention	General	Stock certified pathogen-free fish. Use lower stocking densities. Vaccinate fish. Isolate diseased fish in bags, rather than nets. Allow net pens to sit fallow between stockings. Apply IPM. Filter or ozonate the effluent from pond and recirculating tank systems.
		Finfish	Avoid unnecessary or excessive handling of fish; this will minimize stress and prevent disease. Avoid unnecessary disturbance of the fish by restricting activities around the cage site. Promptly remove diseased and dying fish. During disease outbreaks, retain aquaculture effluent to prevent disease from spreading to wild populations.
		Shrimp	Consider treating influent water supply (for example, with chlorine) to eliminate pathogens and carriers; this may reduce disease incidence and associated use of chemicals.
	Excess of organic nutrients	General	Treat aquaculture and human wastes according to sanitation guidelines. Use polyculture (i.e., raise several species, including at least one herbivorous species) to consume excess nutrients. Do not discharge nutrient-enriched water into freshwater bodies.
		Finfish	Move fish pens to different locations periodically to prevent buildup of fish wastes and sediments below cages. Manage fish wastes through bag systems, fallowing, vacuuming or harrowing.
		Shrimp	Avoid frequent draining of shrimp ponds in order to allow microbial processes and deposition to remove nutrients and organic matter from within. This will also conserve freshwater. Use aeration and water circulation to break down organic matter and minimize anaerobic sediment accumulation at the bottom of shrimp ponds. Aeration may also remove ammonia. Use settling ponds to treat suspended solids. Always settle effluents released at the time of harvest.
	Inadequate dissolved oxygen supply	General	Use seaweed to oxygenate the water and to improve water quality by removing ammonia and phosphorus.

Activity	Problem/Impact	Applicability	Mitigation Techniques
	Adverse impacts from use of anti-fouling chemicals	General	Use IPM or polyculture to control weeds. Construct deeper ponds. Consider use of less-toxic alternatives to hazardous products. Designate areas for storage and refueling. Apply chemicals with proper containment away from watercourses or wetlands. Prepare an Emergency Spill Response Plan. Contain spills and treat contaminated soil and water as required.
	Erosion	General	Consult extended-range weather forecasts. Predetermine shutdown criteria for bad weather conditions. Maintain vegetated buffer zones. Stabilize disturbed areas as soon as possible. Monitor sediment in water and treat as required prior to release.
	Predation (wild animals eating aquaculture fish)	General	Use properly tensioned netpen lines and thick ropes to avoid entanglement from birds or aquatic animals. Use double nets to reduce predation. Rotate deterrence techniques to give predators less opportunity to get used to a particular technique.

<table>
<tr><th>Activity</th><th>Problem/Impact</th><th>Applicability</th><th>Mitigation Techniques</th></tr>
<tr><td></td><td></td><td>Finfish</td><td>Place protective netting on the sides and tops of cages to protect fish from bird and mammal predation.
Place the nets as far from the cages as possible, and weight them to prevent them from being pushed together by water movement.
Choose a size of net mesh that will prevent birds from becoming entangled.

Bird predation can be reduced by:
▪ eliminating safe roosting and perching places;
▪ placing the containment units deeper below the surface of the water to reduce the attraction of surface-feeding birds such as gulls;
▪ moving young/small stock to an area where they are less accessible to predatory birds;
▪ placing nets above cages to keep birds off;
▪ adjusting top nets so they do not sag under the weight of preying birds, enabling them to more easily reach the fish;
▪ using brightly colored nets to reduce the likelihood of birds accidentally swimming into nets.</td></tr>
</table>

Resources and References

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Resources

- ***A Brief for Fisheries Policy Research in Developing Countries***. M. Ahmed, C. Delgado and S. Sverdrup-Jensen (1997). 16 p. ISBN 971-8709-59-2. Available at: http://www.cgiar.org/iclarm/pubsof/newbooks.html#towards

Outcome of the International Consultation on Fisheries Policy Research in Developing Countries, jointly organized by International Center for Living Aquatic Resources Management (ICLARM), the International Food Policy Research Institute and the Institute for Fisheries Management and Coastal Community Development, and held 3-5 June 1997 at the North Sea Centre, Hirtshals, Denmark. Forty-two scientists, academicians and policymakers from developing countries, together with representatives from donor and international organizations, contributed to the development of a set of recommendations that include: (1) policy research priorities and an agenda for international and national research initiatives; and (2) guidelines for improving the capacity of developing country institutions in fisheries' policy research, including enlargement of the scope for collaborative research.

- ***A Roadmap For the Future for Fisheries and Conservation***. M.J. Williams, Ed. (1998). ICLARM Conf. Proc. 56, 58 p. ISSN 0115-4435, ISBN 8709-94-0. Available at: http://www.cgiar.org/iclarm/pubsof/newbooks.html#towards

These proceedings report on the fisheries session of the Marine and Coastal Workshop convened by IUCN, the World Conservation Union, 17–18 October 1998. The workshop sought to present and review the state of the art in marine and coastal conservation and sustainable development issues, and to discuss and develop directions, priorities and the role of IUCN in addressing these issues. The seven papers in the book discuss views from fisheries, conservation and resource management experts. The consensus expressed is that fisheries conservation is becoming more complex: it was previously the domain of fishers, fisheries managers and scientists, but now multipolar interests are concerned, including fishers and fisheries experts, consumers, local communities, civil society and other economic sectors.

- ***Code of Conduct for Responsible Fisheries***. FAO. Available at: http://www.fao.org/fi/agreem/codecond/ficonde.asp

This code sets out principles and international standards of behavior for responsible practices, with a view to ensuring the effective conservation, management and development of living aquatic resources, with due respect for ecosystems and biodiversity. The code recognizes the nutritional, economic, social, environmental and cultural importance of fisheries, and the interests of all those concerned with the fisheries sector. The code takes into account the biological characteristics of the resources and affected environment. It also addresses the interests of consumers and other users. All those involved in fisheries are encouraged to apply the code and give effect to it.

- ***Co-management in Small-Scale Fisheries. A Synthesis of Southern and West African Experiences***. (1998) Paper presented at IASCP conference in Vancouver, Canada, 9–14 June. In: *Fisheries Co-*

management in Africa. Proceedings from a regional workshop on fisheries co-management research held 18–20 March 1997 in Mangochi, Malawi. [16]. Available at: http://www.ifm.dk/reports/16.PDF

This presentation summarizes the findings from eight African countries where case studies of co-management arrangements in artisanal fisheries were undertaken during the period 1996–97. In most of the cases, co-management represents a new approach to fisheries management. In some cases, it has only been applied within the last 3–5 years, and in a few it is merely being considered as an option. The comparison of cases at this early stage may help address critical issues in the planning and implementation of fisheries co-management in Africa. These include the provision of incentives for fishers and other stakeholders to cooperate among themselves and with government in managing fisheries. The level of cooperation is determined by key factors affecting the local politico-historical, biophysical, economic and sociocultural environments of fishing communities and associated fisheries. Incentives for cooperation are determined by the character of the decision-making arrangements in place. These include setting collective choice rules and, in particular, the operational rules for a fishery, and thus the legitimacy of the arrangements in the eyes of the fishers. The co-management approach is intended to replace ineffective conventional, centralized management systems. The differing bio-physical environments seen in the cases represent three ecological systems: lake/reservoir, lagoon/estuary and open coast. In most of the cases only a few fish species are target species. These are often subject to heavy fishing pressure or are already over-fished. In most cases the fishers and their families are totally dependent on the fishery for their livelihood since, with few exceptions, they have no alternative sources of income.

- Alyanak, Leyla. *Fisherpeople launch patrol of their own slack waters*. FAO, 1996. http://www.fao.org/news/1997/970102-e.htm

Account of community-based management of Lake Malombe.

- ***FAO Technical Guidelines for Responsible Fisheries*** (1997). No. 5: Aquaculture Development. FAO, UN, Rome. 40 pp. Available at: http://www.fao.org/

- "Farming fish the right way". R. Kapadia and M. Williams (2000). ICLARM, USAID. ICLARM Focus for research, 3(2), April, 4 p. USAID order no. PN-ACK-990.

- ***Fisheries and Aquaculture in Sub-Saharan Africa: Situation and Outlook in 1996*** (1996) FAO Fisheries Circular No. 922 FIPP/C922, ISSN 0429-9329. Rome. Available at: http://www.fao.org/fi/publ/circular/c922/c922-1.asp

The contribution of the fisheries sector to the economy of the region has been largely beneficial. Over the last decade, significant progress has taken place including strengthened artisanal fisheries development; the consolidation of a small industrial base; growing export receipts leading to a positive trade balance; and, more recently, indications of a promising takeoff for aquaculture. However, in marine capture fisheries, most bottom-dwelling stocks are thought to be fully exploited, and catches by distant-water nations are steadily decreasing. The immediate potential for increases in production and supply for local markets is primarily with lower-value small pelagics species. Inland fisheries figure importantly in food security, providing over 40 percent of domestic catches.

Freshwater production is close to its estimated potential. Since 1990, per-capita fish supply has followed an alarming downward trend. The major challenge for the fisheries sector will be to maintain production to meet current levels of demand. This will require significant efforts to improve the management of capture fisheries, to support the development of aquaculture, and to promote intra-regional trade.

- ***Fisheries and Aquaculture Research Planning Needs for Africa and West Asia***. J.H. Annala, Ed. (1997). ICLARM Conf. Proc. 50, 80 p. ISSN 0115-4435, ISBN 971-8709-67-3. Available at: http://www.cgiar.org/iclarm/icpub2.htm

Proceedings of the ICLARM workshop on 23–25 September 1995 in Cairo, Egypt. Discussion of coral reef resource systems; coastal aquatic and inland aquatic resource systems; African Great Lake and reservoir resource systems; social sciences and co-management; and the partnerships between national aquatic research systems and ICLARM in Africa and West Asia.

- ***Fisheries Policy Research in Developing Countries: Issues, Priorities and Needs***. M. Ahmed, C. Delgado, S. Sverdrup-Jensen and R.A.V. Santos, Eds. (1999). ICLARM Conf. Proc. 60, 112 p. ISSN 0115-4435, ISBN 971-802-005-5. Available at: http://www.cgiar.org/iclarm/pubsof/newbooks.html#towards

Organized into three sessions, the first session focused on policy issues related to major changes in the demand and supply of fish. The second session focused on the impact of fisheries policies on food security and the environment. The third session was a discussion of priority areas for fisheries policy research targeted to developing countries. Regional and global fisheries policy issues, recommended topics for fisheries policy research in developing countries and implementation strategies were also discussed.

- ***Forgotten Waters: Freshwater and Marine Ecosystems in Africa—Strategies for Biodiversity Conservation and Sustainable Development***. Caroly A. Shumway USAID (1999), x, 167 p. Available at: http://www.dec.org/pdf_docs/PNACF449.pdf Electronic copy cost: $2.00

This report provides a primer on Africa's threatened aquatic biodiversity, along with lessons learned from successful and failed conservation projects and options for biodiversity conservation. The report provides an overview of the value of aquatic biodiversity, identifies the biologically and socio-economically most important sites, discusses threats, and recommends activities for urgent conservation action. The report addresses both freshwater and marine biodiversity, covering the following aquatic habitats and their associated flora and fauna: lakes, rivers, and streams; wetlands, including floodplains, freshwater swamps (also known as marais), mangroves, and coastal wetlands; and coral reefs. Associated wildlife include all terrestrial and aquatic organisms whose survival depends on wet habitats. Ocean pelagic areas are addressed briefly. Key recommendations include: improve institutional capacity for aquatic resource management; encourage appropriate economic and sectoral policies; involve the community in aquatic resource conservation and management; support needed research; mimic natural disturbance regimes in order to maintain or restore natural hydrological cycles; assist in establishing critical aquatic resources that can provide both conservation and fisheries benefits; and assist in developing fisheries that are compatible with biodiversity goals. Includes bibliography.

- ***Research for the Future Development of Aquaculture in Ghana***. M. Prein, J.K. Ofori and C. Lightfoot, eds. (1996). ICLARM Conf. Proc. 42, 94 p. ISSN 0115-4435, ISBN 971-8709-43-6. Available at: http://www.cgiar.org/iclarm/icpub2.htm

Proceedings of a workshop held in Accra, Ghana, 11–13 March 1993, which presented the preliminary results of a project entitled "Research for the Future Development of Aquaculture in Ghana." The project was funded by the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), and was executed by ICLARM in collaboration with the Institute of Aquatic Biology (IAB), Accra, Ghana. The aim of the project was to determine "what makes sense" for aquaculture development in Ghana, focusing on smallholder farmers.

- ***Sustainable Aquaculture: Seizing Opportunities to Meet Global Demand*** (1998). Rural Development Department, The World Bank. Agriculture Technology Notes No. 22, December. Available at: http://wbln0018.worldbank.org/essd/essd.nsf/rural+development/aquaculture

This document reviews the continuing growth and importance of aquaculture globally. According to FAO statistics, 1995 worldwide production from aquaculture represented about 21.3 million tons (19 percent) of the total annual fish production from all sources. Aquaculture grew at an annual average rate of 10 percent during the last decade. In contrast, during the same period, the catch of wild fish from both inland and marine waters (capture fisheries) averaged an annual growth rate of less than 2 percent. Moreover, the contribution of aquaculture to human nutrition between 1990 and 1995 increased, while that from capture fisheries declined by about 10 percent. This reversal occurred because an increasing percentage of the wild catch are species of lower value that are being used to produce fishmeal for feed and fertilizer.

- ***The Third International Symposium on Tilapia in Aquaculture***. R.S.V. Pullin, J. Lazard, M. Legendre, J.B. Amon Kothias and D. Pauly, Editors (1996). ICLARM Conf. Proc. 41, 575 p. ISSN 0115-4435, ISBN 971-8709-42-8. Available at: http://www.cgiar.org/iclarm/pubsof/newbooks.html#towards

The proceedings of the Third International Symposium on Tilapia in Aquaculture held in November 1991 in Abidjan, Côte d'Ivoire. The conference reviewed the latest research and discussed recent and future developments in tilapia culture. Attended by fishery scientists from around the world, the conference was the most important meeting held in western Africa and made important contributions to the sustainable development of aquaculture in Africa and other countries. Available in English and French, with translation by Catherine Lhomme-Binudin.

- UNEP World Conservation Monitoring Centre. ***GEO3 Endangered Animals Snapshot***. http://valhalla.unep-wcmc.org/isdb/geo3.cfm

This online database lists endangered species by geographical location (region and country) and animal type. Species are further divided into critically endangered, endangered, and vulnerable categories. Information available about each species includes its native range, when it was listed as an endangered species, and links to resources about the specific animal.

Chapter 7

Forestry: Reforestation, Natural Forest Management, and Agroforestry

Contents

Overview	7-1
Reforestation	7-11
Natural Forest Management	7-15
Agroforestry	7-24
References and Resources	7-28

Forests are a land-use option that in many cases, and on otherwise marginal land, can help meet basic human needs for fuel, food, fodder and building materials.

Forestry Overview

Forestry sector development activities—including reforestation, natural forest management and agroforestry—play an important role in sub-Saharan Africa for several reasons:

- They represent a viable and productive land-use alternative that in many instances, and under a variety of otherwise marginal site conditions, can help meet basic human needs for fuel, food, building materials and fodder for animals.
- Properly managed shrub and bush forestlands are an important element for stabilizing arid and semi-arid grazing lands and keeping them productive.
- On a larger scale, forest protection and management are essential to watershed management. They are also a critical component in stabilizing the water supplies needed to:
  - o upgrade agriculture through irrigation;
  - o allow development of hydropower; and
  - o provide potable water for growing populations and expanding cities.
- Rational forest management engages local people in the stewardship and conservation of habitats, biological diversity and ecosystems.
- There is emerging worldwide recognition of the need for systematic development of sustainable forest management practices, as well as a growing "green" marketplace for sustainably produced timber and non-wood forest products. (See box on the Forest Stewardship Council, which accredits certifiers of responsibly managed forests.)

Forestry Overview

Forestry activities can have a significant effect on environmental conditions in sub-Saharan Africa, for several reasons:

- They represent a viable and productive land use choice
- They are an important element in stabilizing arid and semi-arid lands
- They are critical to watershed management
- They help local people acquire natural resource management skills
- They are a source of commodities for the emerging green market place

Awareness of the threat to natural forest cover has grown significantly since the UN Conference on Environment and Development in Rio de Janeiro in 1992 focused the world's attention on this critical issue. The establishment of the Intergovernmental Panel on Forests (IPF) by the UN Commission on Sustainable Development was specifically intended to counter the danger by encouraging sustainable forest management. The UN Convention to Combat Desertification, ratified by the United States in 2000, focused attention on land use in Africa, including the degradation of forest and shrub lands.

The Forest Stewardship Council (FSC)

FSC is an independent, non-profit, non-governmental organization that supports environmentally appropriate, socially beneficial, and economically viable management of the world's forests by:

- evaluating and accrediting certifiers,
- encouraging the development of national and regional forest management standards, and
- providing public outreach about independent, third-party certification as a tool for ensuring protection of the world's forests for future generations.

Certification of forest management practices and conditions is a first step towards the "green" marketing of forest products. Consumers buying products carrying an FSC label can be assured that their purchase comes from a forest that has been responsibly managed according to FSC principles of forest stewardship:

1. **Compliance with Laws and Principles**: Forest management shall respect all applicable national laws, international treaties, and agreements to which the country is a signatory, and comply with all FSC principles and criteria.
2. **Tenure and Use Rights and Responsibilities**: Long-term tenure and use rights to the land and forest resources shall be clearly defined, documented and legally established.
3. **Indigenous Peoples' Rights**: The legal and customary rights of indigenous peoples to own, use and manage their lands, territories and resources shall be recognized and respected.
4. **Community Relations and Workers' Rights**: Forest management operations shall maintain or enhance the long-term social and economic well-being of forest workers and local communities.
5. **Benefits from the Forest**: Forest management operations shall encourage the efficient use of the forest's multiple products and services to ensure economic viability and a wide range of environmental and social benefits.
6. **Environmental Impact**: Forest management shall conserve biological diversity, water resources, soils, and unique and fragile ecosystems and landscapes, and, by so doing, maintain the ecological functions and integrity of the forest.
7. **Management Plan**: A management plan appropriate to the scale and intensity of operations shall be written, implemented and kept up to date. The long-term objectives of management, and the means of achieving them, shall be clearly stated.
8. **Monitoring and Assessment**: Monitoring shall be conducted to assess the condition of the forest, yields of forest products, chain of custody, management activities, and their social and environmental impacts.
9. **Maintenance of Natural Forests**: Primary forests, well-developed secondary forests, and sites of major environmental, social or cultural significance shall be conserved. Such areas shall not be replaced by tree plantations or other land uses.
10. **Plantations**: Plantations shall complement, not replace, natural forests. Plantations should reduce pressures on natural forests.

More information on the FSC can be found at their Web site http://www.fscoax.org/

Forestry and USAID

Forestry development activities, particularly reforestation, have been an important part of USAID's sub-Saharan Africa development strategy since the late 1970s. A widely discussed fuelwood crisis emerged at that time, coinciding with a period of significant drought and concerns about desertification. Over time, forestry activities have evolved and diversified to include the management of natural forests, woodlands and savannah tree cover; agroforestry (the integration of trees and crops into a farming system); and community-based natural resources management (CBNRM).

USAID forestry development activities must comply with section 118 of the Foreign Assistance Act, which clearly and specifically prohibits the use of

Forestry development activities, particularly reforestation, have been an important part of USAID's sub-Saharan Africa development strategy since the 1970s. Photo: Oregon State University.

USAID funding for the "procurement or use of logging equipment . . . unless an environmental assessment indicates that all timber harvesting operations involved will be conducted in an environmentally sound manner which minimizes forest destruction."

While these regulations are often noted for their prohibitions (see sidebar), they also foster positive measures that advance the conservation and sustainable management of tropical forests. They call for policy discussions

Regulations Affecting Forestry Activities

Section 118 of the Foreign Assistance Act calls for denying aid to several activities affecting forests unless an environmental assessment shows that the activity "will contribute significantly and directly to improving the livelihood of the rural poor and will be conducted in an environmentally sound manner which supports sustainable development:

- Activities which would result in the conversion of forest lands to the rearing of livestock.
- The construction, upgrading, or maintenance of roads (including temporary haul roads for logging or other extractive industries) which pass through relatively un-degraded forest lands.
- The colonization of forest lands.
- The construction of dams or other water control structures which flood relatively un-degraded forest lands."

with USAID partner countries to address the "importance of conserving and sustainably managing forest resources for the long-term economic benefit of those countries." They also stress the need for the agency to support projects and activities that increase national capacity to formulate and implement forest policy, as well as improve forest management. Additionally, in each of their country development strategies, USAID missions must now include an analysis of the actions needed to conserve and sustainably manage tropical forests (Section 118) and to conserve biological diversity (Section 119), as well as the extent to which their proposed programs meet these needs and opportunities.

Items Which Deserve Special Attention

Several threats to natural forests and forestry projects deserve special attention. These include deforestation trends and processes; forest fires; forest resource depletion, such as overharvesting; and unsound government policies.

Deforestation. Deforestation often reflects a larger land-use issue driven by factors outside the forestry sector, including:

- **Misguided subsidies** that lead to forest conversion or degradation.
- **Policy attitudes and decisions** driven by population pressures and employment needs. These may result in resource mining, rather than management and conservation.
- **Underdeveloped capacity** for land-use planning and mapping.
- **Underfunded and understaffed forestry institutions** unable to manage the forest resource base and forest-related activities.
- **Narrowly focused development strategies** that fail to recognize the integrated nature, and the ecological and economic impacts, of land-use decisions.
- **Forest revenue systems** that allow or induce the concessionaire to adopt cost-cutting measures that disregard long-term sustainability of the resource base.
- **Rent-seeking behavior** by forestry and other authorities that sell national forests and timber resources to the highest bidder.
- **Failure to recognize local communities' rights** in forest areas in favor of outsiders, thereby undermining local initiatives for conservation of forest resources.
- **Governmental policies geared towards providing cheap energy** (typically charcoal or wood) to urban areas. Such attitudes distort the economics of forest management operations and plantation forestry.

Reforestation has often been cited by policy- and decision-makers, as well as foresters, as the solution to deforestation. Yet FAO statistics estimate global deforestation rates at about 15 million hectares per year, while reforestation barely reaches 1 million hectares annually. The enormous net loss of forest attests, among other things, to the drawbacks of reforestation, including the high cost of tree planting, reduced productivity of sites under rehabilitation,

Important Policy Issues Facing Forestry Projects

- **Deforestation trends**, which are often driven by improper policy decisions and lack of capacity among local forestry institutions
- **Forest Fires**, used by farmers and herders to clear land for crops and grazing
- **Overharvesting and depletion of forest resources**, particularly by 'high grading' and clear cutting trees
- **Creating a policy environment** to support sustainable forestry projects

and the probable lower value of plantation-grown wood. These costs, however, pale beside the costs of lost ecosystems, biodiversity and timber.

Forest fires. In the forests of Africa, farmers and herders traditionally use fire to clear land and/or promote plant renewal for grazing. Over time these practices tend to degrade forest resource quality. Campaigns to prevent forest fires have not generally been successful. The Center for International Forestry Research (CIFOR) and the World Agroforestry Centre (formerly ICRAF), particularly its Alternatives to Slash and Burn Program, are important sources of information on the biophysical and social dimensions of forest fires and their economic impacts (see www.cifor.cgiar.org/fire-project and www.asb.cgiar.org; both sites include links to other organizations active in this area).

Over-harvesting and/or forest resource depletion. One of the pivotal principles of forest management is *sustained yield*—managing forests to produce a steady flow of the desired products and services over the medium and long term. Yield can be measured both quantitatively, by the volume of existing stock and extraction rates, and qualitatively in terms of product excellence. Activities that undermine sustained yield, such as over-harvesting, *high grading* (the practice of cutting only the most valuable trees and leaving the rest), and sometimes clear-cutting, harm both forests and the various species of animals, trees and plants they harbor. Sustained yield provides the best way to maintain the value of forest ecosystems in the eyes of society, local communities and landowners. Standing forests that are valued by society usually fare better in decisions about appropriate land use and stewardship of the resource base.

Policy Environment. Local policy and institutional frameworks can seriously damage the sustainability of forestry activities. Poor policies can lead to over-exploitation, careless harvesting of products, or failure to invest in proper management. Even more problematic are government policies that undervalue forest cover and its potential products in favor of other agricultural or livestock development options. These options often turn out to be unsustainable because the sites involved are so fragile: relatively poor land that can sustain a forest may degrade rapidly under the stress of farming or grazing. Unfortunately, it is difficult to analyze the suitability of remaining forests for development. Studying them takes time and money, as well as institutional and staff capabilities that developing countries may not possess.

Guidance for Forestry Projects

Potential environmental impacts need to be addressed early in project planning. Sound design criteria include:

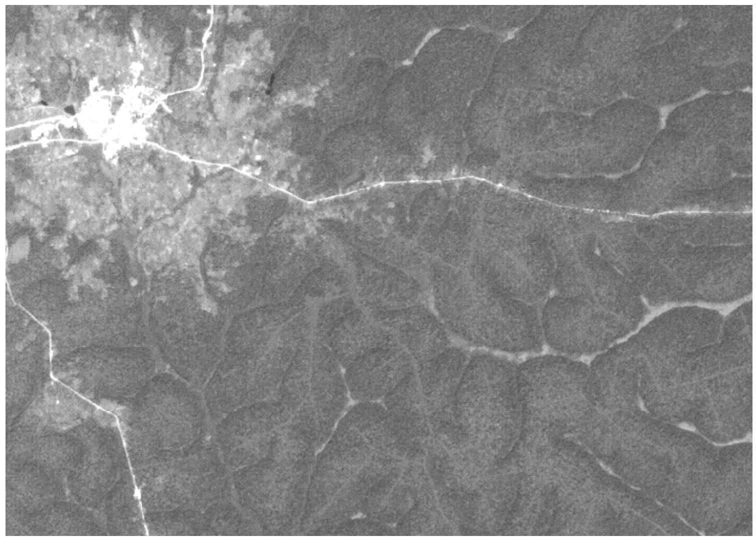
- Ensuring community participation in the design and management of forestry projects
- Using the best available tools to design the project, including modern GIS and mapping technology, satellite imagery and field studies
- Considering such things as policy design, public outreach, capacity building and the role of women when developing forestry projects

Guidance for Forestry Projects

As with other program and project development activities, potential harm to the environment needs to be addressed early in the design process to avoid costly mistakes or project failures. Sound management practices and design criteria that can help prevent environmental damage and project failure are summarized below.

Community Participation: Most community forestry has traditionally focused on helping local communities obtain forest resources for basic needs through reforestation or agroforestry interventions. Many recent projects, however, have involved community management or co-management of *natural forests*—with significant and (to some) surprising results. Communities genuinely engaged in participatory management of natural forests have shown they understand that they will have both *rights* to the resource (sharing of the benefits stream of a productive and managed natural forest) and *responsibilities* for it (accountability for safeguarding the resource base).

This sharing of rights and responsibilities has led to outstanding examples of community action to protect and conserve the forest, respecting the



Satellite imagery—such as this photo showing logging and logging roads in Cameroon—can be a useful tool in planning forestry projects.

management plan's restrictions and defending forest areas from the inroads of others. It is essential to ensure that government supports the community's right to protect the managed forest from third parties who wish to exploit its resources.

Tools for Forestry Projects. Important tools for forestry project design include:

Maps can show where sustainable harvesting of forested areas might not be possible, such as those with steep slopes, poor soils, concentrations of endangered species, or prime habitat for conserving biodiversity.

- **Modern technologies.** Sound forest management planning for all activities begins with an assessment of the current forest resources, classifying ("stratifying") different areas according to the way they are used. In the past, this involved tedious and labor-intensive comparisons of current field conditions against existing data based on aerial photography and topographical maps. Access to new technologies, such as geographic information systems (GIS), global positioning systems (GPS) and enhanced satellite imagery, make it easier to classify different areas. Using these, project planners can quickly prepare maps of the program area showing the overall layout of the land and the inherent qualities of its various sites.
- **Maps.** The scale and scope of many small-scale forestry activities are typically larger than those of the agriculture sector. Good maps are essential to planning, implementing and monitoring these activities. Maps can show areas where sustainable harvesting might not be

possible, such as those with steep slopes, poor soils, concentrations of endangered species, or prime habitat for biodiversity conservation. Activities in these areas may be technically difficult, costly, or environmentally harmful. Maps also illustrate the areas where protection and conservation are necessary, and where more detailed surveys are required to make sound management decisions.

- **Field studies.** Sustainable forest management requires an interest in the complexities of the forest ecosystem and the skills and experience to understand cause and effect in forest management. Classifying different forest areas to distinguish between those suited for production and those needing conservation is the first step in sound management. However, data about the effects of forest management on specific types of forests are insufficient in many countries of sub-Saharan Africa. The information needed to fill in these gaps can be generated by keeping good records of stand conditions, of the activities (both planned and unplanned) that have taken place within the forest, and of the follow-up observations of field staff.

Forestry Policy. Important considerations for forestry policy include:

- **Policy design and public outreach/participation.** A constant issue with small-scale, experimental or pilot forestry projects is that their promising findings and results are often not widely disseminated and cannot be used by others to promote large-scale change. These activities generate important lessons that can illuminate the policy, administrative, economic and institutional barriers to promoting sound field activities on a far broader scale. Program implementers (NGOs, governmental forest services and donors) should make a concerted effort to apply important lessons learned to larger policy and program contexts.

  Forestry program implementers should also engage the government in policy dialogue. While it is true that this dialogue takes time as well as staff or contractor resources, it is essential to building awareness and capacity at the national level and overcoming policy errors that lead to deforestation or undermine sustainable forestry production and conservation programs.

  In many developing countries of sub-Saharan Africa, the forestry sector is also confronted by a public relations challenge. Public awareness and environmental education campaigns ensure that lessons learned in the field receive wider attention. Encouraging forest recreation, ecotourism and public awareness among the emerging middle class can create a home-grown constituency for sustainable forest management. Similarly, an advisory council representing all stakeholders should use key lessons learned to advise the government forestry service and sector decision-makers on issues beyond forest management or reforestation technologies.

Encouraging forest recreation, ecotourism and public awareness among the emerging middle class can create a home-grown constituency for sustainable forest management.

- **Capacity building.** Certain obviously harmful activities—such as clear-cutting, constructing poorly built logging roads, harvesting on steep slopes, and making inroads into protected areas and ecosystems known to be sensitive—can be readily addressed. However, much of the eventual success of forest management endeavors will lie in building institutional and human resource capabilities for forest stewardship in

The program and exit strategy for any NGO forestry project should ensure that the technical and professional services needed for participatory forest management are institutionalized.

partner countries. This must include both governmental and non-governmental capabilities—the former to ensure that the conditions for sustainable forestry management are present in a given country, and the latter to create a constituency to monitor those conditions' development and implementation.

- **Appropriate roles for the government forest service.** Many small-scale forestry development activities are carried out under the aegis of local or international NGOs working in collaboration with communities living in or near forest areas. These programs cannot, and should not, operate in isolation from government forestry services.

  The program and exit strategy for any NGO should include ensuring that the technical and professional services necessary for participatory forest management are institutionalized. Although local communities may be the *de facto* implementers of forest management plans, they will continue to need technical advice and assistance in forest resource assessment, management planning, silviculture and harvesting practices, among other skills. The government's forestry service or department can provide this service, which requires government commitment to a trained staff, adequate budget, and proper equipment and materials.

  Situations leading to conflicts of interest or lack of transparency should be anticipated and prevented. For example, experience has shown that the unit in charge of preparing forest management plans should not be the body to approve them as well.

- **Balancing reforestation with natural forest management**. As noted earlier, many people still have the mistaken impression that reforestation is the solution to deforestation. In fact, continued efforts by governments and their donor partners to counter deforestation through reforestation projects is one reason that natural forest management capacities and systems remain underdeveloped in sub-Saharan Africa. Even more disturbing are well-intentioned reforestation campaigns and programs that lead to the final clearing of secondary natural forests in order to establish tree plantations.

  In most countries, as discussed earlier, deforestation is driven by policies and programs outside the forestry sector, and it easily outpaces the reforestation rate. It makes little sense to pour scarce resources into reforestation and agroforestry if the forces leading to degradation (e.g., high-grading and illegal logging) and deforestation (e.g., land clearing because of exhausted soils and population growth) remain unchecked.

- **Balancing short-term pressures with long-term sustainability.** National policies must also balance short-term pressures on forests with long-term sustainability. The long gestation period for forestry projects requires a supportive, stable policy environment and the capability to produce planned benefits. Since many of the pressures on forests arise from local people's efforts to meet urgent, basic needs, forestry development programs must supply tangible benefits for communities on a shorter time scale. These short-term returns should, however, be coupled with longer-term sustainable payoffs.

Many sub-Saharan African communities already depend on resources harvested from shrinking or degraded forests. Forestry programs cannot expect local communities to absorb all of the tradeoffs (such as loss of production) required to implement sustainable forest management, even if the measures are the direct results of their own unsustainable use of the resource base. Governments and their donor partners must, therefore, create appropriate incentives that allow local communities the luxury of planning for the future. Again, enabling local communities to profit from better management of the forest resource base has proven to be the most effective method for guaranteeing conservation and wise use of forests and woodlands.

In most countries, deforestation is driven by forces outside the forestry sector, and it easily outpaces the reforestation rate. It makes little sense to pour scarce resources into reforestation and agroforestry if the forces leading to degradation and deforestation remain unchecked.

- **The role of women in the forestry sector.** In sub-Saharan Africa as in many other parts of the world, women—particularly as gatherers of fuelwood—play a predominant role in the traditional use of forest resources. Women's knowledge, views, needs and involvement should be built into all forestry activities. Forming a women's forestry committee, or similar local organizations, is often fundamental to ensuring the representation and participation of the entire community.
- **Expanding from small-scale/pilot projects to national programs**. In many sub-Saharan African countries, there is a growing awareness of the potential of sustainable forest management as a viable and productive land-use option. Pilot projects for community-based management of natural forests now complement decades of investment in reforestation and agroforestry programs. But, despite growing experience, few African countries can claim that they have a self-sustaining development program in place for the forestry sector. As discussed earlier, short-sighted national policies continue to inhibit the spread of sustainable development approaches.

  Small-scale forestry development activities may overcome these constraints locally because they have the resources or the latitude to operate under special, project-specific conditions. However, if the nation as a whole is to develop a system favorable to sustainable forest management, small-scale activities need to influence overall rural sector policy and programming. Lessons learned in the field must inform national discussions of issues such as governmental capabilities; staffing and budgets for forestry; strategies for participatory development; the marketplace for timber and non-wood forest products; and the vital role of forest cover in watershed stability, biodiversity conservation and wise land use.

Beyond Forestry

Forestry, Watershed Management and Other Environmental Services. USAID natural resource management programs in Africa are beginning to take water resource issues more seriously. This trend needs to be actively encouraged. Considerable attention is currently being focused on the full range of environmental services provided by forests in order to incorporate their value into program planning. Maintaining forest cover preserves forests' critical watershed function, which is of growing importance in Africa as demand for hydropower, potable water and irrigation increases. Such benefits constitute a powerful new rationale for investment in forestry projects (e.g., Landell-Mills and Porras 2002; Nasi, Wunder and Campos, 2002; Smith and Scherr 2002 and World Bank 2002).

Forestry and Integrated Land Use Management: Improving the Land-Use Mosaic. Most small-scale reforestation or tree planting is used to rehabilitate degraded areas and/or meet basic community needs for fuel, food, wood and fodder. If done correctly, tree planting can also support environmental stability by containing erosion and by contributing to a mosaic of sustainable land use.

Nevertheless, in the case of degraded areas, the primary causes of the damage must be addressed first; simply reforesting the degraded area will not resolve the problems. In sub-Saharan Africa, for example, reforestation solutions are often applied to land that has been overgrazed and eroded. Reforestation will not address the reasons for the excessive grazing, which may simply shift to other areas where the cycle of degradation will begin again.

The next three sections take an in-depth look at three forestry strategies—reforestation, natural forest management and agroforestry. These sections describe possible impacts, propose mitigation solutions and offer design guidance for each strategy.

Reforestation

Brief Description of Sector

Small-scale community reforestation programs aimed at providing farmers and smallholders with appropriate ways to use their marginal land are often a sustainable development option. Typically, such programs introduce fast-growing tree species—often exotics such as neem, pine or eucalyptus—to

Reforestation programs introduce fast-growing tree species—often exotics such as neem or eucalyptus—to meet the community's basic need for fuelwood, building materials and fodder. Photo: IFAD.

meet the community's basic need for fuelwood, building materials and fodder. These programs generally involve establishing temporary local or farmstead nurseries and providing minimal technical advice for interested farmers.

To succeed, reforestation programs must have a clear understanding of the market demand and long-term potential for forest products. Programs that offer incentives for reforestation need especially careful planning and management to avoid economic distortions and misuse.

Reforestation projects can often take advantage of the lower opportunity costs of off-season labor and marginal lands. The most serious challenges for small-scale reforestation programs are (1) finding appropriate site/species matches, (2) ensuring that farmers perform required maintenance, and (3) protecting the saplings from grazing animals and fire.

There are also plantation forestry solutions for larger projects that are sometimes attempted simultaneously in multiple small-scale settings, including seed banks, tree seed orchards, centrally operated nurseries and reforestation incentives. One popular technique involves restocking cut-over or secondary forests with enrichment plantings. Strips or gaps in existing growth are cut and replanted with nursery-raised seedlings, normally of high-value native species. However, if the seedlings belong to a slow-growing tree species, their potential value can be overwhelmed by the years of labor and production inputs necessary to keep them free of pests and otherwise ensure their survival. Experience has shown that this type of plantation is economically difficult to justify.

Fundamentally, all successful reforestation programs require a clear understanding of market demand for forest products, as well as their long-term economic potential. Reforestation incentive programs, in particular, need careful planning and management to avoid economic distortions and misuse (see Scherr, White and Kaimowitz 2002).

Potential Environmental Impacts

Reforestation Issues

Small-scale reforestation programs are often a viable development option. They can, however, have adverse environmental effects, including:

- Loss of local biodiversity, including useful niche species
- Introduction of exotic or non-native tree species
- Use of agrochemicals on tree plantations
- Conversion of natural forest to tree plantations
- Disruption of local communities' current land uses

Biodiversity conservation. Plantation programs that establish an extensive area of monoculture (planting with a single species) may offer certain benefits, such as restoring protective forest cover and producing valuable timber and non-wood forest products. Typically, however, such plantations are spread across an area without regard for its basic topography. Native plants suited to special locations—such as stream bottoms, ravines, or niche habitats for wildlife conservation—can be disturbed or destroyed. Plantations also use exotic tree species (e.g., *Eucalyptus spp*.) in lieu of disappearing local species with lower short-term economic value. For example, Eucalyptus are often planted on degraded lands, as well as on slopes and ridges that lack topsoil, in the hope that they will restore soil quality, prevent erosion and generate quick economic returns for impoverished families. Unfortunately, these species neither prevent erosion nor restore soil quality.

The Dilemma of Exotic Species. No discussion of the effects of these activities would be complete without addressing the controversy over the use of exotic species. Typically, concerns are voiced about their replacement of local species that may be disappearing.

An outright ban on the use of exotic species for plantations makes little sense and sets a disturbing precedent—after all, many agricultural crops are, in effect, "exotic species." Nevertheless, project planners should examine whether a local species might be used with the same success to produce the desired commodities, quickly and at a reasonable cost, and thereby meet the needs of the local people.

Plantations and agrochemicals. Like their counterparts in agriculture, single-species forest plantations often require extraordinary measures to protect them from pests and diseases. These measures often have substantial materials and labor costs, require farmer training, and pose serious toxic risks. On degraded sites, efforts to increase productivity may also require the use of fertilizer, which could lead to *non–point source pollution* (pollution from diffuse sources, often carried via runoff).

Conversion of natural forests. Reforestation programs can replace wood and other forest resources unsustainably harvested from threatened natural forests. The idea is to plant new forests on deforested or otherwise sparsely wooded terrain. Unfortunately, strong promotion and extension efforts, or attractive reforestation incentives, may encourage these programs to also convert secondary natural forests (which have already been harvested or high-graded) into tree plantations. This should be avoided, since managing an existing natural forest often costs less than starting and maintaining a new plantation and provides a wider range of environmental benefits.

Community displacement. Reforestation schemes that displace people or communities without compensation can be devastating. Fortunately, such schemes are rare. Reforestation programs can, however, make life harder for local people by disrupting their existing land-use strategies. For example, taking farmland out of fallow for reforestation can lead to lower food production. Even degraded lands or wastelands may still be places where local people find part of their subsistence needs. For example, women who now collect fuelwood on highly degraded brush lands will no longer be able to do so if the land is converted to a tree plantation. Degraded areas may also serve as grazing land that cannot be taken out of production without harming herders' and stock-raisers' livelihoods.

Sector Program Design—Some Specific Guidance

Using reforestation and plantation technology can be exceedingly complex and costly. It involves many steps, from seed collection and nursery production to plantation protection and maintenance. To make a project as sustainable as possible, planners need to consider these critical elements: (1) site/species match; (2) genetic selection of seed source; (3) site preparation; (4) timely planting; (5) weeding; and (6) protection from fire and grazing animals.

Projects can help avoid environmental damage by following these guidelines:

- Plantations should not replace natural forests, not even secondary forests that have already been harvested or high-graded.
- Reforestation plans should consider the effects they may have on the land-use mosaic of the area around the plantation, including impacts on natural forests, biodiversity conservation and alternative land uses.
- Native species should be preferred to exotic species. Any exotic species should be fully tested in an introductory trial under conditions similar to those at the site, to ensure its adaptability and avoid introducing noxious weeds.
- Every effort should be made to avoid large-scale, contiguous blocks of monoculture plantations. Site planning should take into account natural topography—such as ridges, valleys and the margins of watercourses—and, where possible, leave natural corridors of native vegetation suited to such areas.
- To enhance the plantation's robustness, include areas of different ages to spread out the eventual impact of harvesting.
- The plantation's layout should make it easy to transport harvested timber without causing soil erosion or siltation in adjacent watercourses.
- In areas that are prone to wildfires, the forest layout should include firebreaks and provide access for fire equipment.
- To forestall soil degradation and hydrological problems from clearing land for planting, the design should include:
    - contour planting or *bunding* (making earth embankments that follow the contours of the land; intended to hold soil and moisture on medium slopes)
    - buffer strips of native vegetation, and/or

Guidelines for Reforestation Projects

- Don't replace natural forests (even secondary forest).
- Consider the effect of reforestation on all existing uses of the land.
- Prefer native to exotic species.
- Avoid large blocks of monoculture; leave natural vegetation in special areas
- Stagger ages of different planted areas
- Make it easy to transport timber without eroding soil
- Include firebreaks and access to fire equipment as needed
- Use soil conservation measures when clearing land for planting
- Close off degraded marginal slopes
- Use integrated pest management; follow USAID guidelines if applying agrochemicals

    - gully plugging (constructing a series of barriers in a gully to prevent erosion).

- On steep and marginal slopes in need of rehabilitation, close the area to protect it from fire, grazing animals and illicit tree cutting. It is more cost-effective, per unit area treated, to let the vegetative cover grow back naturally rather than reforest the area. If vegetative cover does not regenerate, other lower-cost options include direct seeding, use of cuttings, and bare-root planting stock.

- All use of agrochemicals should conform to USAID regulations and every effort should be made to foster integrated pest management approaches. (See the chapter on "Integrated Pest Management" [IPM] in these *Guidelines*)

Environmental Mitigation and Monitoring Issues

Table 1: Mitigation and Monitoring of Reforestation and Plantation Forestry Activities

Adverse Impacts	Indicators	Causes	Mitigation Measures	
			Specific	General
Loss of forest ecosystem quality	• Natural forests and ecosystems replaced by artificial plantations • Over-dependence on exotic plantation species • Decreases in the supply of essential products and services of the forested areas	• Misunderstanding of the potential returns from natural forest management • Lack of community inclusiveness that leaves out certain segments of society, e.g., women, herders • Misguided incentive programs or subsidies • Market failures that undervalue native species and timber	• Improved integrated program planning, resource assessments and site stratification • Clear criteria for selection of suitable sites • Promotion of values and methods of natural forest management • Testing and development of native species as integral part of reforestation programs	• Developing a reforestation master plan or program strategy • Promoting research and development on native species for reforestation programs • Understand-ing the micro- and macro-economics of sustainable forest man-agement • Enhancing national government's capacity for land-use planning
Unsafe or unauthorized agrochemical use in seedling nurseries	• Program records and physical evidence • Poisoning or pollution accidents	• Failure to carry out environmental assessment of pesticide use • Poorly trained staff or participants • Improper storage or disposal of chemicals or byproducts	• Greater reliance on IPM solutions for pest problems • Improving training packages and pesticide handling guidelines • Training and fielding para-technicians from within farmer community to advise peers	• Development of national agro-chemical use guidelines that include forest nurseries

Adverse Impacts	Indicators	Causes	Mitigation Measures	
			Specific	General
Unintended changes in land use or shifting of use pressures to other areas	• Current users of degraded lands dis-placed by reforestation programs	• Treating the symptoms rather than the causes of degradation • Misguided incentive or subsidy programs	• Improve integrated program planning, resource assessments, and site stratification	• Enhance national government's capabilities for land-use planning

Natural Forest Management

Brief Description of Sector

Sustainable natural forest management is an effort to develop existing natural forests as managed ecosystems that maintain the rights of their owners (states, communities, individuals) to the benefits of commodity production, while ensuring biodiversity conservation and environmental benefits. Wood and non-wood forest products are extracted in ways that foster a sustained yield, assuring natural regeneration of trees affected by harvesting and avoiding depletion of the natural productive capital of the forest. Good management also upgrades the forest resources—in both quantitative and qualitative terms—through thinning, culling and selective harvest.

Over-exploitation of forest resources for their products may threaten their survival, at least locally. The yohimbe trees in this photo have been felled and stripped for their bark, valued as an aphrodisiac.

Natural forest management addresses several rural development needs and opportunities:

- It represents *a viable and productive land-use alternative* that in many instances—using a variety of otherwise marginal sites—can contribute directly to basic human needs, as well as providing a source of raw materials for wood and non-wood forest-based industries that create employment, income and export earnings.
- It *offers significant economic advantages.* By using such practices as low-impact logging to avoid the environmental and social damage associated with land degradation, it eliminates the high costs of rehabilitating degraded forest areas, and is likely to provide opportunities for an earlier and steadier benefits stream.
- Large-scale forest protection and management will be *essential to enhancing the critical watershed function of forests* needed to upgrade farming systems through irrigation, develop hydropower, and provide potable water supplies for growing urban populations.
- Rational, participatory forest protection, management and use offers *the best chance to engage local people in the stewardship and conservation* of large areas of habitat that sustain the unique, globally important biological diversity of Africa.

The forest resource base as a key to wise stewardship. Natural forest management provides an important way to help people assign value to the resource base. Where local people or companies realize that they will benefit from the investment in forest management, protection and production, they quickly realize that it is also in their best interest to protect the forests from over-exploitation.

Natural forest management—a proactive measure for biodiversity conservation. At one point, supporters of natural forest management, particularly those involved in logging, seemed to be in direct conflict with the proponents of biodiversity conservation. In recent years, however, growing field experience has shown that natural forest management can support biodiversity conservation goals. While forest management does not provide pure biodiversity conservation or absolute protection, it is much better than the typical next choice for using tropical forestlands—conversion, often irrational and destructive, to agricultural and grazing land.

In many tropical countries, biodiversity conservation needs—beyond some issues like endangered species—are not well known. Even less is known about managing for biodiversity conservation or the more delicate matter of reconstituting biodiversity assets. For this reason, proactive natural forest management aims to maintain forest cover and natural habitats that can have wide-ranging, positive impacts on biodiversity conservation. There is growing acceptance of certified forest management plans that are environmentally responsible, socially beneficial and economically viable. As mentioned earlier, a global network of standards for certified natural forest management is spreading; see box on the Forest Stewardship Council (FSC) on pg. 2 above and the discussion on forest certification in the next section. For details on the progress of certification efforts in Africa see the FSC international Web site http://www.fscoax.org.

Natural Forest Management

Sustainable natural forest management seeks to use forest products, including timber, while respecting local rights and safeguarding the environment. Plan carefully to avoid these common environmental problems:

- Harm to fragile ecosystems and endangered species
- Soil erosion and compaction, potentially leading to runoff, fertility loss, siltation of water bodies and downstream flooding
- Unintended in-migration and resource mining using logging roads
- Damage to residual tree stands after logging
- Social problems and loss of access to traditional resources for local communities

Potential Environmental Impacts of Unsound Forest Use

Disturbance of fragile plant and animal communities and the biological processes that sustain them. Harvesting timber and non-wood forest products may adversely affect biodiversity by harming fragile or endangered species of plants and animals and their habitats. Direct and indirect over-exploitation can fragment forests, disrupting animal behavior and migration patterns. It may also damage aquatic habitats and wetlands when, for example, watercourses are used to transport logs.

Soil and site degradation. Unsound logging or harvesting practices can cause erosion, soil compaction, runoff problems, and contamination and/or siltation of water bodies. The extent of the damage depends on slope, soil depth, and soil type and on how close the activities are to watercourses. When this damage becomes acute or covers large areas, its cumulative effects can destabilize the watershed, leading to significant sedimentation of watercourses and downstream flooding.

Damage from land clearing. Clearing land for tree planting may result in erosion, uncontrolled runoff from the site, changes in the hydrological cycle, soil compaction or fertility loss. If kept in check through careful planning, these problems should disappear once the trees are established. However, they can be catastrophic if appropriate preventive measures are not part of plantation design.

Forest roads and access (skidding) trails. Improperly constructed forest roads, particularly those that fail to take watercourses and drainage into account, quickly lead to erosion and runoff problems. Badly built roads can generate as much as 10 times more erosion than properly engineered ones. Furthermore, unless properly controlled, penetration and service roads intended only for management and harvesting purposes may expose the forest to unintended uses, such as in-migration; conversion to agriculture, livestock, hunting, and mining; illegal fuelwood extraction and/or charcoal production; and colonization by invasive plant species.

Damage to the residual stand after logging. Improper logging practices, including poor felling of trees, excessive skidding of logs through tree stands, and careless transport of logging equipment, can damage the forest's remaining trees and plant communities. These practices leave the residual forest open to pest invasion and weaken its health or regeneration capabilities. Similarly, leaving logging residues ("lops and tops") in the forest can impede natural regeneration and increase the danger of forest fire. Taking too many trees of any one species may eliminate seed sources necessary for natural regeneration and lead to changes in the composition of tree stands.

Human environmental impacts. Activities in previously unmanaged forest areas can have damaging impacts on local communities. These areas are often used for traditional hunting and gathering, and the activities can reduce community access to forest resources. The influx of "outsiders" involved in forest management and harvesting can lead to conflicts between local inhabitants and forest workers, to the spread of sexually transmitted diseases such as HIV/AIDS, and to hardship and social disintegration within the local communities dependent on adjacent forests.

Externalities that limit adoption of reduced-impact logging

Potential reasons that firms don't adopt reduced-impact logging include:

- A perception that reduced-impact logging systems are more expensive than conventional practices;
- The failure of conventional accounting systems to factor in the direct and indirect costs of wasted wood;
- The lack of trained people to implement new practices;
- Low net profit margins that lead loggers to maximize throughput (i.e., aim for the highest possible volumes of wood) rather than overall profit**;**
- Transition costs (to replace machines and train workers);
- Undervaluation of standing timber; and
- Failure to enforce existing environmental regulations.

Source: Holmes et al., 1999.

Sector Program Design—Some Specific Guidance

Paying more attention to economics. Attention should be given to the economics of natural forest management to ensure that:

- communities and concessionaires are optimizing their investment returns (microeconomics).
- country-level planning considers unit cost per area (e.g., the investment needed for a forest to sustainably produce a ton of lumber per hectare) in choosing among different sector and land-use options (macroeconomics).

In many cases, the steps needed to make a forest sustainably productive must be made (and paid for) well before production rises rises enough to pay for them. In the developed world, the key to pre-commercial activities to improve timber stands has been a sound understanding of the costs involved. Because it is so difficult to project timber prices at the end of the next rotation 30–60 years down the road, many European countries, Canadian provinces, and American states offer modest subsidies and incentive programs to convince forest owners to make such investments, which could be applied to African owners as well.

If innovative natural forest management programs are to be effective in Africa, stakeholders will need to pay attention to the microeconomics of their use. Can present activities finance such investments, or will government and/or donors need to chip in? Do local people in government-promoted, community-oriented natural forest management projects understand the costs and benefits in real terms? Calculation of both economic costs and financial returns should be a routine part of these programs.

Certification—a golden opportunity. The emerging worldwide acceptance of certification for the "green marketing" of sustainably produced forest products is a golden opportunity to bridge the gap between conservation and forest production. Although this comparative advantage has yet to be fully realized in the form of premium prices for certified timber products, certification has given several countries a much-needed edge in the marketplace.

Reducing the Paperwork Burden

A project can raise the payoff for constructing a sustainable forest management plan by using the plan:

- For "green marketing" certification
- To comply with USAID Regulation 216
- To demonstrate the project's sustainability to donors
- As a template for monitoring and evaluating the project

Consolidating paperwork this way saves time for donors and projects, making sustainable planning more feasible.

Certification, however, costs money—to finance the enhanced forest management measures to meet sustainability criteria, and to pay for certification assessments and regular monitoring. Until a premium price structure on the world market becomes routine, the payoff for such investments will be longer term—in greater operating efficiency from a satisfied work force and in the growing value of a well-managed forest. USAID missions and partners need to see whether sustainable forest management plans can be used for multiple purposes—for certification, for compliance with USAID Regulation 216, for analysis of their sustainability as development activities, and as a template for monitoring results associated with program performance. (For an important discussion on forest certification and communities, see Molnar 2003.)

If donors are able to coordinate so as to consolidate requirements in this way, repetitive examinations of these plans by different donors should not be necessary. This should substantially lessen the cost burden on aid recipients in this sector.

Reduced-impact logging. Sustainable forest management and harvesting activities rely on the principle of sustained yield—the amount harvested should equal the annual growth increments. In many instances, however, understanding and maintaining the growth patterns of mixed tropical forests takes time. Accordingly, a conservative approach to harvesting, using reduced-impact logging, is recommended in order to avoid or reverse unsustainable exploitation patterns. Reduced-impact logging includes the following best practices:

- Design forest roads and skid trails to minimize the distance logs must be hauled, reducing damage to the forest floor.
- Use directional felling to ensure that harvested trees fall towards the skid trails and avoid harming the residual stand.
- Set minimum diameter limits and maximum harvest densities.
- Ensure good spacing among harvest trees to leave forest cover intact.
- Leave seed trees.
- Avoid cutting trees or stands that serve as critical habitat for animals and birds.

Worldwide experience suggests that reduced-impact logging—when well planned and executed—can actually lower costs and increase profits for timber extraction, while mitigating its impacts on the environment.

Worldwide experience suggests that reduced-impact logging—when well planned and executed—can actually lower costs and increase profit margins from timber extraction, while mitigating the environmental impacts of harvesting. Its achievements include:

- Upgrading the operating capabilities and efficiency of timber harvesting crews, which improves their employer's competitiveness.
- Leaving behind a residual stand with less damage—and a higher future value—giving stakeholders a strong reason to protect the forest from subsequent incursions or conversion to other uses (agriculture or livestock husbandry).
- Minimizing impacts on the ecology of the forest ecosystem, thus helping to conserve its biodiversity.

Much of the investment in reduced-impact logging involves retraining forest workers. Training both provides the immediate economic benefits discussed above and at the same time teaches foresters to value the future economic and ecological benefits of managed forests—an important and very practical lesson for forest conservation.

Rules, Roads, and Realism

The relationship between roads and forests is a complex one. Despite considerable hype and media coverage, the building of new roads does not necessarily lead to forest destruction. The lack of political will and capacity to guide and control what happens *after* a road penetrates an area is far more destructive. Too often, incentives and controls for sustainable forest management are not in place or are distorted by the political process. Much time and energy may be spent fighting against new roads which could be better spent planning for and building roads that will contribute to sustainable local development.

Building new roads does not necessarily lead to the destruction of the forest. Far more destructive is the lack of political will and capacity to control what happens **after** ***a road penetrates an area.***

The condition of many roads throughout the tropical region make rational forest management—and, for that matter, many other production systems—quite difficult. The reason is that the high transport costs resulting from bad roads erode the potential for forest management investments. Logging often contributes to the deterioration of poorly made roads. Water and mud from skid trails or interior forest roads is channeled onto the poorly designed surface of the main road. Heavily laden logging trucks then abuse the road base, making conditions worse. Since these difficult road conditions delay and damage trucks extracting timber, loggers look for every way possible to cut costs—high-grading the forests and paying minimal amounts to local people who extract timber. The high-grading degrades the forest; the low pay limits the development of the local economy. If roads are built badly, with inadequate drainage structures despite typically high rainfall, they cannot be considered development; they are an economic, social, and environmental liability.

Road development can proceed more smoothly:

- if the full social and ecological costs are factored in from the beginning (including the costs of managing the process of colonization that often follows the building of the road); and
- if there is a requirement to plan and implement forest management in the areas through which the road will pass, with appropriate controls and incentives.

Environmental Mitigation and Monitoring Issues

Table 2: Mitigation and Monitoring Issues for Natural Forest Management

Adverse Impacts	Indicators	Causes	Mitigation Measures	
			Specific	**General**
Forest degradation from unsustainable harvesting practices	• Harvesting records or physical condition of the residual stand • Changes in the availability of forest-supplied basic needs such as fuelwood or medicinal plants • Damage to remaining trees • Erosion along skid trails and logging roads • Trees cut but not removed from forest • Poor regeneration of key species for wood or non-wood products • Continued occurrence of forest fires	• Land tenure uncertainties—high costs, low benefits • Market failures • Lack of community inclusiveness leaving local stakeholding groups, such as women and herders, out of decision-making • Errors in resource assessment • Failure to respect annual cutting plan or plan for selecting trees to be harvested • Poorly trained logging and harvest crews, forest owners, concessionaires or other participants • Poorly laid-out road or skid trail system • Unauthorized use by third parties not addressed in the plan or management agreement • Lack of understanding of silvicultural practices	• Ensure that results of monitoring are factored into revisions of the management and annual operational plans • Enhance training in reduced-impact logging for forest management staff • Train and field additional para-technicians from farmer community to advise peers • Enhance record-keeping on the causes and effects of the stand's response to interventions • Develop forest fire prevention/manage-ment program	• Examine micro- and macro-economics of sustainable forest man-agement to ensure proper incentives for investments • Routinely revise forest management plans and review monitoring records • Conduct research and development on growth, yield, and impact (eco-nomic, social, environmental) of sustainable forest man-agement on natural forests

Adverse Impacts	Indicators	Causes	Mitigation Measures	
			Specific	General
Increased threats to endangered species or biodiversity assets	• Logging or forest disturbance in protected areas or on sections set aside to preserve biodiversity values in productive forests • Changes observed in composition of flora and fauna	• Failure to take biodiversity values into account during forest management planning or execution • Uncontrolled hunting • Forest fires • Roads that allow improved access to sites by poachers, gatherers, farmers and miners	• Conduct additional participant training and field-based inspections by supervisory staff • Control forest access • Develop forest fire monitoring, prevention, and control systems	• Review the basic forest management plan and ensure that proper prescriptions are in place • Increase training in the local community about conservation rights and responsibilities

Agroforestry

Agroforestry Products and Services

Beyond timber, trees in agroforestry systems can yield many valuable *products*, such as:

- Food
- Fodder
- Fuelwood
- Poles and rustic building materials
- Fiber
- Mulch
- Medicines and cosmetics
- Oils and resins

In addition to their role in improving degraded sites, agroforestry trees may serve important *functions* in the farming system, including:

- Improving crop field microclimate
- Conserving soil, enhancing soil fertility and suppressing weeds
- Anchoring a living fence or demarcating a field boundary
- Sequestering carbon to slow the rate of global climate change
- Protecting biodiversity
- Stabilizing watersheds

Brief Description of Sector

Agroforestry is a better use of marginal or infertile land than traditional farming, and can be particularly important where smallholders have expanded onto fragile, sloping or hilly areas.

Agroforestry is the practice of adding a tree component to common farming systems. Better reflecting the diversity of natural systems, the combination enhances the overall sustainability and productivity of agriculture. In a farming system, trees can provide an array of environmental and economic benefits. Agroforestry is a better use of marginal or infertile land than traditional open-furrow agriculture, and can be particularly important where smallholders have expanded onto fragile, sloping or hilly areas. Agroforestry can also ease growing demographic pressures on land use in the near to medium term. This is especially true where restricting access to degraded land in order to restore it would involve undue hardship and, in effect, turn local people into environmental refugees.

Trees can help crops in a number of ways. Some trees send their roots deep into the subsoil, absorbing moisture and nutrients, and returning them to the soil as leaf litter or prunings. Chopped into mulch, pruned branches can help suppress weeds and maintain soil moisture. Many trees can enrich the soil by fixing nitrogen. Trees with a light, thin canopy can help certain crops by sheltering them enough to reduce the rate of evapotranspiration while allowing them enough sunlight to grow. When planted as windbreaks, contour hedges or living fences, trees protect crops and the soil from heavy winds and rain. Trees may also, of course, have direct economic value themselves by producing fruit, nuts, bark, fodder, timber and fuelwood.

There are two basic types of agroforestry systems: **simultaneous and sequential**.

In **simultaneous agroforestry,** the tree and crop components grow at the same time, though they may compete for light, water or nutrients. Examples include *home gardens* that incorporate useful trees; *alley cropping*, in which crops are planted between rows of shrubs or trees; and several types of *silvopastoral* systems, which combine shade-tolerant grasses with trees useful for timber, fodder and/or shading livestock.

In **sequential agroforestry,** the maximum growth of the crop and the tree components occurs at different times, even though they may have been planted at the same time and quite close together. This minimizes competition for light, water and nutrients. Examples include:

- *Taungya* farming, which is much like alley cropping in that trees and crops grow side by side for a couple of seasons. When the tree canopy closes and blocks out sunlight, the farmer moves the planting of crops to fields with younger trees, leaving the older trees to form a tree plantation.
- In the *shifting cultivation* typical in many parts of Africa, trees and bushes grow wild on fallow fields; in the *improved (*or *enriched) fallows* system, farmers sow or plant useful trees and bushes on a harvested field before leaving it in fallow.
- *Multistrata* systems involve planting annual crops with several species of trees. The tree species vary in size, shape and use (fruit, timber, etc.) and grow to form two or more canopies (strata) of different heights. Leguminous ground cover is often planted to control weeds and provide fodder.

For both types of agroforestry, trees are chosen to suit different ecosystems. In a simultaneous system, trees are selected for fast growth during the agricultural off-season and diffuse crowns to minimize shade on field crops. In a sequential system, desirable tree characteristics are fast growth, the ability to recycle nutrients from deep soil layers, nitrogen fixing, and a heavy canopy to minimize weed growth.

It is important to carefully assess soil, topography and climate, as well as markets for possible products, before choosing a particular agroforestry system. Studies have shown that alley cropping, for example, succeeds only under certain very specific conditions. (See, for example, Kiang 1996 and the Web site for the World Agroforestry Centre [formerly ICRAF].)

Examples of the two types of agroforestry systems are summarized in the table below.

Table 1: Types of Agroforestry Systems

Simultaneous	Sequential
• Boundary plantings • Living fences or hedges • Hedges planted on the contour • Alley cropping • Parkland or tree canopy systems • Silvopastoral systems • Home gardens • Shaded perennial crops • Windbreaks	• Shifting cultivation • Improved bush fallows • Fodder banks (concentrated stands of legumes sown on natural grass or in fallows for supplementary dry-season grazing) • Relay intercropping • Taungya plantation system • Multistrata systems

Potential Environmental Impacts

Agroforestry activities are generally aimed at developing sustainable farming systems. As such, the chances of their causing environmental harm are minimal. There are, however, several considerations that need to be taken into account:

Choosing strategies wisely. The choice of tree species and technological approach is a complex challenge for new programs, due to the many possible combinations of production goals and ecological conditions. Efforts to introduce agroforestry flounder when too much emphasis is placed on the search for “miracle trees.” Experience demonstrates that a sound understanding of farming systems—especially their constraints and opportunities—is the key to finding out which combination of approach and species will be most productive and sustainable.

If agroforestry interventions only slow an ongoing process of natural resource degradation, consider other options. Otherwise, the gradual deterioration of the resource base will lead to a downward spiral in which productivity plunges, rural poverty worsens, and environmental and social rehabilitation becomes ever more difficult.

Competition between trees and crops. Despite agroforestry’s many advantages, improperly designed agroforestry projects can actually undermine productivity and the farmer’s well-being. Trees may compete with, rather than support, agricultural crops because they:

- cast too much shade
- use too many scarce nutrients or too much water
- reduce growing space
- interfere with farming operations such as plowing and tilling the crops
- host pests and diseases
- deplete soil fertility over the long term from overuse.

Labor intensity and cost/benefit awareness. Like the soil and water conservation technologies with which it is often combined, agroforestry increases farm labor requirements. Farmers may consider the extra labor overly burdensome, and feel that returns from these efforts are not quick or tangible enough. Without suitable incentives, farmers may stop applying agroforestry solutions appropriately and return to less sustainable land-use patterns.

Recognizing the limitations. Some projects and programs use agroforestry systems to mitigate smallholders’ impact on fragile land. Under certain conditions, this may be an appropriate solution. However, the danger exists of institutionalizing subsistence agriculture, or maintaining an unacceptable status quo, when more radical solutions are needed. If agroforestry interventions only slow an ongoing process of natural resource degradation, other alternatives should be considered. Otherwise, the gradual deterioration of the resource base will lead to a downward spiral in which productivity plunges, rural poverty worsens, and environmental and social rehabilitation becomes ever more difficult.

Sector Program Design—Some Specific Guidance

An agroforestry intervention is generally planned for a specific site, reflecting the need to restore a degraded area or raise productivity. In many situations a variety of agroforestry techniques can be used, and the choices can become quite complex. The following general design principles should be applied:

- Carefully assess the agro-ecological conditions, needs and opportunities of the local farming system, to choose the best agroforestry technology and plant species for the site.
- Ensure that the combination of trees and crops will yield a net benefit for both the farmers and the local ecosystem.
- Agroforestry may compete directly with productive forestry and agriculture for suitable land. The potential economic tradeoffs should be carefully examined by all those concerned with the project, especially the members of communities where the approach is being promoted.
- When applying agroforestry techniques in hilly areas with broken topography, micro-site adjustments may need to be made—combined with soil and water conservation technologies—to prevent erosion.

To repeat, agroforestry should not be viewed as a panacea for all forms of smallholder damage to marginal or fragile lands. While it is possible to use agroforestry to improve land-use capabilities, these practices are typically labor-intensive and costly, and thus may be limited in their applicability.

Because it is typically labor-intensive and costly, agroforestry should not be viewed as a panacea for smallholder damage to marginal or fragile lands. When projects are considering an agroforestry activity, they must thoroughly document the needs and opportunities of the farming system and local agro-ecology, using good baseline data.

Environmental Mitigation and Monitoring Issues

Agroforestry technologies are, in and of themselves, mitigation measures for the adverse environmental effects of traditional or conventional agricultural practices on marginal land. Properly designed, they can increase the productivity and sustainability of the farming system over time at acceptable costs.

The following points should be kept in mind when monitoring agroforestry systems:

- Assessments of the needs and opportunities of the farming system and agro-ecological conditions require thorough documentation with good historical baseline data. This requires a significant commitment on the part of the project, as the fragmented nature of farm plots and the sequential approach to harvest can make data collection difficult for mixed smallholder farming systems. It is also important to monitor ecological factors that would indicate resource degradation—soil erosion, fertility loss, climatic extremes that affect productivity, etc.
- The ultimate test of the sustainability of agroforestry technologies is farmer satisfaction. Lead farmers should be identified, closely monitored, and used as para-technicians to disseminate technology among their peers. Annual post-harvest evaluations involving all participating farmers can be especially valuable in gauging their perceptions of the success (or otherwise) of the technology. These events can be scheduled as part of the extension program and also serve as training and promotional activities.

References and resources

Internet Sites:

- Both the Forest Stewardship Council (International) http://www.fsc.org/en/ and the Forest Stewardship Council (United States) http://www.fscus.org/ have extensive information on forest certification.

- U.S. Forest Service/Office of International Programs has a long-term working relationship with USAID to provide technical support to forestry programs. http://www.fs.fed.us/global

- The Center for International Forestry Research (CIFOR) is located in Bogor, Indonesia. It is part of the Consultative Group on International Agricultural Research (CGIAR) system, and is a useful source of up-to-date information on sustainable forest management. http://www.cifor.cgiar.org

- The World Agroforestry Centre (formerly the International Center for Research in Agroforestry, or ICRAF) is located in Nairobi, Kenya, and provides information on including a tree component in farming systems. Like CIFOR, this center is a member of the CGIAR system. Its offerings include an "agroforestree" database, useful for screening specific tree species' suitability for application in different countries. http://www.worldagroforestry.org/

- The World Wildlife Fund–World Bank Forest Alliance is a partnership to promote forest conservation and best practices in forest management. http://www.worldwildlife.org/alliance/

- The UN Food and Agriculture Organization (FAO) Forestry Department in Rome has long been a center of excellent information for forestry sector development in the developing world. Their INFOSYLVA database offers a summary of forestry sector statistics and information on a country-by-country basis. See the database at http://www.fao.org/forestry/newsroom/en/news/2005/highlight_101934en.html or contact the Forestry Department, Community Forestry–Oriented Forests, Trees and People Programme at http://www.fao.org/forestry/index.jsp The FAO also has a listserve on Reduced Impact Logging that is conducted in French. Subscribe at: http://www.fao.org/forestry/foris/webview/forestry2/index.jsp?siteId=1100&sitetreeId=1980&langId=1&geoId=0

- The International Tropical Timber Organization (ITTO), located in Yokohama, Japan, is an excellent source of information on tropical timber use and its relationship to sustainable forest management. Established as a framework organization for consultations between producer and consumer member countries on all aspects of the world timber economy, ITTO maintains a Web site that includes access to up-to-date market information on tropical timbers and on criteria for sustainable management. http://www.itto.or.jp

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Chapter 8

Healthcare waste: Generation, handling, treatment and disposal

Contents

Brief Description of the Sector	8-1
Potential Environmental Impacts	8-2
Environmental Mitigation and Monitoring Issues	8-5
Minimum Elements of a Complete Waste Management Plan	8-11
First Steps	8-13
Sector Program Design Questions	8-15
References and Useful Resources	8-20

Brief Description of the Sector

Small-scale healthcare activities, such as rural health posts, immunization posts, reproductive health posts, mobile and emergency healthcare programs, and urban clinics and small hospitals, provide important and often critical healthcare services to individuals and communities that would otherwise have little or no access to such services. They are the front line of defense against epidemics such as AIDS, malaria, and cholera and a key component of any comprehensive development program. The medical and health services they provide improve family planning, nurture child and adult health, prevent disease, cure debilitating illnesses, and alleviate the suffering of the dying.

Currently, little or no management of healthcare wastes occurs in small-scale facilities in Africa. Training and supplies are minimal. Common practice in urban areas is to dispose of healthcare waste along with the general solid waste or, in peri-urban and rural areas, to bury waste, without treatment, in an unlined pit. In some cities small hospitals may incinerate waste in dedicated on-site incinerators, but often they fail to operate them properly. Unwanted pharmaceuticals and chemicals may be dumped into the local sanitation outlet, be it a sewage system, septic tank or latrine.

Although small-scale healthcare activities provide many important benefits to communities, they can also unintentionally do great harm through poor design and management of waste management systems.

Problems

- Little or no management of healthcare wastes
- Disposal of healthcare wastes with general solid waste
- Improper burial of wastes
- Improper operation of incinerators
- Dumping into sewage and water systems

Potential Environmental Impacts of Development Programs in the Sector and Their Causes

Although small-scale healthcare activities provide many important benefits to communities, they can also unintentionally do great harm through poor design and management of waste management systems.

A new health post at an internally displaced persons (IDP) camp – Pomba Nova – near Sumbe Angola. The Health post has no water supply.

Healthcare waste is dangerous. If handled, treated or disposed of incorrectly it can spread disease, poisoning people, livestock, wild animals, plants and whole ecosystems.

Types of Waste

- General waste
- Hazardous waste
- Highly hazardous waste

Types of waste. These wastes generally fall into three categories:

- ***General*** healthcare waste, similar or identical to domestic waste, including materials such as packaging or unwanted paper. This waste is generally harmless and needs no special handling; 75–90% of waste generated by healthcare facilities falls into this category.
- ***Hazardous*** healthcare wastes including infectious waste (except sharps and waste from patients with highly infectious diseases), small quantities of chemicals and pharmaceuticals, and non-recyclable pressurized containers.
- ***Highly hazardous*** healthcare wastes including sharps, highly infectious non-sharp waste, stools from cholera patients, and bodily fluids of patients with highly infectious diseases. They also include large quantities of expired or unwanted pharmaceuticals and hazardous chemicals, as well as all radioactive or genotoxic wastes.

Table 3.1: Types of hazardous and highly hazardous medical wastes relevant to small-scale facilities

Hazardous Waste		Highly Hazardous Waste	
Infectious	Wastes thought to contain low concentrations of infectious agents, such as disease-causing bacteria, viruses, parasites, and fungi, that could spread the disease *Examples*: tissues/swabs; materials or equipment that have been in contact with infected patients; human excretions such as pus, feces and vomit from patients without highly infectious diseases; wash water	Sharps	Sharp objects that can easily cut or injure a handler. Used hypodermic needles are the most common and dangerous, as they are often contaminated with highly infectious blood *Examples*: syringe needles, scalpels, knives, infusion sets, broken glass
Pathological	Tissue or body fluids from humans or animals without highly infectious diseases *Examples*: blood, body parts, organs, animal carcasses	Highly infectious (non-sharps)	Contain high concentrations of highly infectious agents and pose an extreme health hazard *Examples*: body fluids, such as blood, from patients with highly infectious diseases; microbial cultures; and carcasses of inoculated laboratory animals
Chemical (in small quantities)	Waste containing purified chemical substances that are toxic, corrosive, flammable, reactive, and/or explosive *Examples*: unwanted disinfectants, solvents, film developer, laboratory reagents	Chemical and pharmaceutical (in large quantities)	The same pharmaceuticals and chemicals that are only hazardous in small quantities may be highly hazardous in large quantities
		Heavy metal	*Examples*: Some rechargeable batteries, mercury from broken thermometers or blood-pressure gauges, some medical equipment batteries
Pharmaceutical (small quantities)	Waste containing pharmaceuticals *Examples*: bottles/boxes of expired or unwanted medications	Genotoxic	Wastes containing substances which can cause mutations, birth defects and cancer. Facilities with laboratory facilities might stock some genotoxic chemicals *Examples*: chemotherapy drugs
Pressurized containers	Gas cylinders, gas cartridges, aerosol cans	Radioactive	Waste containing radioactive substances *Examples*: Some laboratory wastes, wastes associated with radiation therapy. Not likely to be used by small-scale healthcare facilities.

Major Threats From Improper Waste Handling

- Disease transmission, through infectious waste, sharps, and contaminated water.
- Chemical and toxic threats, through chemical and pharmaceutical exposure.

Disease transmission. Transmission of disease through infectious waste is the greatest and most immediate threat from healthcare waste. If waste is not treated in a way that destroys the pathogenic organisms, dangerous quantities of microscopic disease-causing agents—viruses, bacteria, parasites or fungi—will be present in the waste. These agents can enter the body through punctures and other breaks in the skin, mucous membranes in the mouth, by being inhaled into the lungs, being swallowed, or being transmitted by a vector organism.

People who come in direct contact with the waste are at greatest risk. Examples include healthcare workers, cleaning staff, patients, visitors, waste collectors, disposal site staff, waste pickers, drug addicts and those who knowingly or unknowingly use "recycled" contaminated syringes and needles.

Although sharps pose an inherent physical hazard of cuts and punctures, the much greater threat comes from sharps that are also infectious waste. Again, healthcare workers, waste handlers, waste-pickers, drug addicts and others who handle sharps can, and have, become infected with HIV/AIDS and hepatitis B and C viruses through pricks or reuse of syringes/needles. These infections may be fatal.

Contamination of water supply from untreated healthcare waste can also have devastating effects. If infectious stools or bodily fluids are not treated before being disposed of, they can create and extend epidemics, since sewage treatment in Africa is almost nonexistent. For example, the absence of proper sterilization procedures is believed to have increased the severity and size of cholera epidemics in Africa during the last decade.

This pit contains sharps and some bloody cotton swabs. It will fill with water when it rains, and the waste material may attract various disease vectors, including flies, birds and rodents.

Chemical and toxic threats. Chemical and pharmaceutical wastes, especially large quantities, can be health and environmental threats. Since hazardous chemical wastes may be toxic, corrosive, flammable, reactive, and/or explosive, they can poison, burn or damage the skin and flesh of people who touch, inhale or are in close proximity to them. If burned, they may explode or produce toxic fumes. Some pharmaceuticals are toxic as well.

When chemical and pharmaceutical waste is disposed of in unlined landfills, especially unlined pits, these wastes may contaminate ground and surface water—particularly when large quantities are disposed of.

This can threaten people who use the water for drinking, bathing and cooking, and damaging plants and animals in the local ecosystem.

Burning or incinerating healthcare waste, while often a better option than disposal in an unlined pit, may create additional problems. Burning or incineration of healthcare waste may produce toxic air pollutants such as acid gasses, Nitrogen Oxides (NO_x), particulates, dioxins and heavy metals and distribute them over a wide area. Dioxins and heavy metals are of particular concern. Dioxins believed to be potent cancer-causing agents, do not biodegrade, and accumulate in progressively higher concentrations as they move up the food chain. Heavy metals such as mercury and cadmium are toxic and/or cause birth defects in small quantities and can also concentrate in the food chain.

Finally, disposable pressurized containers pose another hazard for incineration, as they can explode if burned.

In short, disposal of large quantities of hazardous chemicals and pharmaceuticals is a serious problem. In most of Africa, no methods are available to small-scale facilities that are safe and affordable.

The solution:

An incremental approach

Since money for healthcare waste management is scarce, the first priority is actions and procedures that reduce risk the most at the least cost.

Environmental Mitigation and Monitoring Issues

Another health post waste disposal site in a village near Segou, Mali. What might be the cumulative effects over time of leaving this pit uncovered?

This guideline recommends that designers and managers of small-scale healthcare facilities take an incremental approach to improving waste management practices. The first priority are actions and procedures that will reduce risk the most at the least cost. The ultimate goal is to develop a complete, if minimal, program.

The two subsections that follow outline the minimum elements of a complete healthcare waste management program for a small-scale facility. They indicate:

- which elements will result in the most significant improvements at least cost—and should therefore be introduced first; and
- what questions to ask

when developing a healthcare waste management program for a small-scale facility.

Two tables are also included that should be useful to planners and managers. Table 3.2 covers treatment and disposal options appropriate for small-scale healthcare activities; table 3.3 covers best management options by waste category. These do not cover every option, but highlight those that are realistic for small facilities.

Table 3.2: Treatment and disposal options appropriate for small-scale healthcare facilities

Treatment/ disposal method	Description	Effective for	Advantages	Disadvantages
Single-chamber incineration	A permanent simple furnace of solid construction, e.g., concrete. Waste is placed on a fixed grate. Burning is maintained by the natural flow of air. Operating temperature reaches <300°C. May need to add kerosene or similar fuel to maintain combustion. Pictured in Prüss et al. 1999, chapter 8, figures 8.3 and 8.4.	Infectious waste Sharps waste Pathological waste	Disinfects effectively. Reduces waste volume by ~80%; burning efficiency of 90–95%. Low investment and operating costs.	Emits pollutants such as fly ash, acid gases, and some toxins. May produce odors (can be limited by not burning PVC plastics). Sharps in ashes will still pose physical hazard. Not good for most pharmaceutical or chemical waste.
Drum or brick incinerator	A simple furnace with less mass and insulating value than a single chamber incinerator. Constructed out of an empty oil drum or a short chimney of bricks placed over a metal grate and covered with a fine screen. Operating temperature < 200°C. May need to add kerosene or similar fuel to maintain combustion. Pictured in Prüss et al. 1999, chapter 8, figures 8.5 and 8.6.	Infectious waste Sharps waste Pathological waste	Disinfects reasonably well, destroying 99% of microorganisms. 80–90% burning efficiency.	Emits black smoke, fly ash, acid gases, and some toxins. May produce odors (can be limited by not burning PVC). Sharps in ashes will still pose physical hazard. Not good for most pharmaceutical or chemical waste.
Open-air burning	Burning of wastes in or next to pit where they will be buried. May need to add kerosene or similar fuel to maintain combustion. Not recommended as a permanent solution, but better than burying untreated on site.	Infectious waste Sharps waste	Similar to drum or brick incinerator.	Burning may be incomplete and residues still infectious. More hazardous to staff involved. Greater risk of scavenging by waste-pickers or of transfer of pathogens by vectors including insects, animals or birds. Not effective for pathological waste. Even if disinfected, sharps in ashes will still pose physical hazard. Not good for most pharmaceutical or chemical waste.
Autoclaving	Steam treatment of waste at high temperature and pressure for a sufficient amount of time for sterilization. Usually used for sterilizing reusable medical equipment. Steam must be able to penetrate the waste.	Highly infectious wastes	Efficient at disinfecting. Has no significant environmental adverse impacts. Relatively low investment and operating costs.	Requires qualified operators. Cannot be used on pathological, pharmaceutical, and chemical waste. Autoclaves designed to sterilize equipment have a limited capacity.
Encapsula-tion	Containers are filled three-quarters full with hazardous waste. Material such as cement mortar, clay, bituminous sand, or plastic foam is used to fill the container. When capping material is dry the container is buried or landfilled.	Sharps waste Small amounts of chem. and pharm. waste	Simple and safe. Low cost.	Not effective for non-sharps infectious waste.

Treatment/ disposal method	Description	Effective for	Advantages	Disadvantages
Safe burying	Burial of waste in a pit on site. Access to site should be limited. Pit lined with clay, if available. To extend useful life of pit, should be used only for hazardous waste Less than 1 kg buried at one time. Each layer of waste is covered with a layer of earth. Illustrated in Prüss et al. 1999, chapter 8, figure 8.12.	Infectious waste Sharps waste Small amounts of chem. and pharm. waste	Provides some measure of human health and environmental protection by making waste inaccessible. Organic materials will eventually biodegrade.	Soil can become polluted if permeable. Difficult to prevent scavenging.

The methods below are included for completeness. However, they are unlikely to be available to most small-scale facilities in Africa:

Wet Thermal Treatment	Similar to autoclaving. Waste is shredded and exposed to high-pressure, high-temperature steam.	Infectious wastes	Efficient at disinfecting. Has no significant environmental adverse impacts. High capacity. Relatively low investment and operating costs.	Shedder liable to mechanical failure. May require off-site transport. Cannot be used on pathological, pharmaceutical, and chemical waste. Requires qualified operators.
Microwave irradiation	Waste is shredded, humidified and irradiated with microwaves. Heat destroys micro-organisms.	Infectious wastes	Efficient disinfection. Environmentally sound. Shredding reduces waste volume.	Relatively high capital and operating costs. Shedder liable to mechanical failure. May require off-site transport. Cannot be used on pathological, pharmaceutical, and chemical waste. Requires qualified operators.
Sanitary Landfill	Waste is packaged to minimize exposure and placed in a shallow hollow dug below the working face. Waste is then immediately covered with 2 m of mature waste. Alternatively, packaged waste is placed in a 2 m-deep pit in mature waste and covered immediately. Waste-picking must be prevented.	Infectious waste Sharps waste Small amount of chem. and pharm. waste	Low-cost option. Organic materials may eventually biodegrade.	Requires access to sanitary landfill. Transportation to site creates many opportunities for exposure. Improper handling of leachate (liquid that filters through the waste) can cause water pollution and potential public health risks. May be difficult to prevent scavenging.
In all cases where waste is treated, the treated waste should be buried using safe burial methods or disposal in a sanitary landfill.				

Table 3.3 : Best management options by waste category for small-scale activities

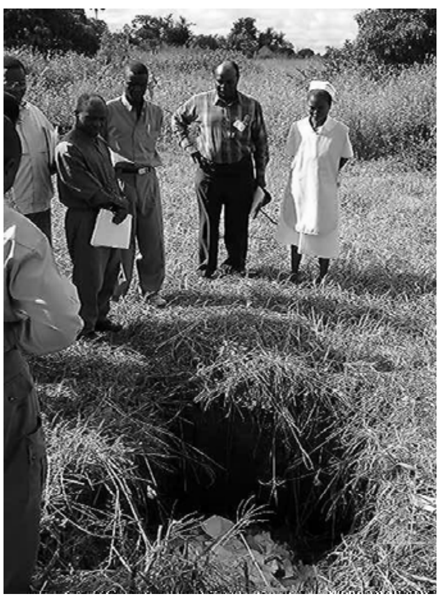
Type of waste	Management Options	Comments
Solid infectious waste	Autoclave, incinerate/burn, or bury	Autoclaving is ineffective for pathological waste such as body parts.
Stools from patients with cholera or other forms of diarrhea	Isolate patients if possible and capture stool/excreta in a bucket. Disinfect this excreta by adding chlorine oxide powder, dehydrated lime oxide (CaO), bleach (sodium hypochlorite) or other disinfectant. In case of epidemic, disinfect all hospital sewage. Pour treated stools into a pit where they will be filtered by the soil, but will not contaminate drinking water.	
Blood and other infectious bodily fluids	Disinfect by adding chlorine oxide powder, dehydrated lime oxide (CaO), bleach (sodium hypochlorite) or other disinfectant. Pour treated fluids into a pit where they will be filtered by the soil, but will not contaminate drinking water.	
Sharps	Separate from other waste. Immediately after use put in plastic, metal, or cardboard container that will keep liquid from leaking; cardboard containers should be lined with plastic bags. If possible, containers should be colored yellow and marked "SHARPS," "Infectious waste," "Dangerous," or something similar, in all relevant languages. Burn or encapsulate the sharps when containers reach ¾ full. If container is to be reused, sterilize with bleach or other disinfectant.	
Pharmaceutical waste, small quantities	In general, bury. • If collected together with infectious waste, small quantities of pharmaceutical waste can be treated as infectious waste. (I.e., follow the same procedures of incineration/burning and safe burial.) Note: crush ampoules and bury; these can explode if burned. • If collected separately, encapsulate semi-solids.	For more information see: *Guidelines for safe disposal of unwanted pharmaceuticals in and after emergencies*. World Health Organization, Geneva, 1999, Chapter 4. http://whqlibdoc.who.int/hq/1999/WHO_EDM_PAR_99.2.pdf
Pharmaceutical waste, large quantities	Return to supplier. Subcontract for incineration in a double-chamber incinerator that operates at >900°C, if available. Water-soluble, mild pharmaceuticals, such as vitamin solutions, cough syrups, intravenous solutions, eye drops, etc., may be diluted with large amounts of water and discharged to fast-flowing watercourses. Other options are available for some subcategories. If no other option is available, waste can be encapsulated.	Acceptable options are neither cheap nor easy and are not likely to be readily available to small-scale facilities, i.e., there is no safe way to dispose of these materials. It is therefore critical to minimize the amount of pharmaceutical waste generated.
Chemical waste, small quantities.	In general, bury. If collected together with infectious waste, small quantities of chemical waste can be treated as infectious waste (i.e., follow the same procedures of incineration/burning and safe burial).	

Type of waste	Management Options	Comments
Chemical waste, large quantities	Return to supplier. Subcontract for incineration in a double-chamber incinerator that operates at >900°C, if available. Export to a location with adequate facilities for safe disposal. Other options are available for some subcategories.	Acceptable options are neither cheap nor easy and are not likely to be readily available to small-scale facilities, i.e., there is no safe way to dispose of these materials. It is therefore critical to minimize the amount of chemical waste generated.
PVC plastic and other halogenated materials	Bury.	DO NOT BURN. Doing so will create highly toxic pollutants and spread them over a wide area.
Materials containing heavy metals	E.g., broken thermometers, manometers, rechargeable batteries. Capture mercury and reuse or recycle via local cottage industry, if available. Batteries may also be locally recyclable via cottage industry.	DO NOT BURN. Doing so will spread highly toxic pollutants over a wide area.
Pressurized containers	Return undamaged containers to supplier. Empty damaged containers completely and recycle via local cottage industries. Small cans can be buried with ash, residues and other waste on site.	Do not burn/incinerate because of high risk of explosion.
Wash-water and sewage	Treat using best available treatment system (see *Water Supply and Sanitation* guideline in this volume for more information). If sewage will not be treated, disinfect wash water by adding chlorine oxide powder, dehydrated lime oxide (CaO), bleach (sodium hypochlorite) or other disinfectant. Pour treated liquid in a pit where it will be filtered by the soil, but will not contaminate drinking water.	
Incinerator ash/ residues from burning	Bury in pit on site.	
In all cases where waste is treated, the treated waste should be buried using safe burial methods or disposal in a sanitary landfill.		

Minimum elements of a complete waste management program

Small-scale facilities require a sound healthcare waste management system to minimize damage to health and the environment caused by their wastes. A comprehensive minimal program includes the following practices:

1. *A written waste management plan*. The plan describes all the practices for handling, storing, treating, and disposing of hazardous and non-hazardous waste, as well as types of worker training required. Usually drawn up after doing a comprehensive assessment of waste handling at the facility.
2. *Clearly assigned staff responsibilities.* Make responsibilities clear so that workers feel accountable for how well tasks are completed and so that no step in the process is overlooked.
3. *Written internal rules for generation, handling, storage, treatment, and disposal.* Formalize desired practices, as written rules may be better maintained.
4. *Staff trained in safe handling, storage, treatment, and disposal.* Training is necessary to ensure that staff are aware of all hazards they might meet and that they are practicing good hygiene, safe sharps handling, proper use of protective clothing, proper packaging and labeling of waste, and safe storage of waste. Training helps ensure correct response to spills, injury, and exposure. Untrained workers handle wastes in ways that endanger themselves and the local community.



Identifying and training responsible staff is a first step in the effective management of healthcare wastes.

5. *Protective clothing available.* Workers need specific types of clothing, such as surgical masks and gloves, aprons, and boots, to protect themselves when moving and treating various types of collected infectious waste.
6. *Good hygiene practices.* Many infectious agents must enter the mouth or be swallowed to cause disease. Even if protective clothing is worn, some organisms will get on workers' hands and faces. Thus, workers need to wash their hands and faces regularly with soap and warm water. They get sick more often when they do not observe good hygiene practices.

Minimum Program Elements

1. Written plan
2. Clear responsibilities
3. Written, internal rules
4. Staff training
5. Protective clothing
6. Good hygiene practices
7. Vaccinated workers
8. Designated storage locations
9. Waste minimization
10. Waste segregation
11. Waste Treatment
12. Final disposal site
13. Periodic reviews

7. *Vaccinated workers.* Workers should be vaccinated against potentially deadly viral hepatitis B and tetanus infections.
8. *Temporary storage containers in designated locations.* Hazardous healthcare wastes should be stored only for short periods—less than 24 hrs in the warm season in warm climates. Also, they should be put in a labeled, covered container in a fixed location—for example, a specific corner of the room. They should not be stored near patients or food.
9. *Minimization, reuse, and recycling procedures.* The less waste generated, the less there is to manage. Unnecessary disposal of valuable chemicals and pharmaceuticals can be avoided through good inventory practices: for example, by using the oldest batch first; by never opening a new container before the last one is finished; by preventing products from being thrown out during routine cleaning; and by checking on delivery to make sure materials are not about to expire. Where possible and safe, using reusable syringes and needles generates approximately 0.5–2% of the waste of using disposables, and costs 5 to 15 times less. Minimize use of products containing PVC plastics. Competitively priced substitutes for PVC plastic are available that perform equally well.
10. *A waste segregation system.* Segregating (sorting and separating) waste both reduces the volume of waste and enables different kinds of materials to be handled appropriately. Approximately two-thirds of waste from small-scale facilities is general waste. Separating hazardous from general waste reduces the amount that must be treated by 75–90%. The dangers of sharp waste can be minimized when sharps are collected in separate puncture-proof containers. Other elements that can be segregated for separate handling, treatment, and/or disposal include hazardous liquids, chemicals and pharmaceuticals, PVC plastic, and materials containing heavy metals.
11. *Treatment methods for hazardous and highly hazardous waste.* Treatment options available to small-scale facilities for hazardous and highly hazardous waste are limited (see table 3.2 for details). **The most important function of treatment is disinfection.** It is the high concentration of infectious agents that makes infectious waste dangerous. Risks associated with current methods for managing healthcare waste exist because little is being done to reduce these concentrations prior to disposal. For rural facilities, burning in the open air in a drum or brick incinerator, or a single-chamber incinerator, preferably combined with good waste segregation practices, is the recommended option.

    Because the air pollution produced by burning poses a much greater hazard in urban areas, autoclaving of infectious waste combined with encapsulation of sharps may be the best option for urban facilities. If a larger nearby hospital with more advanced treatment and disposal systems is located nearby, small facilities could investigate piggy-backing on those systems, although precautions will need to be taken to reduce risks associated with transporting the waste.

12. *A final disposal site.* Facilities must have a place to dispose of waste that cannot be treated, and the residues from treated waste. **It is recom-mended that small-scale facilities bury waste on site,** ideally in a pit lined with clay or a similarly impermeable material to prevent contamination of ground water. Most urban facilities lack adequate space for on-site burial, and disposal in a public landfill may be the only option. However, many precautions must be taken under this option, to protect handlers and waste-pickers from infection. Sharps should be encapsulated to prevent accidental sticks and recovery for intentional reuse.
13. *A schedule for periodic review of adherence to the plan and effectiveness of the plan.* Maintaining good waste management practices is a process of continuous improvement. A program schedule must be established for regular follow-up to ensure planned practices are in place, are being carried out correctly, and are actually minimizing risk, damage and disease.

First steps

A facility does not need to do everything at once. Implementing just a few key practices can dramatically reduce risk and improve the health and safety of facility personnel, patients, and the surrounding community. **IF A FACILITY DOES NOTHING ELSE, AT A MINIMUM IT SHOULD TAKE THE FOLLOWING FOUR STEPS**:

1. *Burn or incinerate the healthcare waste on site* (rural facilities). Ideally, burning should be conducted in a single-chamber incinerator. Second in desirability is burning in a drum or brick incinerator. If no other option is available, burning may be conducted in open pits. (See table 3.2 for a description of the various treatment options) Alternatively, bury in small pits (e.g., 2 meters in depth and 2 meters on each side), but above the water table or lined with clay or plastic, and protected by a fence or other effective barrier (e.g., rows of thorny brush).

   Autoclave infectious waste and encapsulate sharps (urban and peri-urban facilities) and bury on site or

2. *Segregate the waste*. Begin with sharps. Separate hazardous and general waste, if possible.
3. *Motivate managers and other staff to follow new practices.*
4. *Give workers minimal training in how to safely handle hazardous waste, including:*
   - personal hygiene—make soap and water readily available.
   - sharps handling, especially how to avoid being pricked with hypodermic needles that could transmit HIV/AIDS, viral Hepatitis B or C, or other blood-borne diseases.
   - use of protective clothing—provide thick gloves and aprons for staff handling healthcare waste.

Key Practices:

The four best steps to take at the beginning of a waste management program:

- Burn/incinerate waste on site
- Segregate waste
- Motivate staff to follow practices
- Give minimal waste-handling training to staff

Starting with these four steps is probably the best way for facilities with limited resources to begin working towards a complete minimal healthcare waste management program.

An outline of such an approach can be found in *Safe Management of Healthcare Waste at Health Posts and other Small-Scale Facilities* in Annex___. This guide is designed as a supplement to *Safe management of wastes from health-care activities*, edited by A. Prüss, E. Giroult and P. Rushbrook (see reference list). Available at http://www.who.int/water_sanitation_health/Environmental_sani/MHCWHanbook.htm.

Note on facility siting and design:

To minimize the potential spread of disease and environmental impact when planning a new facility, healthcare planners should:

1. Select a location with easy access to safe drinking water. The drinking water source should be dedicated exclusively to the facility, if possible, to reduce the risk of spreading disease.
2. Install adequate sanitation facilities to prevent the spread of disease from infected patients.
3. Avoid locations adjacent to schools to minimize children's risk of exposure.
4. Pick a location where waste can be safely buried (e.g., above the water table and protected from scavenging) or easily shipped off site off safe disposal in a sanitary landfill.

Sector Program Design—Questions to help guide development of a healthcare waste management program

The following is a list of questions to help guide development of a healthcare waste management program:

General facility information

1. How many employees will the facility/facilities have?
2. How many patients will the facility serve on a daily basis? How many beds will the facility have, and what is the expected bed occupancy rate?
3. How broad a range of health services will the facility conduct? Family planning or HIV testing services only? Mother and infant health support? General primary care? What kinds of resources will these services require: Distribution of pharmaceuticals? Laboratory facilities for testing? Food preparation? Bathing? Laundry?

Handling of healthcare waste

4. How much and what types of healthcare waste will be generated routinely, e.g., infectious sharps? What materials are used and stored that could at some point become waste, e.g., (expired) pharmaceuticals?
5. How much of this will be hazardous or highly hazardous waste?
6. How and where will the facility's healthcare waste be stored before collection and/or treatment?
7. How much segregation (separation) of waste is feasible? Sharps from other? Sharps and hazardous from general waste? Separate collection of sharps, hazardous and highly hazardous wastes?
8. What will happen to bath water? Water from laundry operations?
9. Where will patient urine and excreta be disposed of?

Treatment and disposal of healthcare waste

10. How will waste be treated? If it will be burned, how will the remaining ash and materials be handled and disposed of?
11. If waste is to be transported off site, how will this be done? How will the waste be packaged? What types of vehicles will be used to transport the waste? What precautions will be taken to protect handlers and bystanders?
12. Will any of the waste be taken to a dump or landfill site? If so, how will it be handled at this facility? Will it be buried immediately after arriving at the landfill/dump? Will it be burned on site? Is it likely to be left unattended at any time after being unloaded?

Steps to designing a healthcare waste management program.

- Collect general facility information
- Plan how the facility will handle the waste it generates
- Plan how waste will be treated and disposed through all steps in the process
- Clearly define management responsibility for waste handling

13. If there is open access to the landfill/dump, will waste-pickers, children, others be at risk?
14. Is there potential danger of well or ground water contamination from wastewater, or patient excreta or urine? How can these potential effects be mitigated?

Management issues

15. Who will be responsible for healthcare waste management at the healthcare facility?
16. What are the current operational standards for healthcare waste, and what are the applicable national, regional, and local policies?

Minimal Program Checklist and Action Plan

Small-scale facilities require a sound healthcare waste management system to minimize adverse health and environmental impacts caused by their wastes. The following elements of a complete minimal healthcare waste management program should be in place in all facilities. Adapted from "Healthcare waste: Generation, handling, treatment and disposal," in Environmental Guidelines for Small Scale Activities in Africa, 2nd Edition (Working Draft)*. Washington, D.C., USAID AFR/SD. 2002.* *http://www.encapafrica.org/EGSSAAsectionsfrom18Jun01draft/EGSSAA3-13medwastedraft.pdf*

Elements/Actions	In Place?	By Whom	By When	Outcome Expected
Written Plans and Procedures				
1. A written waste management plan *Describing all the practices for handling, storing, treating, and disposing of hazardous and non-hazardous waste, as well as types of worker training required.*				
2. Internal rules for generation, handling, storage, treatment, and disposal of healthcare waste.				
3. Clearly assigned staff responsibilities that cover all steps in the waste management process.				
4. Staff waste handling training curricula or a list of topics covered.				
5. Waste minimization, reuse, and recycling procedures.				
Staff Training, Practices, and Protection				
6. Staff trained in safe handling, storage, treatment, and disposal. ▪ *Do staff exhibit good hygiene, safe sharps handling, proper use of protective clothing, proper* ▪ *packaging and labeling of waste, and safe storage of waste?* ▪ *Do staff know the correct responses for spills, injury, and exposure?*				
7. Protective clothing available for workers who move and treat collected infections waste *such as surgical masks and gloves, aprons, and boots.*				
Staff Training, Practices, and Protection cont'd.				
8. Good hygiene practices*. Are soap and, ideally, warm water readily available workers to use and can workers*				

Elements/Actions	In Place?	By Whom	By When	Outcome Expected
be observed regularly washing.				
9. Workers vaccinated *for against viral hepatitis B, tetanus infections, and other endemic infections for which vaccines are available.*				
Handling and Storage Practices				
10. Temporary storage containers and designated storage locations. 11. *Are there labeled, covered, leak-proof, puncture-resistant temporary storage containers for hazardous healthcare wastes?*				
12. Minimization, reuse, and recycling procedures. ▪ *Does the facility have good inventory practices for chemicals and pharmaceuticals, i.e.:* o *use the oldest batch first;* o *open new containers only after the last one is empty; procedures to prevent products from being thrown out during routine cleaning; and*				
13. A waste segregation system. ▪ *Is general waste separated from infectious/hazardous waste?* ▪ *Is sharp waste (needles, broken glass, etc.) collected in separate puncture-proof containers?* ▪ *Are other levels of segregation being applied e.g. hazardous liquids, chemicals and pharmaceuticals, PVC plastic, and materials containing heavy metals ((these are valuable, but less essential)?*				
Handling and Storage Practices cont'd.				
14. Temporary storage containers and designated storage locations. ▪ *Are there labeled, covered, leak-proof, puncture-resistant temporary storage containers for hazardous healthcare wastes?* ▪ *Is the location distant from patients or food?*				
Treatment Practices				
15. Frequent removal and treatment of waste				

Elements/Actions	In Place?	By Whom	By When	Outcome Expected
▪ *Are wastes collected daily?* ▪ *Are wastes treated with a frequency appropriate to the climate and season?* o *Warm season in warm climates* *within **24 hrs*** o *In the cool season in warm climates* *within **48 hrs*** o *In the warm season in temperate climates* *within **48 hrs*** o *In the cool season in temperate climates* *within **72 hrs***				
16. Treatment mechanisms for hazardous and highly hazardous waste*.* *(The most important function of treatment is disinfection).* ▪ *Are wastes being burned in the open air, in a drum or brick incinerator, or a single-chamber incinerator?* ▪ *If not are they being buried safely (in a pit with an impermeable plastic or clay lining)?* ▪ *Is the final disposal site (usually a pit) surrounded by fencing or other materials and in view of the facility to prevent accidental injury or scavenging of syringes and other medical supplies?* ▪ *If the waste is transported off-site, are precautions taken to ensure that it is transported and disposed of safely?*				

***For more detailed checklists and guidance consult**:* Safe management of wastes from health-care activities*, edited by A. Prüss, E. Giroult and P. Rushbrook. Geneva, WHO, 1999, 228 pages. Available at: http://www.who.int/water_sanitation_health/Environmental_sanit/MHCWHanbook.htm. English (French and Spanish in preparation).*

References and Useful Resources

- ***Safe management of wastes from health-care activities,*** edited by A. Prüss, E. Giroult and P. Rushbrook. Geneva, WHO, 1999, 228 pages. Available at: http://www.who.int/water_sanitation_health/Environmental_sanit/MHCWHanbook.htm. English (French and Spanish in preparation). Can be ordered from WHO, MDI, CH-1211 Geneva 27 (e-mail: publications@who.ch). Price: SwF 72, SwF 50.40 for developing countries.

  This comprehensive handbook recommends safe, efficient and sustainable methods for the handling, treatment and disposal of wastes from healthcare activities. It addresses a variety of technical options, as well as organizational and policy issues essential in managing healthcare wastes. The handbook is targeted at public health professionals, regulators, and hospital managers and administrators.

- ***Teacher's Guide – Management of wastes from health-care activities***, A. Prüss & W.K. Townend, World Health Organization, Geneva, 1998, 227 pages. Available at: http://www.who.int/environmental_information/Information_resources/worddocs/HCteachguid/health_care_wastes_teacher.htm. English (French and Spanish in preparation). Can be ordered from WHO, MDI, CH-1211 Geneva 27 (e-mail: publications@who.ch) Price: SwF 35.-, SwF 24.50 for developing countries.

  The Teacher's Guide accompanies the WHO handbook on management of wastes from healthcare activities described above. It provides teaching materials (ready-to-copy texts for overhead transparencies, lecture notes, handouts, exercises and course evaluation forms) and recommendations for a three-day training course. It is designed mainly for managers of healthcare establishments, public health professionals and policy-makers.

- ***Guidelines for safe disposal of unwanted pharmaceuticals in and after emergencies.*** World Health Organization, Geneva, 1999, 31 pages. Available at: http://whqlibdoc.who.int/hq/1999/WHO_EDM_PAR_99.2.pdf. Can be ordered from WHO, MDI, CH-1211 Geneva 27 (e-mail: publications@who.ch). Price: CHF 8.-, CHF 5.60 for developing countries.

  Practical guidance on the disposal of drugs in difficult situations in or after emergencies, in relation to armed conflicts, natural disasters or others. In such situations, large quantities of unwanted drugs may accumulate due to difficulties, mismanagement of stocks and inappropriate donations. The guidance provided consists of relatively simple and low-cost measures and is addressed to local authorities, healthcare personnel or other professionals confronted with these kinds of problems.

- ***Vital to Health? Briefing Document for Senior Decision-Makers, 1998.*** World Health Organization/US Agency for International Development (USAID). Contact: WHO Headquarters, attention Mario Conde, CH 1211, Geneva 27, Switzerland. Tel 41-22-791-4374 or US Agency for International Development, Children's Vaccine Programme, Office of Health and Nutrition, 3.07-037 Ronald Reagan Building, Washington DC 20523. Tel 1-202-712-4808, Fax 1-202-216-3702.

  This document provides information on unsafe injections. It illustrates misuse of medical sharps, and circumstances that lead to misuse. The document provides detailed information about safety standards for disinfecting sharps and their disposal. It also addresses the choice of different kinds of injection equipment and the issue of waste management.

- ***Healthcare Waste Management Guidance Note.*** Johannessen**,** Lars M. et al., Waste Management HNP Anchor Team. The World Bank, 2000, 68 pages. Available at: http://wbln0018.worldbank.org/hdnet/hddocs.nsf/c0d65c5ea6fcb4688525670c004d14c2/0d87e869807f2f69852568d20054e66b.

  A working document that attempts to synthesize currently available knowledge and information in healthcare waste management. It is meant to complement WHO's guidelines and provide particular information necessary for World Bank projects. Gives attention to management and policy issues and technical background on particular issues in greater detail than the WHO guidelines.

- ***Managing medical wastes in developing countries: report of a Consultation on Medical Wastes Management in Developing Countries***, Geneva, September 1992. World Health Organization, Geneva, 1994. Available at: http://whqlibdoc.who.int/hq/1994/WHO_PEP_RUD_94.1.pdf. WHO/PEP/RUD/94.1. Unpublished document.

  This report is concerned with waste management practices in hospitals and other facilities which are associated with health care. It promotes procedures and facilities to reduce the risk of disease transmission and the occurrence of accidents associated with such wastes. The main focus is on countries in tropical areas and those which are seriously constrained by the lack of financial resources and trained manpower.

- **Safe Management of Healthcare Waste at Health Posts and other Small-Scale Facilities** (Draft). 2000. USAID AFR/SD and REDSO/ESA. Available at: http://www.encapafrica.org/resource_docs/USAID_Healthcare_Wastemanagement_Guide.pdf

  A quick but thorough introduction to healthcare waste hazards and practices to minimize those hazards. Designed to be used in conjunction with. *Safe management of wastes from health-care activities*, Prüss et al., 1999, World Health Organization. Emphasizes an incremental approach to healthcare waste management at small-scale facilities. Designed to address the practices most predominant in Africa.

- **Healthcare or Health Risks? Risks from Healthcare Waste to the Poor**, Jenny Appleton and Mansoor Ali, WELL, Loughborough University 2000

  Study considers relative risk of various potential adverse environmental impacts of healthcare waste and considers these in relation to people most likely to be exposed to risk focusing particularly on the poor. The report provides examples of good practice and suggests an overall strategy for healthcare waste management that stresses an incremental approach with attention to areas of highest risk.

Chapter 9

Housing

Contents

Brief Description of the Sector	9-1
Potential Environmental Impacts	9-2
Sector Program Design	9-5
Mitigation and Monitoring Issues	9-12
Resources and References	9-15
Sample Survey Instruments	9-16

The ultimate impact of housing projects extends beyond the construction or reconstruction phase. The existence of housing tends to attract both economic activity and additional settlement. Thus, the environmental and environmental health impacts of the original project are typically amplified by its expansion over time.

Shelter is a basic human need. Thus, providing adequate housing is a fundamental development objective. It is also one of the most complex. Successful housing activities can rarely be isolated from the development of associated infrastructure—e.g., water, sanitation, transport—and social services.

This section focuses on housing reconstruction after natural disasters—when pursuing an integrated approach is particularly difficult. The section does not address technical standards for construction of housing units, water supply and treatment, etc. Instead, its purpose is (1) to convey the full range of environmental and environmental health issues associated with housing construction, and (2) to provide a guided framework for considering these issues in the siting, design and implementation of housing projects, particularly in post-disaster reconstruction and in risk-prone areas.

Note: Readers should also review the following sector briefings: water and sanitation, solid waste, rural roads, and small-scale construction.

Brief Description of the Sector

Many areas in Africa have been wracked by civil strife, or because of geology and geography are highly vulnerable to floods, extreme rainfall, cyclones and volcanic eruptions. Such man-made and natural disasters can have disastrous effects on houses and other dwellings, accompanied by large loss of life and persistent hardship for displaced persons.

Reconstruction needs arise in both urban/peri-urban and rural areas. Natural disasters in densely populated urban areas can be particularly devastating. Typically, the urban poor are disproportionately affected by any natural disaster—both because they tend to occupy poor-quality housing stock in high-risk areas (e.g., flood plains or steep slopes) which are, even in the best of times, poorly served by municipal services, and because they lack the resources to rebuild after a disaster.

Housing reconstruction in rural areas after a natural disaster is also a real and pressing issue. Rural reconstruction needs are often more difficult to assess than those in and around cities. Even in the absence of natural disasters, living standards in rural areas are lower than in urban ones. Failure to address rural post-disaster housing and infrastructure needs can only encourage further out-migration from rural areas and weaken agricultural productivity.

Housing projects can have significant environmental impacts, but can also help mitigate poor existing condition caused by building on slopes, in watersheds or in flood prone areas.

Potential Environmental Impacts of Housing Reconstruction and Their Causes

A fundamental issue facing post-disaster reconstruction efforts is whether to rebuild/repair housing where it was ("in-place") or develop a new site. In densely populated urban areas, there may be little choice but to pursue reconstruction in-place. In either case, the environmental impact of housing development comes from the permanent occupation of the land by built structures and the introduction of domestic waste streams into the environment. Well-planned and -implemented housing projects have far fewer impacts—and result in much healthier populations—than unplanned or poorly planned housing development.

Potential Environmental Impacts of Housing Projects

- Destruction of important ecological, archaeological or historical areas
- Deforestation
- Contamination of soil or water resources
- Erosion

In the case of a new settlement, the housing actually constructed by the activity will cause some level of impact. However, the *ultimate* impacts may be significantly larger. The existence of the new housing tends to attract both economic activity and additional settlement. Thus, the environmental and environmental health impacts of the original project are typically amplified by its expansion over time.

Potential impacts arising from land development and the introduction of human waste streams and resource demands include:

- Destruction of important ecological, archeological or historical areas. This may be caused either by land clearing for the housing and associated infrastructure, or by the subsequent exploitation of the land and other resources by inhabitants.

- Deforestation, arising from (1) clearing of land for construction and associated infrastructure (e.g., roads); (2) clearing of land for agriculture by inhabitants; or (3) overharvesting of fuelwood by inhabitants, for domestic use or for small-scale charcoal production.
- Contamination of soil, surface water and groundwater from sewage and solid waste (refer to the “Water and Sanitation” sector description in the Guidelines); creation of breeding grounds for animal and insect disease carriers.
- Erosion from construction of houses and access roads, resulting in destruction of agricultural land, sedimentation of waterways, etc.

Construction impacts. Construction also has serious environmental impacts. These are discussed at greater length in the general sector briefing on “Small-Scale Construction” in the *Guidelines*. Prominent among these impacts are:

- Erosion, caused by water or wind and aggravated by sloping terrain when the earth is left barren after the site is cleared, leveled or filled in. Erosion may also be associated with access roads, or with quarry or borrow areas that provide construction material.
- Water contamination, from (1) the dumping of demolition debris or excess soil from land leveling into watercourses; (2) runoff from on-site machine maintenance (oil change, refueling, washing) affecting surface and groundwater supplies; and (3) lack of adequate sanitary facilities for construction workers.
- Airborne dust and particulate contamination, caused by removal of ground cover from access roads, quarries, borrow pits and construction sites.
- Destruction or depletion of local natural resources, such as sand and rock taken from riverbeds, quarries or borrow areas and wood cut from neighboring forests for construction or for firing brick-making.
- Loss of hillside stability caused by the removal of vegetation cover, water saturation from altered drainage, and poorly designed quarries and borrow pits; results include landslides and slumping.
- Creation of an environment favoring disease vectors. For example, demolition rubble may serve as a breeding ground for rats; standing water may serve as a breeding ground for insect vectors and harbor water-borne diseases.
- Marring of viewsheds and aesthetic qualities by failure to properly dispose of construction and demolition waste (including trash produced by workers) and by scarring associated with quarries and borrow pits for construction materials.

Environmetal Damage from Housing Construction

- Erosion, particularly from quarries or borrow pits
- Water contamination
- Airborne dust and particulate contamination
- Destruction or depletion of local natural resources
- Loss of stability on slopes and hillsides
- Creation of areas where disease bearing insects and animals can breed
- Destroying or damaging scenic vistas

In general, the consequences of these impacts persist after construction is complete. Eroded land does not regain its fertility. Contaminated waterways will recover only slowly.

Environmental Damage from Built Housing

- Inadequate of non-existent sanitation
- Natural disasters, such as floods or landslides
- Dangerous or polluting local industries and activities
- Standing water, creating breeding grounds for disease-bearing insect
- Unhealthy conditions inside houses from poor design or construction

Quarries and borrow pits are breeding grounds for disease bearing insects, contribute to deteriorating water quality and cause erosion.

Impacts of the built environment. As noted above, housing construction changes the natural environment. But housing also *creates a built environment* for its inhabitants. Badly planned and constructed housing/settlements can create severe environmental health hazards for both the existing population and new inhabitants.

Environmental health issues include:

- Inadequate or absent sanitation facilities (water, sewage and solid waste disposal), leading to higher rates of diseases borne by oral-fecal transmission and by insect and animal vectors (e.g., mosquitoes, rats).
- Possible natural dangers—e.g., landslides and flooding.
- Dangerous prior or ongoing human activity near the site—such as highly polluting industrial, mining or farm operations, military operations, etc.
- Creation of standing water due to poorly constructed drainage systems or abandoned borrow pits, with associated increases in vector-borne disease.
- Unhealthy interior conditions due to improper house design or to construction materials that are inappropriate for the local climate and anticipated use of spaces within the home (e.g., creating interior conditions that are either too hot or too cold, or improper ventilation for heating or cooking).

Impacts on environmental resources. Creation of a new housing settlement can also affect the environmental resources available to the *existing population* in the area, particularly in rural locales, from:

- increased competition with new residents for water, forest resources (including fuelwood and game), and/or farmland.
- complete loss of access to resources or farmland, as a result of land clearance for the project itself, changes in land tenure, etc.
- degradation of land and—particularly downstream—of water resources.

Finally, the new housing development's built environment can put pressure on the resources available to the existing population—for example, by overloading transportation, power and water supply systems and crowding schools and health centers. This applies to both urban and rural environments.

Assessing the environmental impacts of a housing project requires knowledge of the baseline situation—in other words, the impacts of a proposed project must be assessed against what would happen without the project. In the case of housing projects, baseline assessment can be a particularly difficult proposition. The alternative to planned reconstruction may be unplanned and ad hoc resettlement of the site, reproducing—or even worsening—preexisting public health hazards and the poor construction practices which may have contributed to the disaster in the first place.

Damage to Environmental Resources from Housing Projects

- Increased competition from residents for local resources, such as firewood
- Loss of access to farmland
- Degradation of land and water resources

Sector Program Design—Some Specific Guidance

Overview

Land tenure. Resolving outstanding land tenure issues is an absolute necessity for any project. Obviously, it is critical to the project's general viability. In addition, any environmental and environmental health protections put in place by the project can be counteracted by those with legal claims on the land. However, resolving land tenure questions is rarely straightforward. Land tenure for poor, urban populations, for example, is often unclear or highly informal in Africa.

Governance and maintenance. Ongoing mitigation of environmental and environmental health impacts—as well as the benefits and services individuals derive from the built environment—is contingent upon proper maintenance and good community governance. In some cases, reconstruction will occur within a community that already has an effective, pre-existing governance system. In other cases, new community institutions must be established. Large-scale reconstruction efforts, or those that involve building a new community, should include a complete Community Development Plan (CDP), including the following elements as a minimum:

- *Administration of standard services and maintenance.* This should include responsibility for providing potable water supply systems, sanitation facilities, solid waste disposal systems, transportation, and cooking, educational and health facilities.

- *Provision of social services.* Community counseling in topics such as adapting to change and living in a community (especially important for resettlement/disaster relief-related housing); communal organization services (aid in the formation of civic associations, water boards, etc.); educational activities in water storage and latrine maintenance; in health and nutrition; in the construction, use and maintenance of fuel efficient stoves; as well as job assessment programs that include training and placement.
- *Establishment of a coordinating committee.* It is imperative that a functional group be established with the technical, organizational and administrative capacity to execute the development plan. Ideally, the committee should include an NGO representative, community representatives, local school representatives, a social worker and a municipal authority.
- *Supervision and monitoring program.* Regular on-site visits, surveys and quality testing of the facilities are needed to ensure their proper functioning. The Coordinating Committee should provide necessary oversight.

Design Elements for Successful Housing Projects

- Resolve outstanding land tenure issues
- Ensure proper maintenance and community governance
- Begin design with good baseline data on the community
- Always complete a preliminary project design
- Use baseline data and project design to anticipate environmental problems

Starting the design process with sound baseline data. Because the various housing activities—construction, facilities planning, etc.—are highly integrated, and because their impacts depend in large part on the *social and economic behaviors* of stakeholder populations, those designing and implementing activities must develop as complete a baseline as possible, describing both current and historical environmental and social conditions.

Two baseline surveys are highly recommended: (1) A social survey, to be administered both to future occupants (if known) and to the existing local population, and (2) an environmental baseline survey of the project site. Samples of these surveys are included at the end of this module.

Setting out a preliminary project design. Following the baseline surveys, a preliminary project profile is developed. The profile contains basic information about the preliminary design of the housing project, and should be filled out *before the project plan is finalized and any construction is undertaken.* (A template profile is also included at the end of this module.)

Using the preliminary design and baseline data to identify environmental concerns. Taken together, the baseline surveys and the project profile allow the most critical questions about the project's impacts to be answered. These questions are presented in the checklists found below. The checklists identify the most likely adverse impacts from a proposed project or program, and point to needed mitigation measures.

Those responsible for the project MUST be willing to adjust the project to address the critical problems identified by the checklists. *If the project* *design is not adjusted in response to identified concerns, then the entire environmental assessment process is meaningless.* Mitigation options are identified in the tables immediately following the checklists.

Any housing project must collect baseline data and develop a project design plan that takes site conditions, construction management and community governance into account.

Key questions: site and design

Note that the surveys and the project design assume construction of new housing units, rather than repair of existing structures. Checklists should be modified for projects oriented toward repair only.

These checklists should be answered using information from the baseline surveys and the project profile. Adverse impacts can be indicated as significant or moderate. For each **significant** adverse impact, a mitigation measure should be considered mandatory. For each moderate adverse impact, mitigation should be considered. Mitigation measures are presented in the final section of this sector briefing.

	Yes		No
	Significant Adverse Impact expected if no mitigation measures are applied	**Moderate Adverse Impact** expected if no mitigation measures are applied	
Will the project have reasonably foreseeable impacts on endangered or endemic species?			
Are any hazardous or highly polluting activities forseen, or currently taking place, in the surrounding areas?			
Could previous land use put the future population at risk?			
Did the environmental survey identify any other local problems or issues? If so, specify ____________			
Is the site at moderate or high risk from natural hazards?			
Does the site slope exceed 20%?			
Associated construction: • Will an access road need to be created or rehabilitated? • Will electricity transmission/generation infrastructure need to be constructed? • Will water supply and treatment infrastructure need to be constructed?			

	Yes		No
	Significant Adverse Impact expected if no mitigation measures are applied	**Moderate Adverse Impact** expected if no mitigation measures are applied	
Does the proposed potable water system meet estimated water requirements for the present and future population?			
If no, are complementary water sources available?			
Does the potable water quality meet relevant national or funding agency standards?			

	Yes		No
	Significant Adverse Impact expected if no mitigation measures are applied	**Moderate Adverse Impact** expected if no mitigation measures are applied	
Has the lighting source and distribution system been taken into account in the design and layout of the project?			
Is the cooking fuel available proportionate to the demands of the community?			
Has a solid waste disposal system been designed for the site?			
Will the solid waste disposal system meet relevant standards and has it been designed with future growth in mind?			
Has a sewage/graywater disposal system been included in the design?			
Will the effluent from the water disposal system meet relevant national or funding agency standards?			
Are the building materials adequate for the local weather conditions? Does construction embody appropriate earthquake resistance?			
Have provisions been made to ensure adequate occupant comfort in hot and cold seasons?			
Has the predominant wind direction been considered in the design of the project houses?			
Has the predominant wind direction been considered in the design of the waste disposal and sewage systems?			
Does the design and layout include the following elements, and do their type and quantity which meet relevant standards? • Internal roads			
• Green areas			
• Social and recreational areas			
• Fire prevention			
• Transportation			
Does the design accommodate future expansion? (Factors include growth in population, expansion of individual houses, and future utility service connections.)			
Is house design consistent with that of other housing projects or existing housing in the area? (Social problems may arise from the differences in quality of the houses and services provided)			

Key questions: construction management

If the answer is “no,” no further action is needed. For each significant impact, an adequate mitigation measure must be implemented. For each moderate impact, some mitigation should be considered. See the sections on small-scale construction and rural roads for further discussion on construction project management.

	Yes		No or N/A
	Significant Impact expected if no mitigation actions are applied	**Moderate Impact** expected if no mitigation actions are applied	
Will construction activities likely produce significant: • Erosion?			
• Water contamination?			
• Airborne dust and particulate contamination?			
• Deforestation?			
• Loss of habitat or biodiversity?			
• Effects on threatened or endangered species?			
• Hillside instability/landslide risk?			
• Noise?			
▪ Obstruction to roads or other existing transportation?			
▪ Construction or demolition waste?			
Will on-site water resources be used to satisfy construction needs?			
Are potentially hazardous construction techniques to be employed with serious risk to worker safety? (e.g., felling of large trees, blasting, large-scale excavation, construction of bridges and towers)			
Will laborers coming into the area require food and housing?			
Will laborers coming into the area plausibly increase the incidence of certain communicable diseases in the local population—e.g., malaria, tuberculosis, or HIV/AIDS?			

Key questions: habitation and community governance

Once people move into a housing project, long-term impacts (beneficial or adverse) will develop, affecting the inhabitants, the surrounding communities and the environment. Careful thought must be given to ensure that the project will have a positive and lasting influence on the area. Mark the answer that will best fit the project characteristics. For every “No,” a clearly defined plan should be designed and ready to implement before the houses are officially transferred to the new inhabitants.

	Yes	No
Will a management structure for the community be in place before the houses are occupied?		
Will the basic facilities (latrines, potable water, graywater and solid waste disposal) be ready for use by the time the houses are inhabited?		
Will there be any training in the use of these sanitary facilities for the project population?		
Have the parties responsible for the operation and maintenance of the facilities been identified and trained?		
Is there an established basic service billing system?		
Has the party responsible for the billing system been identified and trained?		

Environmental Mitigation and Monitoring Issues

Site and design

Potential Adverse Impact	Mitigation Measures
Change in land use pattern	Ensure that present land use at the proposed project site is not critical and that the present activities can be carried out on nearby land before the site is selected.
Destruction of important ecological, archeological or historical areas	Before the site is selected, verify that biodiversity, conservation of endangered or endemic species or critical ecosystems will not be adversely affected. Likewise, verify that no important archeological, historical or cultural sites will be adversely affected by the project. An alternative site should be used if the area is identified as critical.
Contamination of soil and water from sewage and solid waste	Site human waste and solid waste disposal systems to avoid surface and groundwater contamination, taking soil characteristics and historical groundwater and surface water conditions into account. Install adequate and appropriate sewage and solid waste disposal systems (e.g., use above-ground composting latrines in areas with high water tables).
Risk to residents due to possible natural dangers	Ensure that proposed project site is not located in areas: • subject to landslides • subject to fires • subject to flooding • with slopes over 20% • below areas likely to undergo significant deforestation or land clearing If the site is in an area subject to these natural dangers, an alternate site should be used. If no appropriate alternative can be found, mitigation measures must be taken to minimize risk in areas where it is unavoidable (e.g., construct firebreaks, stabilize slopes, construct drainage, elevate housing units on pilings, etc).
Risks to residents due to human activity near site	Before the site is selected: ▪ Ensure that the project will not be located within the area of influence (normally 1 km) of pollution and hazardous waste sources, including factories, mines, military bases, etc. ▪ Insure that the project is not downwind of a contamination source. ▪ If groundwater is to be used for drinking, test it for chemical and microbial contamination if there is any reason to doubt its purity. ▪ Identify and eliminate sources of noise pollution. ▪ Use alternate site if risk to residents is high.
Excessive use and pressure on existing facilities such as schools and health centers	Include the expansion or construction of any necessary infrastructure in the layout and design of the project, if needed.
Deforestation in order to implement project	If forest is dense or forms part of a critical habitat, an alternative site must be found. A forested area equal in size to one and a half to two times the area deforested must be established and maintained. The location and ultimate use of this protected area will be established in coordination with local municipal authorities. For each tree cut in a sparsely forested area, plant 20 new trees. This should be done no later than 6 months after the residents have moved in.
Excessive use of fuelwood as an energy source	Encourage use of alternative energy sources such as gas, electricity and solar. If fuelwood is the dominant energy source, include the planting of fuelwood plots using local species in the project layout and design. Require all residents who cook with fuelwood to use improved stoves.

Potential Adverse Impact	Mitigation Measures
Houses inappropriate for local climate; occupant comfort inadequate	Ensure that the design, construction materials, and siting of windows and doors takes local climatic conditions in cool and hot seasons and seasonal variation in precipitation and winds into account. Use local materials if possible.
Ventilation inadequate	Design houses to ensure adequate ventilation for the potential heating and cooking sources to be used within the home. Take advantage of wind direction in design.
Inadequate attention to type and location of solid waste disposal	Prepare and implement a *Solid Waste Disposal Management Plan* prior to resident occupancy. Include technology and funding for system maintenance and disposal, effects on groundwater, wind direction, etc. in the plan.
Health hazards due to lack of sanitation facilities (water, sewage and solid waste disposal)	Sanitation facilities *must* be included in the project design. Ensure that all sanitation facilities are installed and running before the occupants move in.
Unsafe potable water supplies	Ensure siting of supply systems and choice of supply technologies to minimize health hazards. Conduct seasonal testing of water quality, particularly for coliform bacteria and arsenic. Assess long-term and seasonal shifts in water quantity and quality.
Hazard due to inadequate earthquake resistance or inappropriate materials	Understand local risks of earthquake, floods and winds. Ensure that construction meets appropriate standards. Use locally available materials. Follow, or exceed, official design criteria.
Social impacts within and around the project site	A social analysis of the beneficiaries and the communities around the proposed site must be conducted implemented before the project is designed. If the site's location generates too much social conflict, an alternative site must be selected. Community development programs must be implemented in each community before or during the construction process.
Lack of compliance with mitigation measures	Collect signed binding agreements from the collaborating organizations and contractors before the project begins. Each NGO or partner must have an environmental management plan to ensure compliance with the mitigation measures. Have an independent evaluation of the plan conducted annually.

Construction

Potential Adverse Impact	Mitigation Measures
Risk of injury to workers/local inhabitants from construction	Insure that workers have proper protective equipment (noise and dust protection, boots, gloves, etc.) and follow sound safety practices (e.g., use safety ropes, practice proper blasting safety) as appropriate. Insure that pits are covered or that access to them is impeded during construction. Excavate and rebury trenches quickly. Manage quarry slopes to avoid cave-ins.
Interruption to local transportation	Schedule construction for low-traffic days or hours; stagger construction to dilute the impacts of road closure. Conduct work to permit at least alternating one-way road passage.
Noise	Schedule work so as to minimize noise. Use less noisy construction techniques.
Dust or mud	Spread water to keep dust down. Drain areas prone to mud. If possible, schedule land-clearing, excavation and similar activities to avoid extremely dry and extremely wet conditions.
Breeding grounds for insect vectors (e.g., standing water in borrow pits; demolition debris)	Excavate and rebury trenches quickly. Arrange for construction or demolition debris to be permanently disposed of away from watercourses. Fill borrow pits or assure their drainage. Use shallow wells or streams for construction water rather than diverting natural flows to the construction site.

Potential Adverse Impact	Mitigation Measures
Erosion during construction of houses and access roads	Soil conservation measures must be included in the design and implemented during construction. The exact means will depend on the site and the severity of the impact. Install checks and barriers (e.g., berms, hay bales or other vegetation) to trap sediment runoff and revegetate disturbed areas.
Lack of compliance with mitigation measures	Collect signed binding agreements between the collaborating organizations and contractors before the project begins. Each responsible NGO or other partner must have an environmental management plan to ensure compliance with the mitigation measures. Have an independent evaluation of the plan conducted annually.

Habitation

Potential Adverse Impact	Mitigation Measures
Improper use of environmental and sanitary resources by householders	If applicable, the responsible NGOs and partners must provide environmental and sanitary training for all residents before they move in. Training should address all of the following: • Environmental education for children • Care of domestic animals • Reforestation of green areas • Proper use and maintenance of latrines • Social interactions in housing projects • Proper use and conservation of water • Construction and use of improved stoves • Fuelwood plot management
Lack of compliance with mitigation measures	Collect signed binding agreements between the collaborating organizations and contractors before the project begins. Each responsible NGO or other partner must have an environmental management plan to ensure compliance with the mitigation measures. Have an independent evaluation of the plan conducted annually.

Resources and References

Two types of resources are provided in this section: those concerned with disaster prevention management, and those concerned with construction standards.

Disaster prevention and management.

Resources in this area are organizations and Web sites, rather than specific documents. The Web sites are intended as portals for accessing a wide variety of documents and technical resources.

Documentation of best practice in disaster reconstruction can be accessed via the Best Practices Database (http://www.bestpractices.org/), offered by the UN Commission on Human Settlements (UNCHS and the Together Foundation). Access to abstracts is free.

Technical guidance

Online technical guidance on appropriate and disaster-resistant housing is scarce. In English, Practical Action (formerly known as ITDG, http://www.itdg.org/) Publishing's online "Development Bookshop" service (http://www.itdgpublishing.org.uk/) serves as a single point of search (and ordering) for this and other technical, development-related subjects. (Note, however, that books ship by post.)

Social Baseline Survey: SAMPLE
For potential occupants of new housing and potentially affected local populations

Note: This survey assumes construction of new housing units, rather than repair of existing structures. The survey should be modified if for projects oriented toward repair only. not all elements of the survey will be applicable to all projects or programs. The survey should be modified according to the needs of the particular activity. Some questions—e.g., those pertaining to demographics or land tenure—may be sensitive and should be pursued using the best judgment of the individual administering the survey.

The survey should be administered to the following groups:

- **Where specific future occupants can be identified**, this questionnaire should be completed for at least 10 percent of the future families, with a minimum of 20 families surveyed, even for small projects. Group interviews are acceptable.
- **If specific future occupants cannot be identified**, then representative potential occupants can be interviewed. If interviews are not possible, the survey can be completed for an "average" occupant using expert knowledge.
- **A representative sample (10 to 20 families) in communities (e.g., clusters of more that 50 houses) within a 1 km radius of the project site** should also complete this survey. The sample should include teachers, representatives of municipal authorities and water board members. The questionnaire can be conducted individually or in groups. For this group, "current residence" should be substituted in questions regarding "previous residence."

General Information

Name of the project: ______________________________ Date __________________

Location: ______________________________ (District/Municipality/Department)

Name of surveyor: ______________________________

Type of respondent(s): ________occupant or possible occupant

________potentially affected local population

If local population, name of community ___________________________
Population (est.) ________
Distance from project site: _______________

Type of consultation: _______ Organized group ______________________________(name of group)

_______Non-formal consultation

Number of persons consulted: ____________

Questions

A. If respondent(s) are potentially affected local population, ask if they are aware that a housing project is planned nearby. Yes____ No____

1. In your opinion, what are the most important benefits of the project?
____
____

2. In your opinion, what are the problems associated with the project?

____
____

3. Are there any indications of archeological/historical/culturally important sites in the area of the project? Yes ___ No ___

4. What do you cook with? (check all that apply; if multiple fuels, indicate % of time each is used)

Fuelwood	Charcoal	Kerosene	Gas	Electricity

If the answer is fuelwood:

- What kind(s) of trees do you use? ____________________
- Who collects it? ___________________________________
- Where? ___________________________________
- Is wood plentiful or scarce? ____________________________
- Average time per day spent obtaining wood?_____________________

5. Which of the following did your previous (current) residence have? (check all that apply)

Utility or amenity	**Y/N**	**(Hours/day)**
Electricity		
Piped water—in home		
Piped water—community tap		
Private latrine		
Community latrine		
Private toilet		

- If latrine, what type? Simple pit________ Composting _______ Hydraulic_______

6. What were the walls of your residence made of? (check all that apply)

Wattle and daub	Mud Brick	Concrete Block	Wood	Other (specify)

7. What was the floor made of?

Tile	Cement	Dirt	Other (specify)

8. What was the roof made of?

Corrugated metal	Thatch	Tile	Other (specify)

8. What was your source of water? (check all that apply)

River	Stream	Spring	Hand well	Borehole	Piped

- Is water scarce in the dry season? Yes ____ No _____
- **For potentially affected local population**: Do you think there will be enough water for your community and the new project? Yes_____ No _____

9. What are the most common diseases in the area where you live? (check all that apply, solicit detail if possible)

Disease	**Y/N**	**Comments**
Respiratory ailments		
Diarrhea		
Malaria		
HIV/AIDS		
Other		

10. Did you consider any of the following to be problems in your community? (check all that apply)

Issue	**Y/N**	**Comments**
Water scarcity		
Contaminated river or well water		
Standing water		
Sewage		
Solid waste		
Scarcity of fuelwood		
Deforestation		
Erosion		
Decline in land fertility		
Fires		
Landslides		
Flooding		
Disappearance of fish and game animals		
Insects and animals that carry disease		

11. Household demographics

Datum	**#**	**Comments**
# of individuals in household		

# of children <5		
# of children 5–10		
# of children 11–16		
# of children in school		

Environmental Baseline Survey **SAMPLE**

General Information

Name of the Project: ____________________________ Date ________________

Location: ____________________________

Name of Surveyor: ____________________________

Survey data

1. Land use and tenure

Datum	Surveyor's characterization	Notes
Current land use at proposed site		Change in land use can cause conflict, e.g., if the land is currently being used by a neighboring community for grazing, planting crops, as a source of water, etc.
Previous land use, if different		Past activities such as hazardous waste dumping can endanger the community.
Ecosystem characterization of current site		
What is the current land tenure/title status?		

2. Proximity issues. Is the site located within 2 km of any of the following?

Facility, habitat or activity	Y/N	Comments
Airport		
Military zone		
Protected areas		
Archeological/ anthropological/ cultural/historical sites		
Forested area		
Important flora/fauna habitat, including: ▪ wetlands		
▪ tropical rain forest		
▪ mangrove		
▪ coral reefs		
▪ endangered/ endemic species		
Critical biological corridor		
Critical headwaters/		

source for local or downstream water supplies		
Highly polluting or hazardous industrial or mining activity		

3. Vulnerabilities

How does your survey rate the site/area's vulnerability to …	**Surveyor's characterization High/Medium/Low/ Not Applic.**	**Comments (note any recent natural disasters)**
Flooding		
Hurricanes		
Landslides		
Earthquakes		
Forest/Brush fires		
Drought		
Contamination from external sources (industry, agriculture, animal farms, etc.)		
Erosion		

(Medium to high vulnerability will require choice of an alternate site or use of effective mitigation measures)

4. Anticipated source(s) of water

Primary source(s)	**Average flow (if well, daily yield)**	**Lowest seasonal flow**	**Drinkable without treatment?**	**Nature of current utilization**	**% of flow currently utilized**
e.g., spring					

Secondary source(s)	**Average flow (if well, daily yield)**	**Lowest seasonal flow**	**Drinkable without treatment?**	**Nature of current utilization**	**% of flow currently utilized**
e.g., spring					

5. Soil characteristics and topography

Datum	**Surveyor's characterization**	**Notes**
Soil composition/type		This is an important design consideration in waste disposal systems.
Permeability		
Depth of bedrock		

Average slope of site		Slopes greater than 20% are generally unsuitable for housing.
Depth of water table		Important design consideration for both water supply and waste disposal systems, such as wells and latrines.
Superficial, seasonal and/or sub-superficial watercourses in the project area?		Specify depth and location.

6. Climate and weather

Datum	**Surveyor's characterization**	**Notes**
Average temperature		Hot weather must be considered when designing a house so it may have proper ventilation.
Rainfall pattern		
Average yearly rainfall		
Predominant wind direction		Important for ventilation and the location of waste disposal systems.

7A. Characteristics of the built environment

Datum	**Surveyor's characterization**	**Notes**
Distance to nearest road		The community must have proper access to work, school and health centers.
Distance to public transportation		
Are there other communities within 2 km of proposed site? (Y/N)		If yes, fill out table below.

7B. Facilities and infrastructure of communities within 2 km of proposed site. List the facilities these communities have, including hospitals, health centers, schools (specify levels), waste disposal systems, houses of worship (specify denominations), recreational centers and government offices.

Community name	**Distance**	**Approximate population**	**Facilities and utilities**

8. Topographic mapping. The site must be marked on a topographical map, preferably scale 1:50,000. Water bodies, existing settlements and infrastructure, and facilities, habitats or activities identified under "proximity issues" must be clearly identified.

Preliminary project profile

Complete the following project profile.

1. General Information

Name of the project: ____________________________ Date ________________

Organization: ____________________________

Contact: ____________________________ (name and position)

____________________________ (address)

____

____________________________ (tel/fax/e-mail)

2. Land title

Has title to the entire site been secured? Yes____ No____

3. Basic characteristics/site plan

Characteristic	Estimate	Comments
Total area (ha)		
Lot size		
Number of houses		
Persons/household		
Total population		
Water/person/day		
Total estimated water demand		
Percent of area designated for: • internal roads		
• green area		
• community/ recreational areas		
• transport facilities		

4. Basic construction of housing units

House element	Material	Comments
Floors		e.g., dirt/cement/tile
Roof		e.g., corrugated sheet, tile, tarp
Walls		e.g., adobe, cement block

5. Planned utilities and sanitation

Utility		Comments
POTABLE WATER • planned potable water source		i.e., community well, community borehole, rainwater collection, spring, stream, pipe-borne/community tap,

		pipe-borne/private connections, water trucks
• daily source capacity, seasonal low		
COOKING • cooking fuel		Firewood, charcoal, kerosene, electricity, bottled gas
ELECTRICITY • source		National grid/solar battery/local diesel set/none
• source capacity		kW or kW/hr, as appropriate
• availability		All day; all hours; evenings only; etc.
• public lighting? • house connections?		Y/N; anticipated load Y/N; anticipated load per house
SOLID WASTE • mode of collection/transport		
• final disposal		Incinerator, landfill, other
WASTE WATER • graywater		
• sewage		
RAINWATER DRAINAGE		How will rainwater runoff be managed?
SANITARY FACILITIES • communal or individual household?		
• type		e.g., improved pit latrines, composting latrines

6. Administration and funding of utilities and sanitation. Indicate the institution which will administer each of these services and *how they will be funded.*

	Potable water	Solid Waste	Sewage	Electricity
Local government				
Community organization				
NGO				
National, regional or municipal utility				

7. Social services from the built environment

Schools	
Projected # of school-age children	
Does project plan include a school? (Y/N)	
If no:	

• distance to nearest school(s)	
• do nearest school(s) have sufficient excess capacity	

Health post/clinic	
Does project plan include a clinic/health post?	
If no, distance to nearest health post	

Chapter 10

Humanitarian Response and Natural Disasters

Contents

10.1 Humanitarian Response

Brief Description of the Sector	10-1
Potential Environmental Impacts	10-2
Sector Program Design	10-3
Monitoring and Mitigation Issues	10-11
10.2 Natural Disasters	**10-15**
Brief Description of the Sector	10-15
Environmental Forces Driving Disasters	10-17
Sector Program Design	10-19
Mitigation Measures	10-21
Resources and References	10-23

Experience shows that in times of emergency, there are often direct links between human suffering and environmental harm—and that both can be eased by early attention and pre-planning.

Chapter 10.1 Humanitarian Response

Brief Description of the Sector

The United States has a long history of providing humanitarian assistance to the victims of man-made and natural disasters, as well as to development assistance programs aimed at improving food security for vulnerable populations in developing countries. This assistance is provided through USAID's Office of Food for Peace (FFP) of the Bureau for Democracy, Conflict and Humanitarian Assistance (DCHA), in conjunction with the U.S. Department of Agriculture and U.S. private voluntary organizations (PVOs). Resources are provided through the Food for Peace Program (PL 480) Title II. In many African countries, these PVOs have often been in the forefront of those providing both emergency relief to refugees and various forms of development assistance that are oriented toward food security .

When disasters strike overseas, USAID's Office of U.S. Foreign Disaster Assistance (OFDA), another branch of DCHA, leads the response. OFDA can draw upon a variety of assets in responding to disaster, including stockpiles of relief commodities such as plastic sheeting, tents, and water purification units. OFDA is also charged with working with host governments to develop early warning systems and training programs to strengthen local self-reliance in the face of disasters.

In the past, concern for the environment was seen as a luxury that need not be addressed by those involved with emergency and refugee relief programs. USAID's environmental regulations specifically exempt emergencies and disaster relief operations from environmental review and scrutiny.[1] Experience, however, is leading to an awareness that human suffering in emergency situations is often linked to adverse environmental impacts, and that both can be lessened with early attention and pre-planning. This new awareness grows out of the recog-nition that the environmental damage caused by the disaster itself—or by the disaster victims or the disaster response—can worsen the condition of disaster victims, including refugees and internally displaced persons (IDPs). This is particularly true when the direct effects of environmental contamination threaten the health of an already endangered refugee population.

Potential environmental effects associated with humanitarian programs include:

- Deforestation
- Contamination and depletion of water supplies
- Land use changes
- Air pollution
- Poaching
- Health effects on disaster victims
- Women's and children's safety

Without planning, refugee and IDP camps can cause significant environmental harm to surrounding areas and local communities.

The adverse impacts of large concentrations of displaced people and/or their camps can also affect the local population of host communities and countries. Often, in the case of both natural and man-made disasters, refugees and IDPs flow into nearby areas where the local population may also be facing difficulties, though perhaps not yet at the level of an emergency. It is therefore imperative that those who aid disaster victims ensure that potential environmental problems are anticipated and that a mitigation action plan is followed.

Potential Environmental Impacts of Programs in the Sector and Their Causes

The influx of disaster victims into an area can disturb ecosystems and threaten the livelihoods of local communities. Environmental impacts of emergency, refugee, resettlement and food aid programs may include:

- **Deforestation.** Wood collection for firewood and construction materials can deforest large areas surrounding camps. The loss of forest and ground cover destabilizes watersheds, triggering or worsening soil

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[1] See Regulation 216 (b)(1)(i)(ii).

erosion and flooding. Deforestation destroys animal habitats as well, causing loss of wildlife. Deforestation also reduces the local community's supply of fuel, timber, and non-timber forest products and undermines their efforts to manage their natural resources and parks.

The influx of disaster victims into an area can disturb ecosystems and threaten the livelihoods of local communities.

- **Water contamination and depletion.** Water resources that are not protected from refugee wastes and wastewater may become contaminated. Groundwater sources may also be depleted through excessive pumping.

- **Environmental health deterioration**. Refugees in poorly designed and constructed camps can suffer from disease and accidents caused by insufficient or unsafe water supply; poor sanitation and waste disposal; poor drainage; hazardous terrain (including gullies and ravines); and uncontrolled disease vectors (such as insects and rodents).

- **Changes in land use**. Agricultural production to meet the basic needs of refugees for food and income can lead to conflicts with local land users, changes in land-use patterns, cultivation of marginal areas, and encroachment on areas that are ecologically sensitive or high in biodiversity value, whether they are formally protected or not.

- **Air pollution.** The burning of fuelwood (particularly green wood for cooking), as well as kerosene or other fuel oils, can release harmful smoke and cause acute respiratory infections.

- **Poaching.** Poaching, particularly in protected areas, can decimate endangered species populations and disrupt local communities' revenue streams from commercial hunting ventures.

- **Personal safety.** Deforestation of nearby areas often necessitates long journeys for wood collection. This exposes fuelwood collectors—who are most apt to be women and children—to assault and even kidnapping, especially when there are lawless or disputed territories near the camp.

- **Health impacts from measures to protect food aid resources from contamination**. Treatment of stored food supplies may impair human health. For example, people working in food aid stores as well as those who consume the food may be endangered by chemical residues of treatment, such as the dust from phostoxin tablets used to fumigate storage areas and stored food.

Sector Program Design—Some Specific Guidance

Preparedness is the key to a quick response to emergency relief and disaster situations. Because of the urgency, a quick response capability should be anchored in a series of clear operational directives. The following precautionary operational steps will help to ensure an environmentally sound response:

Rapid Environmental Impact Assessment. A Rapid Environmental Impact Assessment (Rapid EIA)[2] is a shorter impact assessment tool specifically designed for disaster response. While not a substitute for the EIA process normally applied to development programs and projects, it requires less time and expertise, and can therefore better respond to emergency conditions. A Rapid EIA can also be frequently and easily updated to reflect the changing conditions at refugee and IDP camps. Such assessments can be completed in a few hours by one person or within 1–2 days by a small group of people, none of whom need to be experts in environmental assessment. The Rapid EIA includes a community assessment tool designed to capture the needs, views and desires of the disaster victims themselves. Rapid EIAs should be used in the first 90 to 120 days after a disaster strikes. Beyond that threshold, it is better to perform a complete environmental assessment as part of the recovery/rehabilitation process.

Rapid Environmental Impact Assessments

A Rapid EIA is a shorter impact assessment tool specifically designed for disaster response. While not a substitute for a full environmental assessment, it requires less time and expertise, taking from a few hours to two days. A Rapid EIA:

- summarizes the situation
- identifies factors with immediate effect on the environment
- identifies immediate environmental hazards
- identifies unmet basic needs
- identifies the environmental effects of relief activities
- lists actions to address issues, and
- sets out guidelines based on a survey of the affected community.

Rapid EIAs consist of seven sections, each of which helps planners anticipate potential impacts and estimate the risk associated with them:

1. **Context statement**. This short statement summarizes the facts of the disaster, perceived environmental issues, information sources, any needs for further assessment/data, and special environmental assistance needs (e.g., an oil spill, work in an area inhabited by an endangered species).

2. **Identification of disaster-related factors with immediate impact on the environment**. This element lists and prioritizes factors requiring mitigation and identifies ways to mitigate or avoid environmental damage. Sample factors include the number of affected people, population density, the duration and the extent of the disaster, whether the victims are displaced or not, what resources are available, density of settlements, how people make a living, and social structures.

3. **Identification of possible immediate environmental hazards**. This analysis details and prioritizes any significant immediate threats to lives and well-being—for example, a flood passing through a fertilizer factory and contaminating nearby ponds used for drinking water. The focus of this Rapid EIA element is on hazards which may have an immediate impact on the environment and need to be addressed without delay.

4. **Identification of unmet basic needs**. This very important step identifies and prioritizes the unmet needs of the disaster victims, including refugees or IDPs, with their likely environmental impacts. An example would be the need for fuelwood to cook or to generate income and the deforestation that may result. The form rates the

[2] The Rapid EIA was jointly developed by the Benfield Hazard Research Centre /University College of London and CARE International, funded by the UN Environmental Program (UNEP)/Office for the Coordination of Humanitarian Affairs (OCHA) Joint Environmental Program, the Royal Norwegian Ministry of Foreign Affairs, and USAID/OFDA.

level of satisfaction of critical needs like water, shelter, fuel, food, health services and waste disposal.

5. **Identification of potential environmental damage caused by possible relief activities**. This element captures the negative impacts of ongoing or planned activities, including agriculture, irrigation, livestock expansion, introduction of agrochemicals, water supply and sanitation, and healthcare services. The form also lists possible changes to these activities and mitigation steps that could be taken during either relief activities or recovery operations.

The most critical environmental damage begins to accrue right from the outset of emergency situations.

6. **Synthesis action list**. This synthesizes the previous steps to prioritize critical environmental issues, determine actions to address these issues, and note issues which may require action after the relief phase is complete. The list specifies a deadline for completing each follow-up action and names the party responsible for completing the task.

7. **The community Rapid EIA guideline**. This is a useful tool to collect information in a participatory way from a diverse group representative of the affected community. Ideally, it should be completed separately with different segments of the disaster victim community, assuring inputs from women and other disadvantaged groups (youths, elderly people, members of minority populations, people with handicaps, etc.). It collects data on environmental issues as they are perceived by the disaster victims and allows respondents to prioritize their environmental concerns—not only those stemming from the disaster, but those that contributed to it in the first place.[3]

Include competent environmental specialists in disaster and relief teams: Experience has shown that the most critical environmental damage begins to accrue right from the outset of emergency situations. The most acute of these problems relate to basic human needs for water, sanitation and environmental health precautions. It is of fundamental importance to ensure that competent staff is on hand to deal with these problems, as well as provide advice to other team members attending to the food, shelter, health care and organizational needs of disaster victims.

[3] The Rapid EIA documents, including the forms, can be all consulted and downloaded from the BGHRC/UCL at http://www.bghrc.com/DMU/REA/DREA3v2.pdf.

Environment-Related Directives from the *Field Operations Guide* (FOG):

Water Matters:
Reduction in the quantity of water available to individuals has many health consequences. Proper supplementary and therapeutic feeding programs will be impossible unless sufficient water is available...

Minimum water needs vary ... the following amounts (liters per person per day) are desirable: drinking, 3–4; cooking and cleanup, 2–3; personal hygiene, 6–7; laundry, 4–6 = total individual daily need of 20–30 liters per day.

Efforts to control and manage the use of contaminated water should be arranged with community leaders ... immediate steps must be taken to prevent pollution from excreta.

Health Matters:
The risks of communicable (infectious) diseases are increased by overcrowding, poor environmental conditions and the often poor initial state of health of the population.

Measures to improve environmental health conditions are very important, and include: providing enough safe water and soap, properly disposing of excrement and garbage, controlling rodents and vectors, and educating the population.

Camp Site Selection:
WHO recommends a minimum of 30 m^2 per person; of this 3.5 m^2 is the absolute minimum floor space per person in an emergency shelter.

The single most important site selection criterion is the availability of adequate amounts of water on a year-round basis.

Sanitation and Environmental Services:
An acceptable and practical system for the disposal of human excreta is the key to reducing health hazards.

One latrine should be provided for every 20 people. Latrines should be located at least 6 m. from dwellings, 10 m. from feeding and health centers, and 15 m. (and preferably farther) from wells or other drinking water sources.

Once people have been settled in camps, their care and maintenance will also require giving attention to the natural environment and to how it can more sustainably provide food, energy and building resources. In longer-term refugee situations, fostering a degree of self-reliance and independence from external food resources will also require guidance about appropriate and durable land-use patterns that are compatible with the local environment. Finally, specialists will be needed to help plan and implement an effective program for the environmental rehabilitation of host areas once the refugees begin to return to their places of origin.

Distribute and follow environmental guidelines for operational planning. The Sphere project—a multi-year project sponsored by NGOs, the International Red Cross and Red Crescent, donor governments, and UN agencies—has published *The Humanitarian Charter and Minimum Standards in Disaster Response*, an extensive treatise on the standards for water and sanitation, nutrition, food aid, shelter and site planning, and medical services needed to respond to humanitarian crises.[4] The *Environmental Guidelines* of the United Nations High Commissioner for Refugees (UNHCR), the USAID/OFDA *Field Operations Guide (FOG) for*

Planning, information and education are critical to preventing environmental damage during relief efforts.

Disaster Assessment and Response, and the UNEP/OCHA *Guidelines for Environmental Assessment Following Chemical Emergencies* also provide specific guidance for addressing the environmental dimensions of these situations. Chapter III of the FOG provides specific guidelines for assessments and responses related to water supplies, disease control, site selection and planning, shelter, and sanitation and environmental services. (See summary in sidebar, previous page.) Copies of these documents should be issued to all emergency and disaster relief teams.

Additional technical guidance and best practices can be found in the chapters on water and sanitation, forestry, agriculture and irrigation, rural roads, solid waste, and medical waste in the present volume.

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[4] As of summer 2003, the Sphere standards are being reviewed and upgraded to include stronger environmental considerations. For further information, see www.sphereproject.org

Plan for long-term demands. Camps may be used for years beyond their expected lifetime. In anticipation of this possibility, players must coordinate their activities with government and NGO staff to ensure compliance with local laws and minimize environmental damage, especially to sensitive and protected areas. Investments in infrastructure, such as road improvement, riverbank protection, and construction of health posts, should also benefit local communities. Develop an environmentally sound long-term land use strategy involving activities such as conversion of areas for agriculture or agroforestry. Begin planning for rehabilitation activities as early as possible.

Use food aid proactively to avoid dependency: A full discussion of the complexities of the issues surrounding food aid dependency is beyond the scope of these *Guidelines*. In the recent past, the issue has received considerable attention within the humanitarian response community, and a much more integrated approach—including food aid, food-for-work, cash and technical assistance, and development-oriented food aid programs—has become standard practice with both USAID- and UN-funded programs. A number of fundamental principles can help ensure that food aid is used proactively to move refugees, displaced persons and food-insecure people along the continuum from relief to development. The principles include:

- **Apply participatory approaches**. Helping people make environmental choices is a matter of information and motivation. In an emergency or relief situation, local community structures have often been weakened. Instituting a genuinely participatory approach to working with disaster victims and local communities—or, for that matter, with the people involved in development programs that are funded with food aid—can reinforce their resolve, both personal and collective, about their own capabilities, their prospects and their hopes.

  USAID, in its *Food Security Policy Paper,* emphasizes this need: "...interventions must be designed and implemented on the basis of the same principles that guide sustainable development—capacity building, participation and sustainability" (USAID 1995). Building capacity and leadership is key to helping affected individuals and groups better understand the issues, build consensus, and negotiate the tradeoffs that are often required for them to adopt new behaviors in the face of new circumstances.

  In fast-paced humanitarian response settings, where environmental problems tell quickly on the people being assisted, participatory monitoring can be especially effective. A good network of leaders and spokespersons within the community, and regular meetings with them, can help track environmental health conditions on a timely basis. This can be critical to ensuring the health and well-being of vulnerable people.

"Interventions must be designed and implemented on the basis of the same principles that guide sustainable development—capacity building, participation and sustainability."

Source: USAID 1995

Zambia Initiative Benefits Refugees and Local Hosts

Zambia hosts 292,000 refugees, mainly from Angola and the Democratic Republic of the Congo. This is a heavy burden for a poor country with fewer than 10 million citizens of its own.

UNHCR, in partnership with the Government of Zambia, has created a new strategy for supporting development projects to benefit both refugee and local communities in the Western Province of Zambia. The “Zambia Initiative" is a plan to link relief and development assistance, contributing to peace and stability in refugee-hosting areas of Zambia.

The program will establish small-scale projects in:

- agriculture (irrigation, crop production, poultry and fish farming);
- health (HIV/AIDS programs, training, maternity wards, rural health centers);
- education (schools and vocational training centers, material and teachers), and
- infrastructure (water and sanitation, roads).

Source: UNHCR 2002b.

- **Conduct agriculture and natural resource management training that is oriented toward food security**. Much of the discussion of agriculture and small-scale forestry in these *Guidelines* reflects the principle that environmentally sound activities can help to enhance food security by raising the productivity of smallholder farming and other land uses. Readers who are involved in longer-term aid to refugees and displaced persons should familiarize themselves with the principles of environmentally sound design for these activities. Sustainable production models should be used in developing food or fuelwood production activities among camp communities. This can also benefit the participants by giving them knowledge and skills they can apply once they return to their own lands.

- **Provide for environmental rehabilitation.** In the spirit of environmental justice, humanitarian response programs must include the resources and the time needed to rehabilitate damaged areas so that the local populations do not suffer from having hosted the disaster victims. Rehabilitation efforts can include camp cleanup; disposal of waste materials; closure of latrines; removal or conversion of housing and other infrastructure; and the development and implementation of plans for rehabilitating affected resources nearby (e.g., via soil and water conservation and revegetation). The UNHCR estimates that rehabilitation costs for existing refugee camps in Africa could be as high as US $150 million annually. These efforts may extend for years after the refugees depart. In some instances, it may be necessary to work with development organizations to integrate technical expertise and approaches to rehabilitation into other community development initiatives.

Design and Operational Guidance

Site selection. Large population increases in areas with limited natural resources may lead to conflict between disaster victims—particularly refugees (or IDPs)—and host communities. Where feasible, camps should be located away from local populations and should be spaced at least 20km apart to minimize the environmental degradation caused by camp activities. Camps should be at least 15km away from ecologically sensitive or protected areas. Before the camp is set up, planners need to understand the regular and seasonal land uses of the potential area, including grazing, hunting and gathering, wildlife migration, and encampment by nomadic communities. In some cases, camp-related environmental impacts may be reduced by integrating refugees or IDPs into local communities.

Areas with strong winds should not be chosen as camps. Winds damage infrastructure and vegetation, and worsen erosion from deforestation. The soil slope of the site should be between 2 and 6 percent. A 2 percent slope is the minimum recommended to achieve natural drainage. A 6 percent slope is the suggested maximum to prevent erosion from cleared areas.

Camp planners must select a site with an adequate freshwater supply. They should consider seasonal fluctuations, downstream water quality and potential impacts on downstream users, as well as quantity requirements, access, and the needs of local communities. Camps using groundwater supplies must be aware of water table levels and drawdown effects. Planners must also anticipate the long-term effects of deforestation or overgrazing on the local watersheds.

Campsites need to have enough timber resources to meet fuel and shelter requirements. Estimating these requirements and the available supply may require input from forestry or biomass energy experts, as well as the local population and representatives of the displaced people. Planners should consult with host governments and NGOs to develop and manage resource-use plans for designated camp areas. Planners should also budget for wood-harvesting fees, since forestry activities in private or government-managed forests may require royalties.

Planners should design refugee schools, hospitals and, if possible, cemeteries so that the local population can use them after the camp closes.

"Attention to environmental concerns during site selection and planning can be the single most significant strategy in avoiding environmental degradation during mass population displacements."

Source: CARE 1999.

Site selection, design and operations issues	
Site selection	Spacing (away from population centers, environmentally sensitive areas and other camps)
	Area's regular and seasonal land uses
	Local wind speed patterns
	Slope of land
	Water supply; effects of camp on watershed
	Timber resources and effect of camp on them
	Possible local use of camp school, hospital, cemetery after refugees leave
Site design	Proper design of roads (cambering, drainage) and footpaths
	Layout of garden plots (clustering plots, adding ground cover)
	Storage, household supply and fire prevention system
	Proper design and siting of latrines
	Using prefabricated or locally available construction materials
	Refugees' social customs
Site operation	Safe disposal of waste
	Safe control of pests

Site design. If new access roads are required, they should be cambered, have proper drainage and follow contour lines. Drainage ditches should be constructed to control rainwater; their outlets should have control measures (such as check dams) for preventing high-volume or high-velocity flows likely to cause gully erosion. Road gradients greater than 10 percent should be avoided whenever possible. For more on roads, see the rural roads chapter of these *Guidelines*.

Footpaths within the camp, like access roads, should be planned to minimize erosion and potential accidents. Firebreaks should be included; roads, for example, can act as firebreaks. The effects of soil compaction over time should be anticipated in designing pathways and roads.

Family residential and home gardening plots should be arrayed in clusters to encourage communal cooking and energy conservation. Households with family plots of $400m^2$ or larger should be encouraged to cultivate trees and bushes for ground cover.

Sites should include storage facilities for fuel, fuelwood and food supplies. Facilities will also require fire prevention measures and a system for distributing supplies to households.

Latrines should be sited at least 30m from water sources to prevent contamination of surface waters. Latrine bottoms should be at least 1.5m above the water table to prevent groundwater contamination. Timber slabs may be used in pit latrines for short-term, emergency facilities, but concrete slabs should be used if latrines will be needed for more than a few months. Concrete is easier to clean, lasts longer, and does not use wood that is needed for shelters or home energy.

To supply or not to supply firewood?

Firewood is one of the most critical needs for refugees, and camp managers find the issue of supplying firewood equally critical. Supplies of firewood are expensive to truck in and difficult to distribute equitably. However, uncontrolled harvesting of local tree stands by refugees leads to deforestation, destroys habitats, and compromises the physical security of women and children sent to collect the wood.

Refugees can become very passionate about firewood supply programs, seeing them as a source of security and employment. Nevertheless, they may also abuse such programs by continuing to harvest trees to sell for income.

Site construction. If available, prefabricated structures or tents should be used for shelters. Locally supplied materials should be used whenever possible, particularly for communal spaces, offices, and storage facilities. Always consider the refugees' social customs during construction. Rwandan refugees in Tanzania, for example, refused to use improved cookers because they had been built "in the wrong place" in their huts. Somalian refugees in Kenya shunned improved stoves because they were constructed in the shape of graves (UNHCR 2002a).

Areas should be left vegetated or replanted after construction to stabilize the soil. Trees should be planted around family plots and in areas susceptible to soil erosion.

Camp operations. Open water sources should be protected from bathing, laundry and dishwashing. Incentive programs should be designed to reward energy-efficient behavior. Camp enterprises (restaurants, breweries, etc.) should be encouraged to use improved stoves and other energy conservation measures. Plans to manage the use of natural resources should be implemented as soon as refugees or IDPs arrive.

Systems should be in place for reusing or disposing of non-biodegradable waste. If chemicals are used to control disease vectors (e.g., rats, mosquitoes), all guidance on safe storage and use of pesticides must be followed, as outlined in the chapters on safer pesticides and integrated pest management in these *Guidelines*.

Mitigation and Monitoring Issues

Water and sanitation

- Protect water sources from siltation, erosion, human and livestock waste, contaminated surface waters, and rainwater runoff.
- Do not divert surface water flows (e.g., rivers, streams) to the point where the remaining flows become stagnant.
- Mitigate disease threats from stagnant water bodies and ponds by incorporating fisheries into the humanitarian project. Fish can generate income while controlling mosquito populations.
- Use bed nets to protect against lice, mosquitoes, bedbugs and sandflies. Insecticide-treated nets are especially effective, but must be handled with care. [5]
- Mitigate erosion gullies by constructing a system of channels, bridges, culverts, and gabions (baskets of steel mesh filled with stones, used for erosion control along watercourses). These allow safe crossing, alleviate flooding and reduce erosion.
- Promote contour trenching and watershed management efforts as income-generating activities for refugees and local communities.
- Use wastewater for **multi-story gardens,** which recycle the water while growing food in a small space. These miniature gardens are constructed from deep tubular burlap bags filled with soil. A perforated funnel made from scrap tin cans is inserted into the center of the bag and packed with stones. Wastewater is then poured into the funnel, cleansed by the stones, and used to water vegetables, which emerge from small holes in the bag to grow at several levels ("stories") in the soil.

Forest conservation

- Establish harvesting rules and harvest zones with clearly marked boundaries.

Mitigation and Monitoring Issues

The following areas should be the focus of planning for environmental impacts of relief activities:

Water and sanitation. Protect water supplies from contamination. Prevent erosion and runoff and control disease-bearing insects and rodents.

Forest conservation. Establish rules to protect forests and preserve trees and watersheds. Encourage camp residents to replant trees and revegetate areas.

Energy conservation. Use renewable energy sources where possible. Use pre-cooked or easy-to-cook foods. Limit firewood use as much as possible.

Water conservation. Use special taps to minimize the leaking of water at drains and wells. Build tanks to catch rainwater for reuse.

Waste minimization. Compost and reuse organic wastes for gardening and agriculture. Recycle containers and packaging. Reuse wastewater, where possible, in gardens and farm plots.

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[5] To learn more, see USAID Africa Bureau's Programmatic Environmental Assessment for insecticide-treated materials (at http://www.dec.org/pdf_docs/PNACP696.pdf) and "Insecticide-Treated Net Projects: A Handbook for Managers" (click on http://www.liv.ac.uk/lstm/malaria/mcintroductions.htm#itnhandbook for a summary and ordering information).

- Allow area closures for natural regeneration whenever possible.
- Mark specific trees with paint to prevent them from being harvested.
- Plant tree species with the greatest potential for growth and seed production.
- Designate specific tree stands for use in construction.
- Train and equip park rangers to protect vulnerable areas and prevent poaching.
- Transfer production responsibilities for tree seedlings to refugees and local community groups as early as possible.
- Encourage tree planting on household plots first, to generate enthusiasm and develop tree-planting skills.
- As camps are closing, emphasize to refugees the importance of leaving trees as a gift to their host community.
- See the chapter on forestry and agroforestry in these *Guidelines* for additional guidance and mitigation measures.

To conserve forests by saving on energy needs:

- Use milled grains and pre-cooked, soy-fortified, or local fresh foods instead of dried grains and pulses.
- Pre-soak grains, or pre-cook them using infrared radiation; pre-steam cereals and pulses.
- Provide pots with lids, large pots for communal cooking, and insulated pots.
- Encourage use of improved, fireless, and solar stoves and cookers.
- Use kerosene or other wood alternatives for cooking.
- Supply blankets and warm clothing in cold weather.
- Use a water purification system instead of having families boil water.

Energy-conserving activities

Food supply

- Using pre-cooked, blended foods instead of beans for children under three reduces cooking time from 45min to 5min. Milled grains require only 25 percent of the energy needed to cook whole grains. If they cannot be milled in a central facility before distribution, milling facilities should be provided at the camp. Be aware, however, that milled grains require vitamin supplements for complete nutrition.
- Use locally purchased, fresh foods instead of dried grains or pulses. Soy-fortified foods can be used to replace pulses.

Equipment supply

- Energy-saving cooking techniques include (1) pre-soaking whole grains, (2) steaming cereals and pulses before cooking, and (3) using infrared radiation to partially pre-cook grains.
- Provide cooking pots with lids to reduce cooking times. Larger pots encourage communal cooking, which is energy-efficient.
- Provide blankets and warm clothing in cool climates to reduce energy requirements for heating.

- Create incentive programs to encourage the use of improved stoves, fireless cookers, insulated cooking pots, and solar cookers where cost-effective and socially acceptable.

Energy supply

- Use a water purification system instead of having families boil water.

- Kerosene or other fuels can be used for cooking in lieu of firewood.

- Firewood should be supplied to camp residents only when:

  - insufficient fuelwood supplies exist within walking distance.

  - no other sources of fuel are available.

  - fuelwood collection is dangerous due to land mines, military attacks or potential sexual assaults.

  - other populations are dependent on the existing fuelwood supplies.

  - the source of the fuelwood to be supplied can be harvested sustainably over several years.

  - the distribution of fuelwood will be controlled and balanced by strong energy conservation measures.

Water conservation

- Use self-closing water taps and covered water tanks to minimize evaporation and water leakage, as well as reducing the risk of contamination.

- Use **ferrocement tanks** made of cement, chicken wire, and reinforcement bars (rerods) to collect rainwater runoff from shelters and buildings. Collecting rainwater also reduces the risk of flooding and soil erosion.

Waste-minimizing activities

- Distribute food in bulk so refugees can reuse packaging.

- Encourage refugees to reuse tins, containers and plastic bags. Tins can be used to raise tree seedlings and make stoves. Plastic bags can be woven into mats and baskets.

- Organic solid waste should be composted for use in agriculture or kitchen gardening.

Recycle “Waste” to Grow Food

- Reuse food tins to raise tree seedlings.

- Compost organic solid waste using pits or termite mounds.

- Treat wastewater to water gardens and seedlings.

- Treated wastewater can be used to irrigate home gardens, tree seedlings and areas vegetated for soil stability. (See discussion of multi-story gardens on p. 10–11.)

- Waste can also be packed into termite mounds, where it is broken down into fertilizer for crops.

- Consult the chapters on solid waste and on medical waste handling and disposal in these *Guidelines* for more information on this topic.

Environmental Education. Education helps refugees understand the impact of their actions on the environment and also helps establish ties to local communities. Information can be shared in classrooms; in meetings of refugees or of joint refugee and local groups; and through songs and theatrical productions. An added benefit is that refugees can use their environmental management knowledge and skills after returning home.

Chapter 10. 2

Natural Disasters

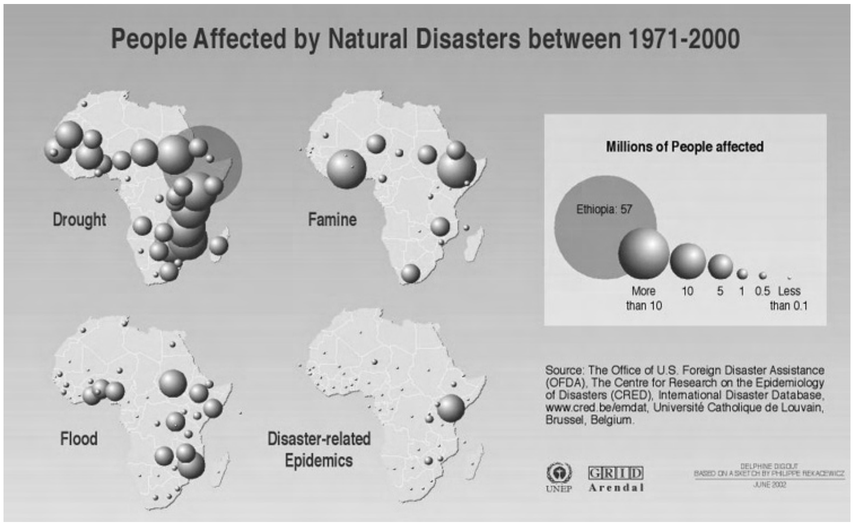
10.2 Natural Disasters

Brief Description of the Sector	10-15
Environmental Forces Driving Disasters	10-17
Sector Program Design	10-19
Mitigation Measures	10-21
Resources and References	10-23

Natural disasters cost the world's least dev-eloped countries 13.4% of their GDP between 1985 and 1999. While some disasters have natural causes, other "natural" disasters are rooted in human actions that call for long-term, sustainable solutions.

Brief Description of Sector

The statistics that capture the frequency and magnitude of global natural disasters are staggering. Since 1990, natural disasters have killed an average of almost 1,300 people per week (Red Cross 2002). The poorest countries of the world—many of which are African nations—suffered 24.4 percent of the economic toll from natural disasters between 1985 and 1999. Disasters cost these countries 13.4 percent of their GDP, an unreasonably high proportion for nations already plagued by myriad economic and financial ills (Abramovitz 2001).



The United Nations Department of Humanitarian Affairs (UNDHA) defines a disaster as "a serious disruption of the functioning of society, causing widespread human, material or environmental losses which exceed the ability of affected society to cope using only its own resources" (UNDHA 2001). However, to group all disasters as "natural" masks the fact that many stem from *un*natural causes (IFRC and RCS 2002). Improved disaster management requires people to identify the human-made root causes of

Deforestation, overgrazing and climate change may all lead to drought.

disasters and find the resolve to tackle them in a sustainable manner.

Drought, flooding, cyclones and earthquakes are among the most common disasters affecting African populations. Southern Africa, for example, experienced five major periods of drought between 1980 and 1998—each lasting for a year or more (Abramovitz 2001). In February and March of 2000, floods in Mozambique killed 650 people and left half a million people homeless; during that same period, cyclones Eline and Gloria left 184,000 people in need of immediate relief support out of the total of 737,000 affected in Madagascar (UNEP 2002). The specter of a higher frequency and severity of these events, due in part to human activities, presents a grave threat to the people of the African continent.

The initial effects of disasters may be less devastating than the long-term economic disruption they cause.

Disasters cause loss of lives and livelihoods, damage to infrastructure and communications, interruption of economic activities, deterioration of social networks, and increased disease outbreaks (GEO 2002). Costs may be direct, through the loss of capital stock (including infrastructure and inventories of materials); or indirect, through decreases in the flow of goods and services, lost income, unemployment and lower output from damaged assets. Secondary effects include declines in economic growth and development as a result of debt, inflation, or distribution of income for relief instead of investment (Anderson 2000). The indirect costs of disasters, natural or unnatural, are the most devastating to many Africans' livelihoods.

This section is divided into the following sub-sections: (1) an overview of the environmental forces that fuel natural disasters or make them worse; (2) specific policy guidance for program design in this sector; and (3) a list of mitigation measures that could potentially reduce the environmental, social and economic impacts of natural disasters.

Environmental Forces That Fuel Natural Disasters

The aim of this section is to underscore the major environmental forces adding to the frequency and intensity of natural disasters. These forces are often caused or worsened by human mismanagement or the unsustainable use of natural resources.

Climate change The general features of climate change—higher temperatures, altered precipitation patterns, and changes in the frequency and intensity of some extreme climatic phenomena—act on both human and natural systems. In Africa, climate change poses a major threat to the environmental systems on which communities depend for survival.

The Second Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) projects that surface air temperatures will increase 1.4–5.8^{o}C by 2100 (relative to 1990) and that "the balance of evidence suggests a discernible human influence on global climate," though the relative importance of human activities vs. natural variability is unclear (IPCC 2001a). Research indicates that African countries could be among the most susceptible to changes in temperature and rainfall associated with changing climate. Some of these changes are expected to manifest themselves as

Changes in Extreme Climate Phenomena . . .	. . . Related Disaster
Temperature Extremes:	
Higher maximum temperatures, more hot days and heat waves	Heat waves and droughts
Rainfall/Precipitation Extremes:	
More intense precipitation events	Flash flood; flood; inundation; mudslide; extreme erosion
Increased evaporation, rainfall variability	Crop failure; drought; land subsidence (slumping); wildfire
Intensified droughts and floods associated with El Niño events	Droughts and floods
Wind Extremes:	
Increased intensity of mid-latitude storms	Windstorms and tornadoes
Increase in tropical cyclone peak wind intensities, mean and peak precipitation intensities	Tropical storms, including cyclones, hurricanes, and typhoons
Adapted from International Panel on Climate Change (IPCC) 2001a.	

disasters: increases in damaging floods, dust storms, and droughts; sea-level rise and flooding from storm surges; and more violent windstorms. The table above summarizes extreme climate-related phenomena in Africa and the disasters that could ensue.

Environmental degradation

Steady increases in deforestation, destruction of wetlands, removal of large expanses of mangroves, overgrazing, poor crop cover, and construction of river embankments, dams and channels are all culprits undermining the natural hydrological cycle. In times of heavy rainfall, forests, mangroves,

Ironically, deforestation can cause both floods and droughts. Heavier runoff during rainy season leads to floods and mudslides; depleted groundwater and reduced evapo-transpiration lead to drought.

floodplains, and wetlands absorb and collect water and stabilize soils; their absence leads to excessive surface runoff. The runoff clogs rivers and floodplains with soil and mud, leading to disasters such as inundation, flash floods, severe erosion, land subsidence and mudslides. The secondary effects are equally serious—loss of farmland, contamination of water supplies, destruction of homes and death of livestock. Ironically, the same activities that may bring on floods and mudslides can also exacerbate a recurring disaster in Africa—drought. Deforestation and overgrazing results in declining soil moisture, depleted groundwater sources, and reduced rates of evapo-transpiration, which disrupts natural rainfall patterns.

Fire is a major factor causing environmental degradation in Africa, especially in its impact on forests. Fire is used to clear land for farming or access to timber, to drive game animals into the open, and to clear dry grass stands so that new green shoots can feed farmers' herds. Smaller fires are used to produce charcoal or to force honeybees from the hive, as well as to cook meals for hunters, loggers and other forest users. Especially during dry season, fires may easily escape their intended boundaries and burn animals, timber, even whole villages. They may change forest ecosystems as light-loving plant species take advantage of the sunny new clearings made by the flames. Finally, they may threaten human (and planetary) health by unleashing clouds of choking smoke and greenhouse gases.

The spread of non-native vegetation—introduced or invasive species—may raise the incidence of intense fires. Some of these species are known to have high water requirements, which may increase local vulnerability to both drought and fire. Timber residues ("lops and tops") left by careless loggers may also feed or intensify forest fires.

Sector Program Design—Some Specific Guidance

Policy change and technical measures must converge to address the gaps and missing links in disaster preparedness. The following section summarizes various policy tools that may be useful in minimizing the impacts of disasters on local communities.

- **Integrate disaster preparedness into related national development programs.** To date, most countries have focused on responding to disasters rather than mitigating them—that is, lessening or protecting against the effects of disasters ahead of time. Although relief efforts are crucial to saving lives, mitigation deserves at least comparable emphasis since, on average, $1 invested in mitigation can save $7 in disaster recovery costs (Abramovitz 2001). Unfortunately, funds for disaster recovery are often obtained by reducing funding to other budgeted programs, which undermines overall development performance. This situation also tends to leave insufficient resources for pre-planning and implementation of disaster mitigation measures.

  It is absolutely essential for the national government to recognize the development challenges that disasters impose. Once it realizes how disasters can turn back the clock on progress, the government can integrate disaster response policies into national development plans and strategies. These must include programs to prepare for, mitigate and prevent disasters. At the same time, the central government should devolve some disaster management authority to local municipalities, townships, wards or local communities. The mandate of local authorities should be expanded from that of solely responding to crises to monitoring potential disasters, managing public education initiatives, and galvanizing public and private action to minimize impacts in advance. Besides encouraging local input and buy-in, this devolution implies that both national governments and local authorities will follow a consistent set of rules and regulations for risk reduction (ISDR 2000).

- **Promote regional disaster cooperation.** Countries with similar socio-economic levels in a sub-region are likely to be grappling with the same threats and vulnerability issues. The principal advantages of regional collaboration in disaster management activities are (1) the efficiencies made possible by cooperation in mitigation planning and (2) the potential savings of resources through economies of scale in responding to disasters. The South African Development Community has identified disaster management as a regional priority and has convened a working

Disaster Preparedness vs. Disaster Relief

Disaster *mitigation*—protecting against the effects of disaster ahead of time—usually receives less attention than disaster *relief*. Yet mitigation deserves equal emphasis: $1 invested in mitigation can save $7 in disaster recovery costs.

group to review disaster-related impacts and recommend mitigation strategies (ISDR 2002).

- **Establish public awareness and designated training centers.** Effective educational and outreach activities create a "culture of mitigation" that ultimately helps to build disaster-resistant communities (Electronic Debate for the World Summit on Sustainable Development 2002). One effective way to promote local participation is to enroll community members in disaster management training. Training institutions instruct enrollees on risk reduction measures that their communities can take. Examples of national training centers in Africa include the Disaster Mitigation for Sustainable Livelihoods Programme of the University of the Western Cape in South Africa; the Disaster Management and Mitigation Unit of the National College for Management and Development Studies in Zambia; and the Emergency Management Training program at Africa University in Mutare, Zimbabwe (ISDR 2002).

  However, such institutions do not replace clear and consistent public awareness campaigns. Campaigns should be tailored to local conditions and aimed at all sectors of society. A comprehensive campaign requires different types of messages and preparatory measures for target audiences such as the illiterate, the homeless, minority communities, youths and the elderly.

- **Explore the possibility of economic incentives for disaster reduction.** Economic incentives and disincentives are potentially powerful tools to raise community awareness about the consequences of certain land uses or environmental practices. (See the box to the right.)

- **Invest in strategic partnerships.** Disaster mitigation policies should build on synergistic alliances between effective community-based civil society organizations (CSOs) and inter-governmental entities, such as the United Nations Development Programme (UNDP) or the International Federation of the Red Cross. The CSOs can provide a vital link between the interagency bodies, which coordinate the emergency phase, and multilateral financial institutions, which support long-term reconstruction (UNDP 2001). Fruitful partnerships may also be formed around a specific topic, such as chronic vulnerability; potential partners include government agencies, international NGOs, and local communities. In Mozambique, for example, the Vulnerability Analysis Group is chaired by the government's Department of Early Warning and Food Security and collaborates with the World Food Programme and local communities to study the causes and effects of a community's vulnerability.

- **Create and enforce hazard mitigation codes.** Regulatory approaches may involve enforcing hazard mitigation codes for infrastructure or restrictions on land use. These have had limited success in developing countries. However, if a community is willing to establish and enforce

Economic Incentives to Help Avoid or Reduce Future Disasters:

- Tax incentives, subsidies and loans to encourage sustainable land use practices
- User fees to manage domestic water use, agriculture, hydropower, fisheries, and recreation sustainably
- Transfer of development rights to avoid undesirable development, e.g., in flood- or erosion-prone areas
- Easements and legal agreements to restrict the type and amount of property development
- Restricted purchase and property rights for particularly exposed lands, e.g., coastlines
- Fines/liability systems for damages caused to human settlements or the environment
- Structuring prices for natural resources in a way that discourages unsound use

Source: ISDR 2002

such regulations, model codes and standards can be helpful, especially when technical assistance is limited (ISDR 2002).

- **Scrutinize harmful or misguided government policies.** A well-managed natural resource base—forests, swamps, upper catchment areas—helps to absorb the shocks of disasters and can even prevent the onset of some disasters. Conversely, certain government programs or initiatives undertaken without adequate impact assessment studies (e.g., the conversion of forest or swamps into agricultural settlements or the construction of homes on unstable hill slopes) may have devastating impacts on the ability of natural systems to lessen the immediate effects of disasters or to rebound over the longer term.

Mitigation Measures—Guidance to Reduce Environmental, Social and Economic Impacts

The following section outlines certain technological options and applied activities for mitigating the damage caused by disasters. Guidance for mitigating social and economic impacts is included, since they are often inextricably linked to the environmental impacts of disasters. The list of measures underscores the value of investing in "soft measures" that emphasize planning for various types of adaptation and that address the underlying causes of vulnerability, rather than relying on "autonomous adjustments"—i.e., private adaptations that occur without government intervention and are usually paid for privately.

- **Focus on housing as part of the recovery process**. Post-disaster efforts are more effective in the long term if they are community-driven and adapted to local conditions. One entry point for community-driven mitigation is the construction of disaster-resistant housing. For families made destitute by typhoons and flooding, a new, more durable house may be the most time-efficient and cost-effective form of relief (IFRC and RCS 2002). Often the use of traditional materials to construct homes is not sustainable; for example, the use of hardwoods contributes to increased rates of deforestation and erosion, which can worsen disasters. Thus communities, with the aid of NGOs (local or international) and donors, should experiment with more appropriate materials (concrete foundations, steel frames) and designs that can be maintained locally.

- **Implement effective early warning systems.** Advances in the science and technology of early warning systems have far outstripped the ability of responsible parties to deliver vital alerts to the public in disaster-prone locations. An added complexity in Africa is that the onset of drought—perhaps the continent's most pressing disaster challenge—is often extremely difficult to detect until major impacts, such as scarcity of water or failed crops, become evident. The publication *Living With Risk: A Global Review of Disaster Reduction Initiatives*, issued by the International Strategy for Disaster Reduction (ISDR) secretariat, identifies four prerequisites for effective early warning systems: (i) national leaders feel a responsibility to promote integrated early warning

The FEWS NET Early Warning System

One prime example of an effective early warning system is the Famine Early Warning Systems Network (FEWS NET), which is a collaborative effort between USAID, government agencies, NGOs and professional groups in Africa. FEWS NET monitors data for early indications of natural and man-made threats to food security. The group also disseminates monthly reports from 17 countries and three regions in sub-Saharan Africa. The FEWS NET Web site is at http://www.fews.net/

strategies; (ii) communities and NGOs are involved in disseminating messages, as well as operating and maintaining warning equipment; (iii) international cooperation is leveraged to finance national early warning capacities; and (iv) the technical skills to identify and monitor hazards are available.

- **Emphasize vulnerability and capacity assessment.** Vulnerability and capacity assessments, like hazard assessments, employ methods that include the collection of primary data, monitoring, data processing, mapping, and application of social survey techniques. However, unlike hazard assessment activities, which are largely reserved for the scientific community, vulnerability and capacity assessments use methods that encourage community participation, such as community-based mapping (UNEP 2001).

Restoring ecosystems is one of the most effective ways to buffer against natural disasters and reduce their effects. For example, dunes, forests, wetlands, and floodplains absorb floodwaters and slow down violent winds; barrier islands and mangrove forests protect against coastal storms.

- **Encourage natural resource rehabilitation.** Many recent studies highlight the need for a stronger emphasis on restoring and rehabilitating ecosystems. This is one of the most effective ways to provide buffers for natural disasters and reduce their effects. As one researcher puts it, "the time has come to tap nature's engineering techniques—using the services provided by healthy and resilient ecosystems" (Abramovitz 2001). For example, dunes, forests, wetlands, and floodplains absorb floodwaters and help diminish violent winds; barrier islands and mangrove forests protect against coastal storms.

- **Strengthen "sustainable livelihoods" approaches.** Sustainable livelihoods (SL) provide employment rooted in the productivity of the community, requiring minimal capital investment and placing minimal pressure on the environment. Environmental management is intrinsic to the SL approach. SL increases the resilience, or coping capacity, of a community toward environmentally related shocks, including disasters. SL involves the community in activities that not only safeguard the natural resource base upon which the population relies for survival, but may, in some cases, mitigate the onset and impacts of drought (PCDF 1995). Examples include use of renewable energy sources; soil management through intercropping, fallow cycling, and forest buffering; water harvesting; windbreak construction; and intercropping.

Resources and References

Internet Sites Pertinent to the Environmental Dimension of Humanitarian Response:

- In July 1997, the Sphere Project was launched by a group of humanitarian agencies. The project aims to improve the quality of assistance provided to people affected by disasters, and to enhance the accountability of the humanitarian system in disaster response. Sphere has developed a Humanitarian Charter and a set of universal minimum standards in core areas of humanitarian assistance: water supply and sanitation, nutrition, food aid, shelter and site planning, and health services. The Sphere Project Web site is http://www.sphereproject.org/.

- The Famine Early Warning Systems Network (FEWS NET) is a USAID-funded activity that can be accessed at http://www.fews.net/

- USAID's Bureau for Humanitarian Response offers a series of postings on the Internet about its mission and organization which can be found at http://www.usaid.gov/hum_response/

- Seventeen U.S. PVOs involved in food aid programs have joined together to form Food Aid Management, an advisory body to USAID's Food for Peace Programs. They offer a variety of services, including an Environmental Working Group and sponsorship of Regulation 216 Training of Trainers Workshop opportunities for member organization staff and others. Reach them at http://www.foodaid.org

  FAM sponsors a free electronic mailing list (listserve) for those interested in food aid and environment issues. The FAM Resource Center also has a 1998 publication, available in PDF format, titled *Selected Bibliography of FSRC Resources on Environmental Issues.* Written by Jessica Graef, it is available on the Internet at http://www.foodaid.org/pdfdocs/environmentwg/environmentbiblio.pdf

- ReliefWeb is a project of the United Nations Office for Coordination of Humanitarian Affairs (OCHA), and its Web site is intended to serve the information needs of the international humanitarian relief community. Its home page can be accessed at http://www.reliefweb.int/rw/dbc.nsf/doc100?OpenForm

- The Benfield Hazard Research Centre in the Department of Geological Sciences at University College, London, carries out work in disaster studies that focuses on disaster mitigation and preparedness. It comprises research, project management, training, consultancy, information dissemination and education. The Center's Web site is http://www.benfieldhrc.org/

- The International Organization for Migration Web site can be found at http://www.iom.int/

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Chapter 11
Livestock Production

Contents

Brief Description of the Sector	11-1
Potential Environmental Impacts	11-2
Sector Program Design	11-7
Mitigation and Monitoring Issues	11-13
Resources and References	11-17

More than a quarter of the world's land area is used for livestock as part of grazing or mixed farming systems. Another fifth of the world's arable land is used to grow grains for livestock feed, primarily for industrial systems.

Brief Description of the Sector

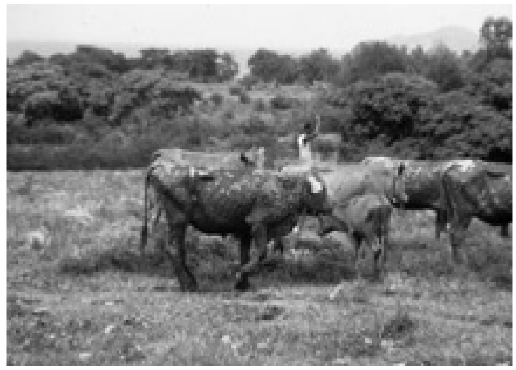
The use of cattle, sheep, goats, pigs, poultry, and other livestock offers many benefits to sub-Saharan Africa. These animals are integral to rural livelihoods and culture, providing food (meat, blood, eggs and dairy products), materials (wool, hide, horns, etc.), income, and mechanical power for pulling carts, drawing water or plowing fields. Livestock manure can serve as a source of fertilizer. Grazing can help sustain vegetation and promote biodiversity by dispersing seeds, controlling shrub growth, breaking soil crusts, stimulating grass growth and improving seed germination. Livestock also may represent savings and currency, and have cultural value as well. For example, gifts of livestock may serve to resolve conflicts or cement marriages.

Livestock production can be categorized under three main systems: grazing, mixed farming and industrial.

- **Grazing** systems generally rely on native grassland or forests for fodder, with little or no use of crops or imported inputs, and are traditionally managed by pastoralist communities.
- **Mixed farming** systems integrate livestock and crop production. Adding livestock to their farms helps farmers diversify risk and extract value from otherwise valueless or low-value by-products of each activity: crop residue becomes feed, manure becomes fertilizer. Soil nutrients can be further replenished by rotating leguminous (nitrogen-fixing) fodder crops with food crops. These systems are managed by settled farmers.
- **Industrial production** systems concentrate livestock populations in special facilities and separate their feeding and waste processing from the land on which they live. Feed is provided directly instead of being acquired through grazing, and manure is transported off-site. Generally, these systems are owned by relatively wealthy individuals and managed by local employees.

Grazing systems are most favored in arid, semi-arid, or other areas of marginal value for crop-based agricultural production, while mixed farming systems flourish in temperate, subhumid, humid, and some highland climates. Industrial production, because it does not depend on local fodder supplies, can be conducted in any climate and generally occurs near the urban centers it supplies, sometimes even in peri-urban areas.

Livestock production is increasing throughout the developing world, although more slowly in sub-Saharan Africa than in most other regions. This increase is driven by growing population, increasing urbanization and rising



Livestock can enhance land quality and socio-economic well-being, but producers must guard against potential environmental and economic damage.

incomes. This situation is expected to continue throughout the next decade. A shift towards industrial production—farming of monogastric species (pigs, poultry) fed with grain—may be an unavoidable trend in areas with rapidly growing demand for animal food products. Over the next decade, however, only select regions in sub-Saharan Africa are likely to exhibit this trend.

Properly managed, livestock production can enhance land quality, biodiversity, and social and economic well-being. However, when improperly managed, it may cause significant economic, social and environmental damage. Increasing livestock production has the potential to increase environmental harm. This guideline will help identify potential adverse environmental impacts and suggest mitigation and monitoring options, as well as "best management practices," to address them.

Potential Environmental Impacts in the Livestock Sector and Their Causes

Large areas of land degraded

Overgrazing

Overgrazing of rangeland reduces the density of vegetation and the amount of organic matter generated. This, in turn, increases soil erosion from wind and water and decreases soil fertility through loss of nutrients. In arid and semi-arid areas these impacts may also contribute to desertification. Fortunately, ecosystems in these areas demonstrate considerable resilience and often recover when grazing pressure is reduced, either through traditional methods or through modern management practices.

Policy and Legal Problems

In areas that traditionally rely on grazing, the health of rangeland is generally best maintained by traditional pastoralist practices, which regulate grazing location and herd size in accordance with drought cycles and the supply of fodder. In fact, government policies or donor interventions that disrupt or discourage these practices may be a root cause of degradation. A variety of government policies may restrict the movement of livestock within a range area and prevent livestock managers from moving stock from areas that have been depleted of fodder to better supplied areas.

Two particular policy-based problems are:

- *Land tenure insecurity*. Lack of confidence in secure title to rangeland (especially on communal lands) has been shown to reduce the incentive to manage the land sustainably. Many national governments have either implicitly or explicitly claimed ownership of range and wildlands and ignored traditional or customary claims.
- *Privatization of communal resources.* Where national governments have privatized, or are privatizing, formerly state-owned or communal lands, new owners may erect fencing or prevent herds from crossing or grazing on their property.

Wells and boreholes

Traditionally, access to water on critical grazing lands has been controlled to limit livestock populations and prevent herds from outgrowing the forage supply in dry areas. Thus, new wells or boreholes, generally sponsored by donors or governments, may undermine traditional livestock management systems practices by allowing herds to grow beyond sustainable levels for surrounding areas. Overgrazing and degradation are most noticeable in the immediate vicinity of the boreholes or wells, but their effects can extend (in gradually decreasing severity) over a considerable radius. Boreholes also reduce pressure on livestock owners to decrease herd size during drought and may discourage movement of herds to other rangelands, disrupting historic wet season/dry season grazing patterns. Larger herd sizes and reductions in pastoral movement may prove to be a recipe for severe degradation of soil and vegetation.

Wet-Season Grazing

Poor timing in the use of rangeland can also damage the soil. Wet-season grazing can compact the moist earth, reducing its ability to absorb moisture This increases erosion from water runoff.

Poor Balance of Livestock Species

Each species or breed of livestock has foraging preferences and will graze favored areas and plants while neglecting others. Browsing animals, such as goats and camels, prefer the leafy tops of shrubs. By contrast, grazers tend to consume ground-level grasses and leafy plants. A poor balance between browsers and grazers can change the mix of plants in ways that degrade the area. For example, too many grazers can diminish the number and populations of herbaceous plant species and allow woody plants to become dominant, changing, possibly irreversibly, the character and utility of the ecosystem.

Damaged habitat and reduced biodiversity

Livestock production can damage habitats and reduce biodiversity in wildlife and domestic stock, in vegetation, and in aquatic and wetland ecosystems.

Harm to wildlife and domestic stock and loss of wildlife habitat

The loss of habitat caused by livestock production in grazing and mixed farming systems may be one of the greatest threats to wildlife. Human population growth and density, and the accompanying increase in livestock, often leads producers to expand livestock grazing ranges into wild lands and the conversion of wild lands to mixed farming use.

In Africa these habitat losses occur through overgrazing, the installation of fencing that impedes or prevents migration and conversion of wild lands or forests to fodder crops. Fencing can exclude a species' subpopulations from their traditional range, thereby reducing their habitat, increasing their vulnerability, and potentially leading to local "extinctions" of species or subspecies. In addition, when livestock and wildlife share the use of rangeland and forests, the potential exists for competition over water and fodder, depending on their fodder preferences. Recent research suggests, however, that in many cases the fodder overlap is smaller than initially assumed and that coexistence is possible if livestock managers restrict herd size to some degree.

Slaughter of wildlife by livestock managers

Another danger to wildlife is intentional slaughter by livestock managers. Fear that the wildlife will prey on livestock and damage crops is a common motivation, as is the belief that the wildlife are competing with livestock for fodder, the desire to prevent spread of disease to livestock, and concern for human safety.

For decades thousands of wild animals in Africa were killed to prevent contact with livestock, under the belief that they served as reservoirs for diseases deadly to livestock. This practice has diminished as the tourist value of wildlife has grown. However, the premise was correct in principle—wildlife do serve as reservoirs for some of the most harmful diseases of cattle: malignant catarrhal fever, theileriosis/East Coast fever, and trypanosomiasis (sleeping sickness). Now livestock themselves are reservoirs for these diseases, and obliteration of wild species would be pointless. Nevertheless, wildlife remains at risk from farmers anxious to protect their livestock and farming investments.

Potential spread of disease to wildlife

In theory, wildlife might also be at risk of contracting diseases from imported livestock; however, no documented evidence exists that significant diseases have been spread by this means in Africa. Nevertheless, livestock disease transmission to wild animals has occurred on other continents, and the risk remains.

Extinction of local livestock breeds.

Systematic livestock production may result in loss of genetic diversity in livestock species. This is unfortunate because genetic diversity is a measure of a species' robustness. Local breeds may have traits conferring resistance to emergent or future pathogens, or have other favorable adaptations to local environments. The consistent replacement of local breeds with more productive imported ones can contribute to the extinction of that breed and of all the genetic diversity harbored within its population.

Livestock can cause serious harm to a variety of environments by overgrazing vegetation and compacting soil.

Harm to Vegetation

Clearing of forest and wild lands

(See "Widely degraded land areas" above.) Vegetation is typically altered or destroyed when forests/wild lands are cleared or are burned to promote new growth. This changes local ecosystems and may contribute to global warming. Fires to burn vegetation are dangerous and degrade air quality.

Loss of rangeland fertility

Ironically, mixed farming systems may reduce the fertility of rangeland while helping to solve a farmland problem. Traditional farming practices cause a net loss of nutrients in farm soils; that is, when crops are harvested and sold (or even when human waste is deposited in a latrine) nutrients that make the soil fertile may be lost. Mixed farming reduces the extent of this loss, by transferring nutrients from the range to the farm in the form of manure. The gain in fertility for the farm is, of course, a net loss for rangeland. Over time, the altered nutrient balance can reduce the productive capacity of the range and/or lead to changes in the composition and density of plant species.

Loss of farm fertility

Damage from mixed farming often occurs when poverty and population growth pressure change the crop/grazing land ratio, where other nutrient sources are not available. As the land area available for each grazing animal shrinks, overgrazing becomes prevalent leading to soil erosion and nutrient loss. Harvesting livestock further reduces nutrients available for crop production.

Damage to riparian soil and vegetation

Livestock in grazing and mixed farming systems often graze very heavily in riparian areas along streams and lakes. Results include trampling, loss of vegetation, soil disturbance, and soil compaction, erosion and/or sedimentation which can severely damage riparian habitats, increase siltation and adversely affect watersheds.

Pesticide contamination from treatments to protect livestock from insect-borne infections (e.g., livestock "dipping") may ultimately reach the aquatic environment. Here it can be toxic to aquatic organisms, as well as people or animals who depend on these sources for drinking water.

Introduction of invasive plants

New breeds or fodder crops can introduce invasive non-native plants into a region. The manure, coats and hooves of newly introduced breeds can carry plant seeds. Most non-native plants are not invasive, but when they are, the results can be devastating.

Contamination from manure

Livestock manure contains relatively high concentrations of nutrients, solids, enteric bacteria and other microorganisms, and organic material. The manure from industrial livestock operations is often discharged or "leaked" into lakes or streams, because it cannot be economically transported to replenish crop fields. When this occurs, the nutrients can cause eutrophication (rapid plant growth in water bodies), solids can create sedimentation, and organic material leads to oxygen depletion (BOD) of the water. Manure from mixed farming, if applied in a concentrated fashion, can lead to similar problems. The absence of regulation and/or effective enforcement in most African countries increases the likelihood of these impacts.

Degrade water quality and reduce water supplies

Where water is scarce, either chronically or seasonally, the diversion of water to sustain livestock potentially limits its availability for other purposes. This is of particular concern in arid and semi-arid regions, where the construction of boreholes to supply livestock can lead to unsustainable withdrawal rates and the dangerous depletion of aquifer reserves.

As noted above, stockpiled manure can contaminate bodies of water, causing myriad adverse effects. These include eutrophication, oxygen depletion, sedimentation, contamination with enteric bacteria and possibly other pathogenic organisms, toxic pollution from pesticides, and contamination of groundwater and aquifers with both nitrates and pesticides. Moreover, high concentrations of nitrate in potable water supplies represent a potential health hazard, especially for children.

Harm to human health

Using water for farm animals may make it less available for the many uses that influence health, such as bathing, washing, cooking, and drinking. Moreover, as mentioned above, excessive contamination by enteric microorganisms, toxic pesticides or nitrates in may render water unfit for human consumption and may be especially dangerous to children. Pesticides or other vector control treatments used on livestock represent threats to the health of livestock managers, their families, and others exposed directly or through water use. These substances may be toxic, cause birth defects, alter children's proper development, promote cancer, or slowly poison one or more organ systems.

Climate change/global warming

Approximately 17% of global methane is produced by livestock digestion and manure. Methane is a greenhouse gas that has 56 times more global warming potential than carbon dioxide over a 20-year time horizon. Furthermore, clearing wild or forest land for new fields reduces the land's ability to act as a carbon sink. As noted above, setting fire to vegetation to clear land or promote new growth for livestock to graze on may also contribute to global warming.

Odor.

Concentrated manure stored at industrial livestock facilities can generate strong and unpleasant odors, damaging the quality of life of nearby residents. This problem is most evident when facilities are located in densely populated areas.

Sector Program Design—Some Specific Guidance

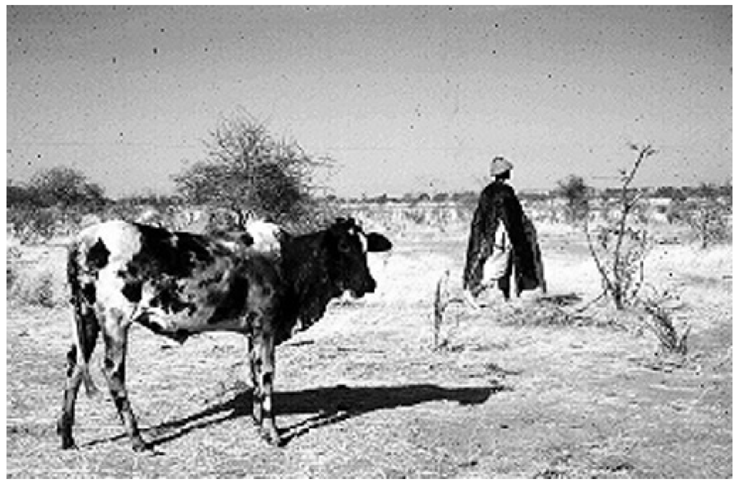
The following questions and suggestions are intended to help project designers and managers identify factors and practices that may cause—or prevent—adverse environmental impacts. Bear in mind that the first priority of most livestock managers and farmers is household food security and family welfare. Sustainable practices must always be balanced against these immediate demands.

Consider climate, terrain, and ecosystem

Since environmental impacts from livestock production vary, depending on the specific climates, terrains and ecosystems involved, project designers need to address these characteristics during the initial design phase:

- What is the climate in the project area (arid, semi-arid, temperate, subhumid, humid)? What do historical records of rainfall patterns and flooding indicate? Is the proposed livestock management practice compatible with this climate?

- What terrains are found in the project area(s) (alluvial plain, highland, rocky desert, wetland, etc.)? Do they have any known vulnerabilities to livestock grazing? For example, are there many unprotected streams or rivers? Are there slopes with limited topsoil sensitive to erosion?



Soil and climate must be considered when planning livestock management projects. Semi-arid lands, for example, pose unique challenges and problems for program designers.

- Will the project encompass or border on protected or ecologically sensitive areas? Are there any threatened or endangered species in the area? Would the proposed project directly or indirectly threaten wildlife or native vegetation? For example, does the project require expansion of grazing into protected areas or make livestock more vulnerable to wildlife predators, triggering reprisals by farmers?

Evaluate policy, legal, customary and cultural context

The policy, legal, and cultural contexts of a project merit attention, since, as illustrated above, these factors may limit program options or erect substantial barriers to success.

Policy/legal

- Do livestock owners and managers have legal and recognized ownership and responsibility for land and grazing resources? What are the current or proposed national land tenure policies, and how are they implemented at the local level? Are they effective in encouraging sustainable management of grazing land and resources?
- What is the tenure status of current or proposed rangeland—Is it owned by individuals or the community? Does the government have claims?
- What wildlife protection laws exist and how are they implemented in the region?

Culture/custom

- What role does livestock play in local culture and customs, and how might the proposed project affect these practices? Would the proposed project disrupt traditional grazing patterns?
- If there are customary land tenure arrangements, what are they and how would the proposed livestock management system work within these arrangements? For example, will livestock herders—who often come into conflict with farmers, particularly during droughts—have a means of working out disputes with farmers?
- If livestock management arrangements are communal, how would these be affected by and/or affect the proposed development activities?

Assess current and proposed species and breeds

Introduction of a new breed into an area should be approached with caution. The new breed may bring with it diseases that can decimate local livestock herds and wildlife. In addition, the foraging habits of a new breed may lead to a sharp decline in available forage and biodiversity. A new breed's reproductive habits can lead to a herd's uncontrolled growth. Weeds can be accidentally introduced along with a new animal species, and they may displace desirable vegetation.

The long term full costs and benefits of introducing a given new livestock species into a particular environment should be assessed. For example, large animals roam over extensive areas in search of food, often require a greater financial investment, can be more difficult to control, and have lower reproductive potential than small animals. It is important not to underestimate the value of breeds that are well adapted to the environment.

Livestock tend to overgraze favored areas and plants while neglecting others. Native plants may not be able to survive heavy grazing. While unforaged plants tend to lose vigor and nutritional value as they mature. The introduction of new plant species (whether accidentally or intentionally) may quickly result in replacement of native plants. Even when grazing pressure is reduced, exotic plant species sometimes retain their dominance.

Ask the following questions when introduction of a new breed or species is proposed:

About current species and breeds

- Which wild and domestic species are already present in the area, and in what numbers?
- How have they been used in local farming systems and traditions?
- What are the feeding preferences of local livestock and wildlife? What is the balance between browsers and grazers? Do domestic species compete for resources with one another and with wildlife?
- Have population sizes of wild or domestic species changed recently?
- Could local breeds satisfy the project's needs?

About proposed species and breeds

- If new species or breeds are being considered, how will their production complement or conflict with local species or breeds, wildlife, and other local resource users?
- How would they fit in local herding systems?
- Are they well suited to the local climate and environment?
- Are they resistant to local livestock diseases?
- Have alternative species or breeds been considered for possible introduction?

Evaluate current and proposed livestock management practices

To maximize forage productivity, it is best to combine or alternate various livestock breeds on a range. Their differing food preferences can help to keep plants productive by minimizing overgrazing of a particular favored area and allowing less preferred plant species time to mature. It is prudent to make superior forage available to those animals with the highest needs. When forage is limited, livestock managers may decide that young and milk-producing animals must have first access to new pastures and ranges with a wide variety of abundant forage.

Managers should investigate the value of various systems of rotating livestock. Rotation allows land to be grazed continuously throughout the year. Livestock can be rotated between fields or ranges to prevent the buildup of disease and to vary grazing pressures. Through either fencing or herding, they can be relocated into croplands to consume crop residues.

Assessment of seasonal grazing patterns should include potential impact on soils. Dry-season grazing can benefit the land by breaking up crusted soil and working seeds into the ground. By contrast, as mentioned above, grazing on moist soil can cause considerable soil compaction, which reduces the soils ability to absorb moisture and can result in increased erosion from runoff during the rainy season.

Many of the environmental impacts from livestock production are associated with particular practices of livestock managers. Thus it is critical to understand current practices and how the proposed project might alter these practices or promote new ones.

- Who are the local community's livestock managers?
- What practices do a family or community use to control the size and composition of livestock herds?
- How do livestock managers currently control livestock movement? Will the proposed project change these movements in a way that might harm the environment?
- Does the proposed project require the construction of fences? If so, will they interfere with wildlife migration or transit of livestock belonging to other communities? Could the fences lead to overgrazing and land degradation? Will the fences be built with local materials? Would living fencing be practical? Would solar-powered electric fencing be technically and economically feasible?

- Are streams and riverbanks currently protected from livestock damage? If the proposed project will open new areas to grazing, will water supplies need to be protected?
- Must steps be taken to prevent new livestock and associated animals (e.g., dogs) from transmitting disease to wildlife? Is there a vaccination/animal disease control program available for this purpose?
- Will the project involve construction of improvements (e.g., boreholes or other infrastructure)? Could these lead to unplanned changes in herding patterns and overgrazing?

Assess demand and use of livestock products

- Who is marketing livestock and livestock products?
- Is the demand for livestock products coming from local or outside populations? How rapidly is it increasing or decreasing? How stable is the demand?
- In preparing livestock products, are people using technologies which reduce impacts on the environment, open additional markets, or improve health and nutrition (of people and animals.)

Assess livestock ectoparasite management

Bloodsucking ticks and flies transmit several fatal or seriously debilitating diseases to African cattle, such as tick-borne East Coast fever and African animal trypanosomiasis (nagana), transmitted by the tsetse fly. Cattle dipping and area treatment with pesticides are often used to control the carriers of such diseases. Although drugs have been used to prevent and treat typanosomiasis, they are expensive, effective for only a few months, and trypanosomes rapidly develop resistance to them. Promising alternatives to such control methods are being researched, including vaccines for tick-borne diseases and highly effective tsetse traps using baits.

Consider population pressure and disease burden

Two factors that may affect the outcome and impact of projects in sub-Saharan Africa are population growth and fatal or debilitating epidemic diseases. Population growth may lead to conflicting uses of grazing lands or reduce individual farms or rangeland to sizes that cannot sustain livestock. Fatal or debilitating epidemic diseases may weaken effective dissemination or replication of proper livestock management techniques. HIV/AIDS is a particular concern, but so are geographically restricted diseases such as sleeping sickness and malaria.

- What is the current and projected population growth rate in the project area? How might this affect project sustainability in the future?
- What is the current extent of the HIV/AIDS epidemic in the region? How might this affect the composition of the population (size, ethnic makeup, age/gender distribution) and family structures

necessary for project sustainability? How will development and livestock technical support services be affected?

- Are there other epidemic diseases in the region, such as sleeping sickness, that might adversely affect project implementation?

Mitigation and Monitoring Issues

Environmental Mitigation and Monitoring Issues for Livestock Projects

Activity	Impact *The activity may. . .*	Mitigation
Introduction of a new grazing livestock production or of mixed farming	Degrade large areas by: - overgrazing - imbalanced foraging - dominance by low-utility plant species - soil compaction - soil erosion Damage habitat and reduce biodiversity by: - overgrazing - imbalanced foraging - competition with wildlife for fodder or water - increased killing of wildlife to "protect herds" -spreading disease to wildlife	To prevent overgrazing and soil compaction, ensure that pastoralists and livestock managers/farmers have secure tenure rights. Monitor implementation of tenure policy. Develop decision-makers' awareness of the long-term economic importance of maintaining balanced ecosystems and resilience, including maintenance of biodiversity and wildlife. Provide similar knowledge to pastoralists and livestock managers/farmers. For grazing systems, guarantee managers and pastoralists sufficient mobility and flexibility to manage grazing areas sustainably, use water and biomass efficiently, destock rapidly in times of drought and restock when rains return. For mixed farming systems, determine farmer/livestock manager's ability to match livestock requirements to available rangeland and fodder crops for long-term sustainability. Strengthen capabilities through education and incentives where needed. To avoid killing of wildlife that is thought to be infecting or preying on livestock, provide livestock managers with financial incentives to maintain ecosystem balance. Explore possible community-based natural resource management (CBNRM) approaches. (See "Community-based Natural Resource Management" in this volume for more information), or other successful integrated wildlife and livestock management methods, such as combined wildlife and livestock ranching. To maintain rangeland and mixed farming system sustainability, ensure a balanced mix of foraging and grazing species, including wildlife where appropriate. Determine fodder preferences of domestic and wildlife species. To ensure balanced use of fodder and water, determine baseline carrying capacity for livestock and wildlife (where appropriate). Establish quota systems for domestic species and wildlife to ensure that carrying capacity is not exceeded. Change domestic species and breeds to minimize overlap between their preferred fodder and that of local wildlife, and/or ensure a sufficient supply of fodder for domestic species and wildlife. Monitor management of the quota system. Establish historical baselines for climate and precipitation, taking into account seasonal and geographic variations. Establish historical baselines for soils, water quality and quantity, flora and fauna, and select indicators to measure deviation from baseline. Monitor indicators to gauge whether long-term resilience of range and mixed farming systems is being maintained. Train herders, pastoralists and farmers as resource monitors.

Activity	Impact *The activity may. . .*	Mitigation
		Assure pastoralists' access to seasonal grazing and water. Strengthen systems for wildlife management and for control of problem animals to minimize adverse interactions with pastoral and mixed farming systems (such as disease transmission, predation and crop damage). To prevent the spread of disease from livestock to wildlife, carefully research any new breeds and associated diseases.
	Generate conflict between livestock managers and other groups, such as farmers	To prevent conflict between livestock managers, farmers, pastoralists and other groups, ensure that the customary or legal rights and responsibilities of all parties are harmonized and accepted. Agreements should cover how each resource will be used, who will use it, when it is to be used, utilization rates and quotas, management costs, and monitoring responsibilities. If such rights and responsibilities are not yet established, work with policymakers to create a respected legal framework.
In highland areas	Cause erosion	To minimize erosion caused by livestock raised in highland areas, avoid overgrazing through the use of quota systems matched to carrying capacity. Ensure that terracing and paths are well constructed, and reduce soil compaction by providing incentives to avoid wet season grazing.
Near rivers and streams	Damage riparian habitat Degrade water quality Damage aquatic and wetland habitat and biodiversity	To prevent erosion, sedimentation, degradation of water quality, and damage to aquatic habitats and biodiversity, protect stream and riverbanks from browsing or grazing through fencing or herding techniques.
Introduction of industrial livestock production	Improper management and/or treatment of manure from industrial facilities may -degrade water quality -damage aquatic and wetland habitat and biodiversity -harm human health -create odor	Preferably, apply manure to crop fields. If the expense of transport makes this uneconomical, treat the manure. Options for treating animal manure are like those for treating human waste. These include construction of artificial wetlands, detention ponds, composting, and biogas generation. Site these treatment systems with care to minimize adverse impacts on water bodies and communities. (See section on "Water Supply and Sanitation" in this volume for more information.)
Introduction of new livestock and breeds	Degrade land Reduce biodiversity and harm habitat Reduce genetic diversity of domestic species Transmit disease to wildlife Introduce invasive non-native plant species	Thoroughly research new species of livestock. Determine their grazing/browsing preferences and compare them to those of current livestock species/breeds and wildlife to minimize overlap and prevent unbalanced feeding. Pilot-test new breeds and species before introducing them in a broad program, and monitor their impacts over time. If local breeds can meet specified needs, strongly consider their use. In particular, even if local breed is a relatively low producer, weigh this drawback against the breed's disease resistance and hardiness in the local environment. Introduce entirely new species or breeds to a region with great care Evaluate the risks of introducing new diseases that might be transferred to wildlife. If breeds or species from other parts of Africa or the world are to be introduced, wash and comb their hooves and coats to remove plant seeds. Feed livestock on grain or other crop feed in transit to minimize the risk of accidentally introducing new plant species.

Activity	Impact *The activity may. . .*	Mitigation
Construction of new fencing	Cause conflict with pastoralists or communities Disruption of migratory patterns and ecosystem balance Damage natural resources viewshed and aesthetics	If the project calls for constructing new fencing, ensure that such fencing is consistent with local customary property and resource-use arrangements and will not interfere with the movement of livestock belonging to traditional pastoralists. Site fencing to minimize impacts on migratory species. Fully research impacts on migratory animals, their role in the ecosystem and the potential effects of fencing on reproduction. Provide corridors which ensure that migratory patterns are not jeopardized. Monitor migration patterns against baseline conditions. Avoid cutting living trees for fence posts in areas where wood is scarce. Investigate the potential for live fences as barriers. Assess the cost-effectiveness of solar powered electric fencing. In or near protected areas, or areas of unique scenic value, make efforts to construct fencing which is hidden from view or which minimizes impact on aesthetics.
Installation of new/improved water supply	Degrade large land areas from overgrazing Compact soil Reduce biodiversity and harm ecosystem and habitat Reduce water availability Degrade water quality	When installing new water supplies, consider how access to water will affect geographical and seasonal grazing patterns. In some cases, such as in a semi-arid climate, it may be best not to construct water supply improvements for livestock, since these will almost certainly lead to environmental degradation. If the improvements are essential, ensure that a mechanism for regulating water use is in place to prevent exhaustion of the water resources and to help restrict the number of livestock dependent on these sources. Water supply improvements should also be designed so that they minimize the risks of water supply contamination by animals and humans. Monitor water supply quantity and quality. (See section on “Water Supply and Sanitation” in this volume for more information).
Control of livestock disease vectors	Harm human health Damage plant and animal biodiversity	Evaluate latest information on integrated vector management (IVM) and integrated pest management (IPM) alternatives to pesticides for control of livestock diseases. If pesticides are to be used to control ectoparasites, such as ticks and tsetse flies, consider alternatives to cattle dipping and area treatment (e.g., vaccines for tick-borne diseases and bait traps for tsetse). Where cattle dipping and/or area treatment are used, ensure that those handling and applying pesticides are fully aware of the hazards, use appropriate equipment and protective clothing, and receive proper training in correct handling, storage, application and disposal. Use only pesticides approved by the U.S. Environmental Protection Agency. Ensure that cattle dips are designed to avoid potential contamination of ground or surface water with pesticide. Be especially aware of the potential for underground migration of chemicals over distance to nearby wells and streams used for potable water, and the potential effects on aquatic organisms. Monitor handling, storage, application and disposal of pesticides. Monitor potential effects on non-target organisms (both terrestrial and aquatic) and human health. Be aware of the potential for bio-accumulation. (See section on “Integrated Pest Management/Pesticides” in this volume for more information)
Increased population and disease burdens		Design projects with attention to mechanisms to maintain human and livestock populations at sustainable levels below the upper limits of the ecosystem’s carrying capacity, including the provision of health and family planning services and incentives. Consider use of permits and quota systems to limit in-migration

Activity	Impact *The activity may. . .*	Mitigation
		and population growth in sensitive or threatened rangelands or mixed farming areas, as well as other areas of special value. Use pollution permits to control pollution from industrial livestock operations, especially near communities and water resources. Monitor growth in population against a historical baseline. Assess the medium- to long-term implications of epidemic diseases (e.g., HIV/AIDs, tuberculosis, sleeping sickness) on livestock managers, pastoralists and farmers, as well as on provision of technical assistance and support. Institute local health and HIV/AIDs education programs in conjunction with technical assistance and training in livestock management.

Resources and references

Websites

LEAD Virtual Research and Development Center: The LEAD (Livestock, Environment And Development) Initiative, an inter-institutional project with the secretariat in FAO supported by the World Bank, the European Union (EU), FAO and many donor countries. In English, Spanish and French. http://www.virtualcentre.org/selector.htm

The project's main goals are to increase awareness, knowledge and understanding of livestock and environment interactions; to identify appropriate options for livestock and environment management at regional and national levels, and to help build sound livestock management and environmental concepts into government and donor policies and projects.

The LEAD Virtual Research and Development Center provides access to decision support tools, electronic conferences, online discussion forums, a digital library, expert consultations, a who's who, a directory, newsletters, and information on project research centers.

Decision support tools include: the Livestock and Environment Toolbox, Livestock Development Planning Systems, Fossil Fuel in Livestock Systems computer models and planning tools, the Digital Library, and the Livestock Environment Policy Dialog.

LEAD Livestock and Environment Toolbox. Part of LEAD Virtual Research and Development Center (see above) http://www.virtualcentre.org/en/dec/toolbox/homepage.htm.

The Livestock and Environment Toolbox is an electronic decision support tool for policymakers, planners and project leaders less familiar with livestock environment interactions, to help them identify which ones should be encouraged (beneficial) or mitigated (adverse). The toolbox offers technical and policy or institutional development options, together with suggestions for increasing awareness of the issues among policymakers, planners and extension officers.

Documents

Boyd, C., R. Blench, D. Bourn, E. Drake, and P. Stevenson (1999). *Reconciling Interests among Wildlife, Livestock and People in Eastern Africa*: *A Sustainable Livelihood Approach*. Overseas Development Institute, Natural Resource Perspectives Number 45. :London, UK. http://www.odi.org.uk/nrp/45.html

From the perspective of local livelihoods this paper explores the complex interactions between wildlife, livestock and people, and options for integrated wildlife and livestock management in the semi-arid rangelands of eastern Africa. The paper draws on the sustainable livelihoods approach which explicitly considers whether households have access to the assets required to engage in an activity, and how that activity fits with existing livelihood activities.

Brandjes, P.J., J. de Wit, H.G van der Meer and H. Van Keulen (1996). *Environmental Impact of Animal Manure Management*. H. Van Keulen International Agriculture Centre Wageningen, The Netherlands. Sponsored by FAO/USAID/World Bank/LEAD Initiative. http://www.fao.org/WAIRDOCS/LEAD/X6113E/x6113e00.htm

This report is part of a comprehensive study on 'Interactions between Livestock Production Systems and the Environment - Global Perspectives and Prospects'. The study examines management of waste from animal product processing, and environmental impact of animal manure management, landless monogastric production systems, landless livestock ruminant systems, and mixed irrigated systems in the (sub-) humid zones.

CGIAR System-wide Livestock Programme (2004). ILRI annual report 2004: achieving more with less: livestock as a tool for agricultural intensification, International Livestock Research Institute, Consultative Group on International Agricultural Research (CGIAR), USAID. http://www.ilri.cgiar.org/InfoServ/Webpub/FullDocs/ILRIAR2004/AnnualReport.htm

This annual report highlights communities adopting new ways of doing livestock business that are creating pathways out of poverty. The main chapters of this document present three case studies of how livestock systems are helping poor people meet the challenges of agricultural intensification in developing countries. The research activities in China, India and Nigeria outlined in this annual report is providing ILRI and partners and donor agencies with lessons for producing global public goods

de Haan, C. et al (2001). *Livestock Development: Implications on Rural Poverty, the Environment, and Global Food Security*. World Bank, Washington D.C. http://www-wds.worldbank.org/servlet/WDS_IBank_Servlet?pcont=details&eid=000094946_01112104010387

This book argues for a people-focused approach to livestock development, giving high priority to the public-goods aspect of poverty reduction, environmental sustainability, food security and safety, and animal welfare. It outlines the primary policy/technology framework for the main production systems and concludes with an eleven-point action plan for the sector.

Heffernan, C. (1998). *Livestock, Destitution and Drought: The impact of restocking on food security post-disaster.* Pastoral Development Network, Overseas Development Network, FAO. Rome, Italy. http://www.odi.org.uk/pdn/drought/heffernan.html

This paper examines concepts of food security in relation to pastoralists and attempts to quantify the impact of restocking on pastoralist households in Northern Kenya. The first section of the paper, analysis how food security can be both theoretically defined and practically applied. Whereas, the second section examines the impact of restocking projects on food security at both the household and project level. Food security parameters such as capital, investments and stores were evaluated. Household economic conditions were utilised as a proxy to measure food security. At the project level, the influence of the size of the restocking package on present and future food security was evaluated.

ILRI and USAID (2000). *ILRI (International Livestock Research Institute) 1999 Annual Report: Making the Livestock Revolution Work for the Poor*. Nairobi, Kenya. ISBN 92-9146-080-X http://pdf.dec.org/pdf_docs/PNACK019.pdf

This report focuses on a farm in central Ethiopia, whose mixed crop–livestock producers were just beginning to participate in the expanding dairy market of the country's capital, Addis Ababa. The study also explores what has happened and what may likely happen to supply and demand for different livestock products in different parts of the world. It discusses the implications for equity, the environment and human health, and then briefly reviews some of the policy, institutional and technological interventions needed to ensure benign outcomes. Many of the suggested interventions are part of the research program of ILRI and its partners around the world.

ILRI and USAID (2000). *Livestock Strategy to 2010: Making the Livestock Revolution Work for the Poor*. Nairobi, Kenya. http://www.ilri.cgiar.org/InfoServ/Webpub/Fulldocs/Strategy_10/toc.htm

Major implications for livestock research are identified from analysis of the major factors expected to influence livestock development over the next decade. This framework is based on ex ante, or preventive, assessment of probable economic surplus from different research investments, taking into account five criteria: contribution to poverty reduction; expected economic impact; expected environmental impact; international relevance of recommendations under consideration; and expected impact on research capacity in developing countries.

Jabbar, M.A., J. Pender and S.K. Ehui (eds), 2000. *Policies for Sustainable Land Management in the Highlands of Ethiopia: Summary of Papers and Proceedings of a Seminar Held at ILRI, Addis Ababa, Ethiopia, 22–23 May 2000*. International Livestock Research Institute, Nairobi, Socio-economics and Policy Research Working Paper 30. http://www.ilri.cgiar.org/InfoServ/Webpub/Fulldocs/Workp30/Contents.htm

The papers presented at this seminar provided information about the interrelated problems of land degradation, low agricultural productivity and poverty in the Ethiopian highlands (emphasizing the administrative regions of Tigray, Amhara and Oromiya);

- the proximate and underlying causes of those problems;
- the responses of individuals, communities and governments to the problems;
- the impacts of some of those responses; and
- the constraints and opportunities affecting the potential in the future for more productive, sustainable and poverty-reducing development pathways in the Ethiopian highlands.

Osofsky, Steve (ed) (2005). *Proceedings of the Southern and East African Experts Panel on Designing Successful Conservation and Development Interventions at the Wildlife/Livestock Interface: Implications for Wildlife, Livestock and Human Health, AHEAD (Animal Health for the Environment And Development) Forum, IUCN Vth World Parks Congress, Durban, South Africa, 14th and 15th September, 2003.* IUCN Occasional Paper 30, IUCN – The World Conservation Union, UK. http://www.wcs-ahead.org/wpc_launch.html

The "Southern and East African Experts Panel on Designing Successful Conservation and Development Interventions at the Wildlife/Livestock Interface: Implications for Wildlife, Livestock and Human Health" forum brought together nearly 80 veterinarians, ecologists, economists, wildlife managers, and other experts from Botswana, Kenya, Malawi, Mozambique, Namibia, South Africa, Tanzania, Uganda, Zambia, Zimbabwe, France, the United States, and the United Kingdom to develop ways to tackle the immense health-related conservation and development challenges at the wildlife/domestic animal/human interface facing Africa today, and tomorrow. This volume attempts to capture invitees' uniquely grounded insights, and their ideas for making the long-overdue "one health" perspective a reality in practice.

Peden, D., A. Freeman, A. Astatke, A. Notenbaert (2006). *Investment Options for Integrated Water-Livestockcrop Production in sub-Saharan Africa.* Working Paper 1, International Livestock Research Institute, Kenya. ISBN 92-9146-183-0 http://ilrinet.ilri.cgiar.org/inrm/InvestingFeb2006.pdf

This paper focuses on opportunities to enhance investment returns in agricultural water through integration of livestock into production systems by considering three issues. The first is the *development context* of the dynamic livestock sector including the anticipated rapid growth in demand for animal products that are transforming the livestock sector and placing increased demand on agricultural water resources. The second is a continent-wide *spatial analysis* of the current and projected distribution of livestock with implications for related pressure on water resources and investment options that better integrate agricultural water and livestock development. Thirdly, this paper suggests a set of *water-livestock investment strategies and options* that can help guide planners toward more effective use of water and more beneficial animal production.

Pratt, D. J., F. Le Gall and C. de Haan (1997). *Investing in Pastoralism: Sustainable Natural Resource Use in Arid Africa and the Middle East.* World Bank Technical Paper No. 365. World Bank, Washington D.C. http://www-wds.worldbank.org/servlet/WDS_IBank_Servlet?pcont=details&eid=000009265_3971110141434

This document offers guidelines for development in arid lands where pastoralism is practiced. It focuses on natural resource management (NRM) on arid rangelands used by pastoralists in Africa and Middle East. Part One provides advice on preparing for project interventions. Part Two provides guidelines for specific project components, addressing five essentials of pastoral development projects: herder organizations, support systems, drought management, phasing of technical inputs, and process monitoring.

Ramisch, Joshua (1999). *The Long Dry Season: Crop-livestock Linkages in Southern Mali*. Agricultural Ecosystems Research Group, Agronomy Department, University of Wisconsin, Madison, WI. http://www.eldis.org/static/DOC9068.htm

This article discusses agro-pastoralist exchanges in Mali. This has increase following the Sahelian droughts of the 1970s and 1980s, in which pastoralists have moved southwards with their herds, into wetter, more productive environments; cultivators are increasingly investing in livestock as the plough replaces the hoe. This paper investigates the interactions brought about by the co-existence of herds and agriculture in a village setting.

Williams, Timothy O (1998). *Multiple Uses of Common Pool Resources in Semi-arid West Africa: A Survey of Existing Practices and Options for Sustainable Resource Management*. Overseas Development Institute, Natural Resources Perspectives Number 38. London, UK. http://www.eldis.org/static/DOC6486.htm

Common pool resources such as rangeland, forests, fallow fields and ponds provide an array of social and economic benefits for a wide variety of users in semi-arid West Africa. However, poor definition and enforcement of the institutional arrangements governing the use of these resources sometimes lead to social conflicts and resource degradation. This paper examines why institutional arrangements are at times weak, and suggests what action can be taken.

Chapter 12
Pest Management I: Integrated Pest Management

Contents

What is Integrated Pest Management?	12-1
Potential Human Health and Environmental Impacts	12-3
IPM Program Design	12-10
Implementation of an IPM Plan	12-16
Mitigating Potential Pesticide Dangers	12-20
Representative International Resources and Programs	12-22
USAID Resources and Programs	12-25
Issues Impacting Pest and Pesticide Initiatives	12-27
Resources and References	12-32

Integrated pest management (IPM) encourages natural and cultural control of pest populations by anticipating pest problems and managing their numbers to reduce losses, while permitting safer pesticide uses where justified and permitted.

What is Integrated Pest Management?

For millennia, farmers around the world used their wisdom, knowledge and skills to develop and integrate multiple tactics for managing the pests on the crops they grew and the livestock they raised. This use of a combined array of anti-pest tactics would come to be termed integrated pest management (IPM). During the 1940s, however, modern organic insecticides were developed as an offshoot of research on nerve toxins being tested for biological warfare against humans. These insecticides were quickly added to the lists of pest management tactics—and soon overwhelmed them. Many of the ancient and time-tested methods for pest management fell into disuse.

Only after the human health and environmental dangers of using these compounds became apparent in the 1950s and 60s did scientists go back to study the time-tested and traditional methods of pest management and develop new ones in harmony with those traditional ones. At this point, the term IPM was coined and the concept became valued as an intelligent way of managing pests.

Many farmers in Africa who were never exposed to pesticide marketing, sales, or extension agents never stopped using and integrating their traditional tactics. Yet now many others who wish to enter markets for trade, and have the resources for it, do use pesticides. This guide is designed to encourage the use of natural and cultural pest management tactics to the

Sector Description

- IPM uses all available tactics for crop protection
- Pests account for 25–50 percent of crop losses worldwide
- Synthetic pesticides are currently the main method of control

extent possible while permitting the safe integration of pesticides, as needed, with farmers' traditional cropping and pest management systems. These tactics are of several kinds:

- cultural (using resistant varieties, rotating crops, varying the time of planting or harvesting, destroying crop refuse, pruning, planting trap crops),
- mechanical (destroying pests by hand, excluding them by barriers, trapping them), physical (using heat, cold, humidity, traps, sound)
- biological (introducing and/or protecting imported or indigenous natural enemies of pests, propagating and disseminating microbial control agents)
- natural chemical (using attractants, repellents, sterilants and growth inhibitors)
- genetic methods (propagating and releasing sterile or genetically incompatible pests)
- regulatory means (imposing plant and animal quarantines, launching suppression and eradication programs)

Differentiating Between Smallholder and Larger-Holder Farmers. Many smallholder subsistence farmers in Africa grow crops on one to two hectares. Others, who wish to sell produce locally, may farm up to five hectares. Still others have larger plots of land for commercial production. The distinction between smallholder and larger-holder farmers needs to be drawn early on, because the circumstances of each group will affect the production constraints they encounter, and thus their implementation of IPM programs, as well as the types of safety and production equipment they can access.

Commercial producers will be more likely to grow one crop on a majority of their land, creating a pest-attracting monoculture, while smaller farmers are more likely to interplant different crops, thus creating a hindrance to pests. Moreover, larger producers may be able to afford pesticides, as well as pesticide application and safety equipment. In addition, they are more likely to be trained and educated. The distinction between relatively small- and larger-scale producers will be drawn throughout this document, to highlight the type of critical thinking and planning required to deal with both.

Integrated pest management is defined as a farmer-based and knowledge-intensive management approach that encourages *natural* and *cultural* control of pest populations by anticipating pest problems and managing their numbers to reduce losses, while permitting safer pesticide uses where justified and permitted. Many indigenous, as well as newly-developed, non-chemical techniques are available for use. These include combinations of biological control, habitat manipulation, soil health management, use of resistant varieties, and modification of cultural practices (expanded upon below). IPM focuses on long-term *prevention* of pests and their damage, and is USAID policy. Pesticides are considered *curative*, and generally should be used as a last resort.

Pests are defined here as organisms that cause damage or destruction to crops, forest plantations, and domestic animals. They include viruses, bacteria, fungi, plants, insects, mites, nematodes, birds, rodents and other animals. Field and post-harvest crop losses due to pests range from 25 percent to 50 percent worldwide, and may be higher in the developing world. Pests responsible for animal diseases may also infect humans; chronic diseases transmitted by insects inflict pain and suffering and diminish people's ability to work.

Synthetic pesticides (herbicides, fungicides, insecticides, rodenticides and other synthetic chemical controls) have, for the past 50 years, become the dominant means of controlling pests in developed countries. Since the Green Revolution in the 1960s, they have also been heavily used in the developing world, especially Asia and Latin America. Now, African farmers wishing to expand production and reach markets for trade are increasingly using pesticides as well. However, markets for organic products confound this use, as the new "green revolution" in organic and pesticide-free products takes off.

Increasing pesticide use can be attributed to a number of factors, including:

- Larger-scale, more intensive crop, forestry and livestock production to meet the demands of expanding populations. Resulting monoculture conditions are highly susceptible to pest outbreaks and require increased and more intensive use of pest controls.
- The aesthetic requirements of export markets (for visually "perfect" or "clean" food, horticulture and floriculture products).
- Use of high-yield varieties and breeds. This helps feed growing populations and may make crops more cost-competitive on international markets. However, these varieties are often more susceptible to pests than traditional ones.

For more detailed developing country IPM information, consult the 2003 CARE publication *Guidelines for Promoting Safer and More Effective Pest Management with Smallholder Farmers: A Contribution to USAID-FFP Environmental Compliance*, by Gladstone and Hruska, along with the resources cited at the end of this chapter. The CARE publication is one of the most up-to-date resources on pest management for developing countries currently available and provides a basis for much of the information in this chapter. To locate a detailed compilation of established organizations providing IPM support in developing countries, short descriptions of each, and a link to their Web sites, look at the end of this chapter. These organizations are potential partners in planning, designing and implementing IPM programs.

Potential Human Health and Environmental Impacts of Pesticide Use

Human Health Impacts of Pesticide Use

Synthetic pesticides are potent nerve toxins to all living organisms, including humans. Many pesticides, especially those available and used very heavily in the developing world, are *not specific* to the pest on which they are used, and are highly toxic to a broad array of living things.

Humans can have both acute and chronic exposures to pesticides. Acute exposure includes large doses of pesticide that are inhaled, ingested, or absorbed through the skin. Chronic exposure consists of smaller amounts taken into the body with cumulative effects on health over time.

Those at greatest risk are those who experience the greatest exposures—typically smaller-holder farmers, farm workers and their families. These populations are also often the poorest members of society. Larger-holders are more likely to have received training on pesticide risk avoidance; however, laborers hired by them may not. Acute and chronic effects vary from pesticide to pesticide in both type and degree, and are listed below.

Potential Environmental Impacts

Significant hazards are associated with the use of synthetic pesticides in the developing world.

- Intrinsic danger to all living creatures, including humans
- Poor quality control
- Poor use practices
- Resistance developed by pests
- Environmental accumulation of residues

Acute human pesticide exposure

Acute effects from some pesticides include death, vomiting, severe headache, skin damage, temporary blindness, shortness of breath, and uncontrollable nervous tremors.

Chronic human pesticide exposure

Chronic exposure can result in cancers, mutations in unborn children, suppression of the immune system, reduced fertility and/or permanent damage to eyes, lungs, liver and other essential organs.

Environmental Impacts of Pesticide Use

Uncontrolled pesticide use can lead to several unintended and harmful environmental affects. These include contamination of soil and water, pesticide drift, effects on non-target organisms, disruption of natural pest controls leading to pest resurgence, and resistance. Economists have developed methods for determining unapparent or “hidden” losses caused by the impacts of pesticides. These are called externalities, and are covered below as well. Their economic impact can be greater than expected.

Soil contamination

The use of pesticides and their accumulation in the soil can kill and severely reduce the essential soil macro- and microorganisms, including earthworms, insects, spiders, mites, fungi, essential mycorrhizae, and bacteria, thus reducing or stopping important nutrient cycling. Accidental spills on soil, which are usually associated with pesticide mixing and loading operations, can result in localized but severe soil contamination if not contained and dealt with rapidly and adequately.

Effects on surface and ground water

The intense use of pesticides in agriculture or disease vector management can lead to the contamination of surface and ground water. Water runoff resulting from heavy rainfall can transport pesticides and their toxic metabolites to distant places located downstream, contaminating lakes, lagoons, reservoirs, ponds, and estuaries, and adversely affecting aquatic organisms. Discarding pesticides, washing spray equipment, or rinsing empty pesticide containers in or near streams and rivers can cause similar damage.

Pesticide drift

When pesticide is being sprayed, poor aim or a light breeze can cause it to drift away from its intended target. Insecticide drift can be deadly to non-target organisms, including beneficial insects, spiders and mites. Pesticide drift can also expose people to risks associated with such chemicals. Spraying against the wind can poison the person applying the pesticide. Similarly, drifting herbicide can damage non-target crops and native vegetation within reach.

Effects on non-target organisms

Broad-spectrum insecticides not only destroy target insect pests but also destroy the predators and parasitoids that feed naturally on them. Pollinators and insect pests' natural enemies (parasitoids and predators) are especially vulnerable to pesticides—often more so than the pests. Most pesticides are also highly toxic to birds, fish, lizards, snakes, frogs, toads and other arthropods.

Disruption of natural control

By eliminating pests' natural enemies, excessive insecticide use can exacerbate pest problems and create new ones. Without natural enemies to keep them in check, pest populations can recover faster from the effects of a pesticide application than they could have in the presence of healthy natural enemies. This effect is known as pest resurgence. Again, many species that feed on crop plants are normally not a problem because their natural enemies keep their numbers relatively low. Intensive pesticide use, however, can eliminate these natural enemies, triggering a population explosion among their prey. Species that were merely potential pests or secondary pests may rise to "key pest" status as a result.

Pesticide resistance

The development of genetic resistance to pesticides in pest organisms is another adverse consequence of pesticide overuse. Through 1990, at least 504 species of insects and mites, 150 species of pathogens, 273 weed species, 2 species of nematodes, and the Norway rat had developed resistance to at least one pesticide.

Externalities: *Accounting for economic costs of human health and environmental impact*

Externalities are the hidden costs associated with pesticide use, such as lost productivity due to chronic pesticide poisoning and lost ecosystem services such as the activity of natural enemies against pests. Unless these costs are accounted for, the cost to society for the reliance on chemical intensification to increase productivity will be under-recognized. Groundbreaking work on rice in the Philippines showed that when the health costs arising from pesticide exposure are included in the production budget, the most efficient and profitable pest management strategy can be natural control.

Examples of economic externalities of pesticide use in the United States are included in Table 1, next page, to emphasize their economic importance.

Table 1. Environmental and Social Costs (Externalities) Incurred by Pesticide Use in the United States (1997).

COST	$ MILLON/YEAR
Public health impacts	933
Domestic animal deaths and contamination	31
Loss of natural enemies	520
Cost of pesticide resistance	1,400
Honey bee and pollination losses	320
Crop losses (phytotoxicity)	959
Surface water monitoring	27
Groundwater contamination	1,800
Fishery losses	56
Bird losses	2,100
Government regulations to prevent damage	200
TOTAL	**8,346**

Source: Pimentel & Grenier (1997)

Factors That Lead to Risks to Human Health

African Production and Pesticide Use

Use of pesticides in Africa is lower than in other parts of the developing world. For comparison, in parts of Latin America, 90 percent or more of farmers raising a variety of crops use synthetic pesticides. Use in Africa is nowhere near this high, but it is increasing. Where African farmers wish to focus on one silver bullet that will solve their pest problems and can afford pesticides, use is high. The reasons are simple: synthetic pesticides appear to them to be fast, effective, and relatively easy to obtain. The pesticides marketed for farmer use are relatively simple to use, are culturally acceptable, and reduce yield losses to pests over the short term.

However, in Africa, smallholder farmers and many ministry of agriculture officials do not know how to calibrate or use sprayers properly, most farmers do not use safety equipment, recommendations given during safe use pesticide training are not followed, and well-written national regulations are never enforced. Moreover, donors and their implementing partners often do not have the resources to constantly monitor pesticide use schemes to ensure compliance with prescribed regulations and safe use. These problems are outlined below, and are being addressed by USAID programs through initiatives such as the Pesticide Evaluation Reports and Safer Use Action Plan (PERSUAP), described later.

Poor pesticide manufacturing quality control

Almost a third of the pesticides sold in developing countries are of poor quality. They may contain dangerous impurities, pesticide chemical breakdown products that are much more toxic than the active ingredient, and/or excessively high concentrations of active ingredients.

Poor use and dangerous practices

Damage done by synthetic pesticides in Africa is compounded by the way they are used. Synthetic pesticides are intended to be used by trained applicators. The specific pesticide to be used against an identified pest is applied using specially designed machinery, equipment and clothing to protect the applicator. Guidelines are provided on quantity, frequency and timing of application relative to harvest, and these must be followed closely. In Africa, few if any of these procedural controls are adhered to with care by many smallholder farmers, although they are used by more educated larger-holder farmers.

Further, because of economic and educational conditions, smallholder farmers often view the “safe use” paradigm at best a waste of time and at worst a dangerous myth, and they do not appreciate the externalities listed above. Thus smallholders do not and probably will not follow “safe handling” practices even when these practices are taught to them. In addition, they often apply pesticides in excessive quantities, thinking that more is better.

Use of very dangerous new pesticides

Organophosphates, carbamates, and phenylpyrazoles, three families of broad-spectrum pesticides are among the pesticides smallholders most frequently mention using. All of these can cause acute and chronic neurological damage, among other maladies. The World Health Organization has classified some of these insecticides, such as methamidophos and methyl parathion, as extremely or highly hazardous (Class I).

Use of very dangerous old pesticides

Banned synthetic pesticides, such as DDT, dieldrin, aldrin and other so-called chlorinated hydrocarbon pesticides, and pesticides of poor quality are often easy and cheap to produce and are frequently sold, legally and illegally, in developing countries. All farmers tend to use these older pesticides because they are generally cheaper and more potent, and they work well against a broader spectrum of pests. However, larger-holder

Sector Design Elements

IPM is an alternative aiming to:

- Minimize pesticide use
- Minimize health and environmental risks from pesticides

Elements of a program include:

- Understanding of pests and real crop losses
- A clearly defined target audience
- Creating proper conditions for IPM adoption
- Effective activities to promote IPM
- Partnerships with other organizations
- Continuous monitoring and evaluation

farmers focusing on international trade will avoid these, due to developed-country restrictions.

Production and use of homemade botanical pesticide concoctions

Although it is rare, NGO and USAID project managers may, while doing assessments of farmer's own IPM tools prior to project design, find a few smallholder farmers who are using combinations of "natural" products, such as tobacco extracts concocted with other types of plant extracts, that are actually quite toxic to people as well as pests. There are no U.S. Environmental Protection Agency (and thus no USAID) regulations governing the use of many homemade botanical pesticide concoctions. Thus, many of these may not be promoted in a USAID-funded program, and farmers should be cautioned and encouraged to explore alternatives.

Local government policies

Inadequate local policies, regulation, and enforcement pertaining to the manufacture, import, formulation, packaging, labeling, transport, storage, sale, handling, application, and disposal of pesticides and their empty containers contribute to the increasing environmental and especially health risks associated with pesticide use in developing countries (see "Safer Pesticide Use" chapter in these guidelines).

Dangers across the pesticide cycle

Synthetic pesticides pose hazards not only to farmers and farm workers, but also to the health of others and to the environment at several stages in their life cycle:

- manufacturing
- transport, storage and application
- consumption of residues in food
- final disposal of outdated stocks

Hazards at each of these stages must be mitigated (see the "Safer Pesticide Use" chapter in these guidelines and the discussion below), and are the responsibility of the group that orders the pesticide.

Factors That Lead to Risks to Environmental Diversity

Traditional mixed cropping systems, with their wide plant diversity, contain the conditions and resources (refuges, pollen, honey, hosts and prey) needed to support diversified natural enemy populations, which, in turn, contribute to keep populations of plant-feeding species from reaching damaging levels. Several factors discussed below, in addition to those listed above, stimulate overuse of pesticides, leading to environmental contamination.

Monoculture plantings

The introduction of unsuitable crops, cropping systems, and crop-management practices can negatively affect the ecological balance of diverse and stable agro-ecosystems in sub-Saharan Africa. Larger-holder monoculture plantings provide pests with an easily accessible, vast and continuous source of food and shelter in time and space, and are generally predator-free. For instance, cotton grown as a monoculture tends to develop serious pest problems and an increasing dependence on chemical control within a few seasons. Rice and wheat, grown as monocultures, are subject to intense competition from weeds and often require at least one herbicide application per season.

The shift from low-input, highly diversified cropping systems to high-input, large-scale monocultures can exacerbate pest problems in several ways. In addition to the detrimental effects that pesticides have on pests' natural enemies, the introduction of monocultures of itself often results in a loss of natural enemy diversity.

Irrigated production

The introduction of irrigation, primarily by larger-holders, allows crops to be grown year round but also allows some pests to survive and thrive throughout the year, as a new source of food and shelter becomes available during the dry season. These unforeseen pest problems can often lead to increased pesticide use and adverse health, environmental, and economic effects.

Bioaccumulation of pesticides

In some cases, very serious broader or unexpected effects have come to light many years after the introduction of certain inadequately tested pesticides. DDT is perhaps the most famous example. DDT was found to build up or bio-accumulate in the food chain and to have unexpected reproductive and toxic effects, especially in certain predatory bird species.

Factors That Lead to Risks to Both Human Health and Environmental Diversity

Obsolete pesticides

Currently, African countries store an enormous quantity (120,000 tons!) of old pesticides that came from many sources, including donors, the UN Food and Agriculture Organization (FAO), regional development banks and self-purchase by farmers. Many of these now unusable and degraded pesticides were donated for emergency programs against plagues of locusts, grasshoppers, armyworms, rodents, birds, mosquitoes, ticks, tsetse flies, and other disease vectors.

Many of these are not being properly stored. Old deteriorating pesticide barrels leak, non-experts such as children have access to them, streams flow nearby, and some being sold by unscrupulous or unknowing crop protection agents for use. Pesticides often degrade into chemical compounds even more dangerous and toxic than the original pesticide. Be aware of this and beware of allowing the use of these old pesticides in an IPM program. In fact, strongly discourage their use for any purpose.

Pest resistance and a cycle of increased use

When synthetic pesticides are used, a number of naturally resistant members of the pest organism population will survive. Since resistant organisms are the only survivors, the next generation of pests will be more resistant to the pesticide overall than the previous one was. Thus using synthetic pesticides creates a cycle where farmers must use greater and greater quantities of pesticides or turn to new pesticides to control the pest, often at greater expense and/or risk.

Little known about the biology and ecology of many microscopic pests

Pests that cannot be seen, such as viruses and bacteria, or insects that live in hidden habitats during the day and feed at night, are generally unrecognized or misunderstood, except by larger-holder farmers who may have been trained. This lack of knowledge can lead to misuse of pesticides. For instance, some farmers in Latin America have been known to use fungicides against viral or bacterial infections, due to misdiagnosis and/or poor advice.

Market aesthetic quality requirements

High-value crops grown by larger-holders for export, including vegetables, fruits, and cut flowers, are often highly susceptible to pests, yet have high quality requirements imposed by the market. As a consequence, such crops tend to be treated with pesticides more frequently than crops grown for domestic consumption, leading to increased human and environmental dangers. It is not unusual, in such cases, for pest problems to worsen due to pesticide overuse. Farmers then feel compelled to spray more and more often, thus perpetuating and magnifying this unfortunate cycle.

IPM Program Design

The design of an IPM program will ideally be developed with all of the fundamental parts of any good management plan, and will address all of the factors and issues outlined above. The vital parts of a plan include a definition of the targeted primary beneficiaries (small- or larger-holder farmers) as well as secondary beneficiaries (marketers, processors, transporters, and consumers); a list of implementation partners (there are many to choose from, listed at the end of this chapter); and a list production constraints (problem identification), with IPM strategies for dealing with them.

Long-term (three- and five-year) and annual action plans will include the following components: mission and vision statements, goals, intermediate results, activities to achieve these results, a budget for each activity, a responsible person or persons for each activity, indicators of impact, baseline data on human and environmental safety and crop production, and a performance monitoring plan with assessments to check progress.

The special elements and conditions for adoption of successful IPM programs are outlined and expanded upon below.

Elements of an IPM Plan

For IPM to be adopted by smallholders in African countries, it must be effectively marketed and a plan must be written. IPM must actually be equal or superior to current smallholder practice—and the target audience must be convinced that this is so. Initially, the term “integrated pest management” is in itself somewhat of a handicap, since it suggests that IPM is a complicated process. But this hesitency is rapidly overcome once farmers come to realize that they have been using IPM all along.

Concern about the adverse health impacts of pesticide use on family and community—and the local environment—can create strong interest in adopting IPM. This is especially true if health and environmental impacts are communicated in moving and graphic ways. However, if farmers do not perceive the effectiveness of IPM as being *at least equivalent* to that of current pesticide-based practice (generally about 95%), adoption rates may be low.

Be aware that there are many varying conceptions of IPM:

- Some programs almost completely exclude the use of synthetic pesticides. These emphasize the use of physical and biological controls.
- Other programs take a more pragmatic approach. These seek to minimize the use of synthetic pesticides in general and the most hazardous pesticides in particular—but not to the extent that unreasonably complex or expensive controls are imposed that undermine farmers' confidence in IPM.

Remember that the strongest selling points for IPM beyond the health and environmental benefits are:

- IPM is more effective then synthetic pesticides *in the long run.*
- IPM is less damaging to essential soil health and nutrient cycling.
- IPM generally requires less capital investment.
- IPM can be used preventatively to eliminate or minimize the need for "responsive" controls (that is, applying pesticides after a pest outbreak occurs and much damage already has been done).

Step 1: Assess IPM Needs and Establish Priorities. In planning projects, consider the relative importance of agriculture in the overall program. If agriculture is a major component, IPM and pesticide management issues should be addressed. Consider the relative importance of target crops, looking at the surface area they cover, their value (economic, social, nutritional, etc.), and their importance as a source of livelihood for beneficiary farmers. Further, consider crop protection needs, farmers' perceptions of pest problems, pesticide use history and trends, availability of IPM technology, farming practices, access to sources of IPM expertise, support for IPM research and technical assistance, and training needs for farmers and project extensionists. These will vary with farm size.

Next, identify strategies and mechanisms for fostering the transfer of IPM technology under various institutional arrangements, mechanisms, and funding levels. Define what is available for immediate transfer and what may require rapid and inexpensive adaptation and validation research. During the planning stages of an IPM program, the inputs from experienced IPM specialists (such as those from the FAO's Global IPM Facility) will be extremely useful. If possible, set up an initial planning workshop to help define and orient implementation activities, and begin to assign individual responsibilities.

Step 2: Learn and value farmers' indigenous IPM tactics, and link with and use all local resources/partners

Repeated analytic studies and assessments by Africa Bureau and the Global IPM Facility (GIPMF) have found that most farmers are using their own forms of IPM. Many of these are novel, self-created, adapted for local conditions, and many of them work well. These include mechanical and physical exclusion; crop rotation, trap crops, cover crops, and green manures; local knowledge of strategic planting times; water, soil and fertilizer resource management; intensive intercropping; leaving refuge habitat for natural enemies; soil augmentation and care leading to healthy nutrient cycling; transplanting; and weeding.

Accurate assessments of these farmer technologies, as well as of actual losses due to different constraints in farmers' fields, are a must before designing any crop production and pest management program. Be aware that crop-loss figures provided by small- and larger-holder farmers alike, and thus projected and reported by international organizations, are often overestimated.

Before and during project design, key partners will assist you in assessing accurate crop losses and food security in your target country and region. Foremost among this group is FEWSNET http://www.fews.net/, the Famine Early Warning Systems Network funded by USAID, with over 15 years of field-level experience in Africa. Linked with FAO's food security unit, FEWSNET sustains a cadre of local as well as regional experts in most African countries. The experts' primary mission is to scour local markets countrywide for information on commodity availability and pricing, as well as to identify and understand production constraints and losses. They report these monthly and upon request to USAID managers and policy makers. They can also provide valuable insights to market potential for commodities targeted in your program.

Some programs or partners that focus on safe pesticide use training may be using training as a marketing tool for industry. Such training tends to promote use (often overuse) of and reliance on pesticides, frequently promoting brands and formulations that may be inappropriate for the problem or environment. Caution should therefore be exercised when choosing IPM program implementation partners. Links to appropriate partners are given at the end of this chapter.

Step 3: Identify key pests for each target crop. Although hundreds of species of organisms can be found in a crop at any one time, only a few of them may cause substantial crop losses and be considered pests. Become familiar with the key pests of target crops. Know whether they are primary or secondary pests and know how to positively identify them. Monitor their population size, the kind of damage that they cause, and their life cycle.

Key pests usually amount to a relatively small number of species on any one crop and can include any combination of insects, pathogens, weeds, diseases, and vertebrates. A few other species, known as secondary or occasional pests, attain damaging status from time to time, especially if over-spraying occurs and kills natural predators that naturally regulate their populations.

The vast majority of insect species found in any one crop are actually predators and parasites of the plant-feeding species. Many smallholder farmers are not aware of these distinctions and must be taught to correctly identify the more common beneficial species, as well as pests, found in their crops. Incorrect identification of beneficial insects, predators or neutral insect species, may lead to unnecessary pesticide applications. This diagnostic phase requires sampling and careful observation.

The vast majority of insect species found in any one crop are actually predators and parasites of the plant-feeding species—in other words, they help the farmer by feeding on the pest.

Usually, most key pests are fairly well known by local farmers and government extension personnel. However, a few species may be poorly known or understood because they are active at night, hidden, or small. These include soil-inhabiting species such as nematodes and insect larvae (wireworms, white grubs, cutworms), mites, and pathogens (viruses, bacteria, mycoplasma, fungi). In addition, farmers usually do not understand the role of some insects as **vectors** (carriers) of plant diseases.

Step 4: Do effective activities and training to promote IPM. The FAO has shown that a number of activities are very effective in promoting IPM in developing countries:

Learning-by-doing/discovery training programs

Small- and larger-holder farmers in training programs are most apt to adopt new techniques when they acquire knowledge and skills through personal experience, observation, analysis, experimentation, decision-making and practice.

First, frequent (usually weekly) sessions are conducted for 10–20 farmers during the cropping season in farmers' fields by trained instructors or extension agents. Because these IPM training sessions take place in the farmers' own environment, (1) they take advantage of the farmers' own knowledge; and (2) the farmers understand how IPM applies to their own farms.

Of these IPM training sessions, four or five analyze the agroecosystem. They identify and describe such factors as soil type, fertility, and needs; weather; crop stage; each pest; the pest's natural enemies; and relative numbers of both pests and enemies. Illustrations and drawings are provided, as needed. Extensionists use a Socratic method, guiding farmers with questions to stimulate important insights and supplying information only when absolutely necessary.

Farmers may also experiment with insect zoos where they can observe natural predators of their pests in action—and see how pesticide may kill them both. The knowledge and skills necessary for applying IPM are best learned and understood through practice and observation: understanding pest biology, parasitism, predation and alternate hosts; identifying plant disease symptoms; sampling population size; and preparing seed beds.

Recovering collective memory

Pest problems often emerge because traditional agricultural methods were changed in one way or another, or lost. These changes can sometimes be reversed. This approach uses group discussions to try to identify what changes might have prompted the current pest problem.

Smallholder support and discussion groups

Weekly meetings of smallholders, held during the cropping season, to discuss pests and related problems can be useful for sharing the success of various control methods. However, maintaining attendance is difficult except when there is a clear financial incentive (e.g., credit).

Demonstration projects

Subsidized experiments and field trials at selected farms can be very effective at promoting IPM within the local community. These pilots demonstrate IPM in action and allow farmers to compare IPM with ongoing cultivation supported by synthetic pesticides.

Educational material

In many countries, basic written and photographic guides to pest identification and crop-specific management techniques are unavailable or out of date. Such material is essential. Videos featuring graphic pictures showing the effects of acute and chronic pesticide exposure, along with interviews with poisoning victims, can be particularly effective. A study in Nicaragua found videos to be the most important factor in motivating farmers to adopt IPM.

Youth education

Promoting and improving the quality of programs on IPM and the risks of synthetic pesticides has been effective at technical schools for rural youth. In addition to becoming better farmers in the future, these students can bring informed views back to their communities now.

Organic food market incentive

Promoting organic certification for access to the lucrative and rapidly growing organic food market can be a strong incentive to adopt IPM.

Land tenure reform

The more secure people's sense of ownership of the land they cultivate, the more carefully they steward it.

Credit reform

Some financial credit programs may dictate the use of synthetic pesticides in order to receive a loan and thus may discourage IPM adoption. Credit that permits, encourages or requires farmers to employ other less toxic methods, such as microbial controls, can boost adoption of IPM.

Step 5: Partner successfully with other IPM implementers. Many IPM projects consist of partnerships between two or more organization, e.g., donors, governments, private voluntary organizations (PVOs) and non-governmental organizations (NGOs), such as those highlighted at the end of this chapter. If these partnerships are not forged with care, the entire project may be handicapped. The following design steps are considered essential.

Articulate the partnership's vision of IPM

Organizations may forge partnerships based on a common commitment to "IPM"—only to discover too late that that their visions of IPM differ considerably. It is important that partners articulate a common, detailed *vision* of IPM, centered on the crops and conditions the project will encounter.

Confirm partner institutions' commitment

Often, organizations make commitments that they do not intend (or are unable) to fulfill completely. The extent of commitment to integrating IPM into project design and thus implementation depends strongly upon the following key variables:

- **The IPM program's integration into larger projects**. The IPM program is likely to be part of a larger "sustainable agriculture" project. The IPM program must fit into a partner's overall program. The extent of this integration should be clearly expressed in the proposed annual work plan.
- **Cost sharing**. The extent of funds (or in-kind resources) is a good measure of a genuine partner commitment.
- **Participation of key IPM personnel.** Large partner organizations should have staff with expertise in IPM who are assigned specifically to IPM work. In strong partnerships, these staff members are actively involved in the partnership.

Step 6: Monitor the fields regularly. The growth of pest populations usually is related closely to the stage of crop growth and weather conditions, but it is difficult to predict the severity of pest problems in advance. The crops must be inspected regularly to determine the levels of pests and natural enemies, as well as crop damage. Current and forecast weather should be monitored. Farmers, survey personnel, and agricultural extension staff can assist with field inspections. They can train other farmers to be able to separate pests from non-pests and natural enemies, and to determine when crop protection measures are necessary.

Step 7: Select an appropriate blend of IPM tools. A good IPM program draws from and integrates a variety of pest management techniques. IPM does not require predetermined numbers or combinations of techniques, nor is the inclusion or exclusion of any one technique required for IPM implementation. Flexibility to fit local needs is a key variable. Most non-migratory pests of traditional cropping systems in Africa are already under adequate natural (biological) and cultural control; introducing pesticides into such systems may not be economically or environmentally justifiable. In this case, the IPM strategy should be to maximize the effectiveness of traditional and introduced non-chemical control techniques, in the least ecologically disruptive manner.

Pesticides should be used only if no practical, effective and economic non-chemical control methods are available. Once the pesticide has been carefully chosen for the pest, crop and environment, it should be applied only to keep the pest population low. When dealing with crops that are already being treated with pesticides, IPM should aim first at reducing the number of pesticide applications by introducing appropriate *action thresholds* (see "Chemical Control" section below). At the same time, IPM should promote appropriate pesticide management and use practices (see these guidelines' "Safer Pesticide Use" chapter) and help farmers shift to less toxic and more selective products as well as non-chemical control methods. In most cases, NGOs/PVOs will probably need to deal with low to moderate levels of pesticide use. Either way, an IPM program should emphasize preventive measures and protect a crop while interfering as little as possible with the production process.

Step 8: Develop education, training, and demonstration programs for extension workers. Implementation of IPM depends heavily on education, training, and demonstration to help farmers and extension workers develop and evaluate the IPM methods. Hands-on training conducted in farmers' fields (as opposed to a classroom) is a must (see the discussion of "learning-by-doing/discovery training" programs on page 13 of this chapter). Special training for extension workers and educational programs for government officials and the public are also important.

Model Approach to IPM

- Evaluate pests' impact before control programs are implemented, to identify pests, size of problems and possible natural controls
- Evaluate non-pesticide management options, including a range of preventive measures and alternative pest control methods (physical, mechanical, biochemical)
- Evaluate whether synthetic pesticides are necessary or not, whether less toxic varieties are available for the purpose, and how to minimize exposure for users and the environment

Step 9: Monitor and Evaluate. First, develop data collection tools, and then collect baseline data at the beginning of the project to identify and determine the levels of all variables that will need to be tracked. These may include numbers and types of pests, predators, and soil microorganisms; relative numbers of all non-target animals (birds, lizards, etc.) that may be harmed if pesticides are used; soil and water samples to determine levels of pesticide residue; soil samples to learn dominant soil types and to predict soil nutrition, soil requirements, and fertilizer/pesticide activities; pesticides, application and safety equipment available; and the amounts and type of training received by target audiences.

Develop methods for measuring the effectiveness of each IPM tactic used, and of their sum in reducing pest damage and crop losses. Also, develop methods for monitoring environmental health (maintaining and encouraging high levels of predators and soil microorganisms) and human health, if pesticides are used. The "Safer Pesticide Use" chapter includes a checklist for PVOs and NGOs at the end, which will serve as a guide for monitoring pesticide use. Kits are available for determining the level of pesticides to which farmers and applicators have been exposed. Make checklists for farmers to use when applying pesticides that indicate the type of application and safety equipment used, and the rates at which pesticides were applied.

Implementation of an IPM Plan

The following IPM evaluation and implementation process contains very useful preventive and reactive interventions to manage pests. Measures are also included for minimizing risk if synthetic pesticides are chosen as one of the pest management methods integrated into the IPM program.

Step 1: Evaluate and use non-pesticide management options first.

Use both preventive and responsive/curative options that are available to manage pest problems. Farmers may prevent pests (and avoid requiring pesticides) by the way they select plants, prepare the site, plant and tend growing plants. Along with prevention, farmers may respond to or cure the problem via physical, mechanical or biochemical methods.

Preventive Interventions:

Plant selection

- choose pest-resistant strains
- choose proper locally-adapted plant varieties
- diversify plant varieties or intercrop plants
- provide or leave habitat for natural enemies

Site preparation and planting

- choose pest-free or pest-avoiding planting dates (e.g., early planting in rainy season avoids stem borers in cereals)
- improve soil health
- weed before sowing the crop
- use an appropriate planting density
- enhance/provide shade for shade-grown crops
- assign crop-free (fallow) periods and/or rotate crops
- install buffer zones of non-crop plants and/or physical barriers
- rotate crops
- use low-till or no-till methods

Plant tending/cultivation practices

- fertilize and irrigate appropriately
- remove weeds while small

Responsive/Curative Interventions:

Physical/mechanical control

- remove or destroy diseased plant or plant parts and pests
- weed
- install traps

Biochemical control

- pheromones (very effective, but not currently easily accessible or economical; however, they are becoming more so)
- homemade botanical pesticides
- repellents

Biological control

- release or augment predators
- release or augment parasites/parasitoids
- release or augment microbial pesticides

Step 2: Evaluate the use of synthetic pesticides, if needed. The use of synthetic pesticides should be avoided for many reasons. First, they may be serious constraints to IPM adoption. Second, there are many errors associated with pesticide use in developing countries. Below are some common IPM constraints and pesticide use errors, with possible solutions.

Pesticides as Constraints to IPM Adoption

- Manufacturers aggressively market pesticides.
- Governmental policies/donors promote the use of pesticides.
- Institutional habits (extension services, research groups) favor pesticides.
- Centralized decision-making operates in favor of pesticides.
- Economic/financial factors impede training in IPM /use of IPM techniques.

Some Common Errors Associated with Pesticide Use

- Pesticide is not registered in the host country.
- Pesticide is not evaluated/registered in the country of origin.
- Pesticide is not effective for the planned use.
- Formulation is not stable in tropical conditions.
- Formulation is not adapted to the available application equipment.
- Quantities exceed the real need.
- Pesticide is too dangerous for the users.
- Label is missing or is in a foreign language.
- Packaging is too large or too small for the volume of fertilizer.
- Packaging is not strong enough.

Possible Solutions to Help Reduce Pesticide Risks

- Promote IPM as the preferred approach for pest control.
- Help the host country improve its management of pesticides.
- Use good practices in the provision of pesticides.
- Use only EPA- and OECD-registered pesticides.
- Don’t use pesticides in WHO classes Ia, Ib, and II (see below).

- Don’t use pesticides found on Prior Informed Consent (PIC) and Persistent Organic Pollutants (POPs) Convention lists (see references at end of chapter).
- Follow World Health Organization guidelines for vector management.
- Determine status of pesticides in Special Review at EPA.
- Determine acceptable levels of pesticide residues for trade and consumption by checking the United Nations for the CODEX limits.
- Go to PEST-BANK (http://www.silverplatter.com/catalog/pest.htm) to order information that can help to determine pesticides’ suitability for intended uses
- Know how to treat pesticide poisoning—you can find a good handbook on poisoning at http://www.epa.gov/pesticides/safety/healthcare/handbook/handbook.htm
- Check pesticide labels and the U.S. Code of Federal Regulations on the Web before ordering pesticides
- Follow USEPA’s guidelines for biological pesticide registration and use their Web site as a resource for novel green technologies
- Recognize that some botanical pesticides are regulated by USEPA, but additional ones may be evaluated by EPA on a case-by-case basis.

World Health Organization Acute Toxicity Classes

Class	*Toxicity*	*Advice for Africa*
Ia	Extremely Hazardous	DO NOT USE
Ib	Highly Hazardous	DO NOT USE
II	Moderately Hazardous	USE GREAT CARE!
III	Slightly Hazardous	Use with care
U	Unlikely to present any acute hazard in normal use	

Mitigating Potential Pesticide Dangers

If there are no feasible alternatives to pesticides, take the following measures to mitigate and reduce their risks to human health and the environment. Note that risk is a function of both toxicity and exposure. Reducing risk means (1) selecting less toxic pesticides and (2) selecting pesticides that will lead to the least human exposure before, during and after use. For more detailed information on pesticides and their use, refer to the "Safer Pesticide Use" chapter in these guidelines.

Reduce Exposure Time or the Degree of Exposure

Before using

Transport:

- separate pesticides from other materials being transported
- avoid private distribution—it's dangerous

Packaging:

- follow international and national norms and guidelines
- use packaging adapted to needs
- eliminate re-use of packaging materials (even when cleaned, pesticide containers are too dangerous to re-use)

Storing:

- develop strict guidelines for village-level storage
- ensure permanent, well-marked labeling
- follow and respect national norms
- follow and respect FAO norms
- use appropriate language and approved pictograms
- use and respect appropriate toxicology color

Formulating:

- use appropriate type and concentration

During use

Training:

- should be continuous
- identify level and audiences (distributors, farmers, transporters, etc.)

Application equipment:

- should be adapted to user needs and possibilities
- should assure maintenance and availability of parts and service

Protective equipment and clothing:

- should be adapted to local climatic conditions
- should be adapted to user needs and resource possibilities
- should eliminate exposure rather than just reduce it, if at all possible

Focus on "buffer zones" around the following:

- housing
- environment: water, sensitive areas

After using

- know, respect and enforce any **exclusion period** after application (time during which humans, livestock, etc., must be kept away from the treated area)
- assure proper cleaning and rinsing off of:
  - applicators' preparation and application equipment
  - applicators' clothing
  - storage containers
- develop a workable monitoring and evaluation system for:
  - adherence to national and international policies regarding pest management and pesticides
  - health effects on applicators, the local population, and domestic animals
  - efficacy on target pests
  - impacts on environment: water, soils, etc.
  - elimination of pesticide leftovers and containers

Representative International Pest and Pesticide Management Initiatives, Resources, and Programs

This section lists and gives short descriptions of potential international partners and resources for IPM planning and implementation. Here you can find leads to both major and minor IPM resources and ideas.

The Global IPM Facility, Community IPM Program, and Agricultural Conversion 2015 Initiative

The Global IPM Facility (GIPMF) hosted by the FAO intends to be the world leader in developing implementation, experimentation, and policy research in country farmer IPM. Their experience derives from 15 years of IPM experimentation and implementation through the Community IPM Program (CIPMP) in Southeast Asia. It is now active in 30 countries in Africa, Asia, Latin America and the Middle East, and works with all major crop categories. To learn more, see http://www.fao.org/ag/AGP/AGPP/IPM/gipmf/index.htm. Consult GIPMF for assistance with planning or designing an IPM or crop production program, and use their experts to help design and implement your program. They promote South-South collaboration as much as possible and employ trained Africans to train African farmers.

Both the CIPMP and GIPMF use training approaches based on farmer empowerment, farmer field schools, and knowledge-based and discovery learning. In these field schools, communities of farmers are taught to observe and record the daily interactions between the soil, their crop and other organisms. Then, they discuss and design strategies to manage their soil health, crops, beneficial insects and spiders, and pests. With this approach, farmers are the experts, and they become expert trainers.

Farmers in these programs regularly maximize yield while minimizing financial cost, serious health risks, and environmental damage. Lead farmers among these groups even conduct their own experiments, comparing their fields managed using IPM to fields managed with typical pesticide-spraying schemes. IPM-trained farmers, who often further refine their techniques through experimentation, generally succeed in drastically decreasing pesticide use while increasing profits. More than two million farmers in Asia alone have graduated from these community-based farmer field schools since 1990.

In Africa, the CIPMP and new, broadened GIPMF Integrated Production and Pest Management (IPPM) approaches have been pilot-tested and used in 10 African countries, including Burkina Faso, Congo, Ghana, Kenya, Malawi, Mali, Senegal, Tanzania, Uganda and Zimbabwe. They are now being spread to other countries.

The GIPMF is now proposing a bold new approach called AC 2015 (Agricultural Conversion 2015: Detoxifying Pest Management). This sets distinct five-year targets to phase out the most hazardous pesticides first, followed by decreasingly hazardous (though still quite harmful) compounds, while phasing in rounds of new bio-intensive, risk-reducing technologies, methods and policies, through 2015.

Where can one gain access to the types of new technologies that may be phased in as pesticides are phased out? One Web site alone (www.agrobiologicals.com) provides access to a surprising list of over 2,600 companies currently marketing 470 new "green industry" technologies and products designed for low or no impact on human health or the environment. According to EPA, at the end of 2001, there were approximately 195 EPA-registered biopesticide active ingredients and 780 products. As an unintended bonus, many of these new green technologies also augment soil fertility and biodiversity, thus enhancing sustainability. While most of these green technologies target developed countries, it is only a matter of time before developing countries access them. What's more, food security crops are benefiting from this revolution as well.

World Bank IPM Initiatives

The World Bank has a statement in support of IPM and is committed to supporting IPM in client countries through lending and non-lending activities. Find their IPM statement at http://lnweb18.worldbank.org/ESSD/essdext.nsf/26ByDocName/CropsIPMPestControl .

Systemwide Program on IPM (SPIPM)

The primary goal of the SPIPM initiative (http://www.spipm.cgiar.org/) by the Consultative Group on International Agricultural Research (CGIAR) is to contribute to sustainable agricultural development by enhancing the effectiveness of IPM research at the CGIAR's international agricultural research centers (IARCs). This program seeks to encourage better communication and closer coordination among the centers and their partners, the development and adoption of more effective, client-oriented approaches to IPM, and a broader awareness of the benefits of IPM, leading to a policy environment more favorable to its widespread implementation (see Walker 2001).

The centers' most visible successes in IPM include their biological control programs for cassava mealybug and green mites in Africa. Pest management projects (some planned and some implemented) include the following:

- Whitefly and mosaic virus IPM (CIAT)
- Development of farmer participatory methods (CIAT)
- Control of cereal stem borers (CIMMYT)
- Grain legume pest IPM (ICRISAT)
- IPM for nematodes (ICRISAT)
- Management of parasitic plants (*Striga* and *Orobanche*) (IITA)
- Development of microbial pesticides (IITA)
- Weed management in rice (WARDA)
- IPM for soil-borne plant pathogens (ICARDA)
- Analysis of agro-ecosystem diversity and IPM (ICIPE)
- New approaches to loss assessment (Lead center: IRRI)

World Health Organization Africa Regional Office (WHO-AFRO)

The World Health Organization (WHO) (www.whoafr.org) takes the lead on integrated disease surveillance and management for developing countries in Africa. WHO provides integrated vector management initiatives, along with research, publications, international coordination, training, outreach, and inoculations.

Consortium for International Crop Protection (CICP)

The CICP (http://www.ipmnet.org/), a non-profit organization, was formed in 1978 by a group of U.S. universities, led by the University of California. Its principal purpose is to help developing nations reduce food crop losses caused by pests while also safeguarding the environment. CICP's basic goal is to advance economically efficient and environmentally sound protection practices in developing countries and to ensure the health of rural and urban communities. CICP is now headquartered at Oregon State University's Integrated Pest Protection Center.

CICP publishes a useful monthly electronic newsletter, *IPMnet News* (IPMnet@bcc.orst.edu). It provides timely information on IPM for all pests, including latest developments, publications and CDs, important research articles, commentary, Web sites, videos, equipment, materials and services, important policies, and an IPM calendar of upcoming important events across the globe.

Pesticide Action Network International and PAN Africa

The Pesticide Action Network (PAN) International, found at http://www.pan-international.org/, is a network of over 600 participating NGOs, institutions and individuals in over 60 countries working to replace the use of hazardous pesticides with ecologically sound alternatives. Its projects and campaigns are coordinated by five autonomous regional centers. Their Web site provides lists of pesticides to be avoided, USEPA information, and alternatives to toxic pesticides.

The PAN Regional Center for Africa, established in Dakar (Senegal) in May 1996, is coordinated by PAN Africa, http://www.pan-africa.sn. PAN Africa involves volunteers, NGOs, farmers, organizations, institutes, universities and individuals who support the adoption of sound ecological practices in place of dangerous chemical pesticide use all around the world. It publishes three issues per year of *Pesticides & Alternatives*, a newsletter on pesticide news, alternatives to chemicals, and IPM as well as sustainable agriculture.

CAB International Biosciences Crop Protection

The United Kingdom formed CAB in 1913 to support agricultural scientists in what were at the time British colonies. This group of experts identified insects found on crops grown overseas and provided scientific information and technical assistance for their management. In 1985 CABI became fully international, and its services became widely used by other countries working in development. CABI's publishing division produces some of the leading information on IPM in developing countries. The CABI *Crop Protection Compendium* on CD is widely used by IPM professionals worldwide. To use CABI's resources, visit www.cabi.org.

Regional Partners and Initiatives

In Africa, as elsewhere in the world, there are regional networks that deal with pest problems and research initiatives. For migratory pest control, there is the Desert Locust Control Organization for East and Central Africa, the International Red Locust Control Organization for East and Southern Africa, and the Maghreb Task Force for Northern Africa. Most of the international agriculture research centers discussed above also have regional research initiatives to deal with common constraints to production of specific crops. In addition, the Southern Africa Development Corporation (SADC), based in Harare, has regional oversight for agricultural production constraints, IPM, and trade. The African Development Bank, most donors (especially Germany's GTZ), and many NGOs also have regional initiatives. Check for these on the Web, by searching for regional IPM initiatives in Africa.

USAID Pest and Pesticide Management Initiatives, Resources, and Programs in the Developing World

Pesticide Evaluation Report and Safer Use Action Plans (PERSUAPS)

USAID Africa Bureau uses a relatively new concept for permitting safer pesticide use with development funds, while maintaining a reasonable level of control over pesticide choice and use. Targeted studies or evaluations during project or activity design produce documents called PERSUAPS (http://www.encapafrica.org/sectors/pestmgmt.htm). These are produced by or for NGO/PVO and USAID country programs or activities that wish to use pesticides for projects. They accompany an Initial Environmental Assessment (IEE) from USAID, address key USAID regulatory requirements, and emphasize the use of the lowest-risk compounds.

The PERSUAPs focus on the particular circumstances of the programs in question, are locally adapted, outline the risk management choices available, and recommend how a risk management plan would be implemented in the field. Local-level PERSUAPS are needed because many farmers and pesticide users in Africa cannot be expected to act in the same ways as users in the United States, where all of the USEPA's safer-use regulations are formulated and enforced. Literacy rates are much lower, thus most users cannot read labels; most farmers/users do not use safety equipment; regulations are generally not enforced; inappropriate pesticides or formulations are widely used; users often do not know how to properly calibrate or use sprayers safely, leading to gross and dangerous over-applications. PERSUAPS are intended to resolve and prevent many of these risks.

IPM Collaborative Research Support Program (CRSP)

Through the Center for Economic Growth and Agricultural Development in the Global Bureau, USAID supports several agricultural research programs with pest management components. The primary program on agricultural pest control is the Integrated Pest Management Collaborative Research Support Program (IPM CRSP) (http://www.ag.vt.edu/ipmcrsp/). Funded at around $2 million per year, the IPM CRSP is active in seven countries around the world, including Mali and Uganda in Africa. The CRSP's purposes are to develop and implement a replicable approach to IPM that will help reduce agricultural losses due to pests, damage to national ecosystems, and contamination of food and water supplies.

Other CRSPs support pest management activities related to specific commodities. The Peanut CRSP includes two plant breeding projects focused on producing disease- and insect-resistant cultivars. The INSORMIL CRSP supports plant breeding projects developing sorghum varieties resistant to the parasitic plant *Striga*. While not directly involved in pest management, the Soils CRSP at Montana State University (discussed below) is collaborating with the IPM CRSP on a modeling project in Ecuador that incorporates pest management parameters.

Integrated Vertebrate Pest Management Initiatives at USAID

Through the Denver Wildlife Research Center, now the National Wildlife Research Center or NWRC (www.aphis.usda.gov/ws/nwrc), USAID began supporting a vertebrate pest research and management project in 1967. Historically, the agricultural damage wreaked by vertebrate pests has been overshadowed by the public health risks associated with them, such as outbreaks of leptospirosis, salmonellosis, West Nile fever, hantavirus, Q fever, and bubonic plague. These pests, however, cause not only loss of farm yield, but also loss of inputs such as labor, fertilizer, pesticides, water, harvesting, and processing, leading to sectorwide economic damage.

Many African ministries of agriculture (MOAs) also focus on control of birds, primarily Quelea birds. These birds can come in plague proportions and can, at times, be extremely destructive to grain crops such as rice, maize, millet and sorghum.

Integrated Vector Management (IVM) Initiatives at USAID

USAID's Global Health Bureau (http://www.usaid.gov/our_work/global_health/) provides program support to several malaria control projects, primarily in Africa. Its insecticide-treated bednet (ITN) program is the largest management element of USAID's malaria control efforts. The ITN program supports a number of individual NGO/PVO projects as well as the NetMark project, an Africa regional project to promote the use of ITNs through collaboration with the commercial sector. This program provides technical assistance for community-based malaria prevention as well as the materials for bednets.

To promote judicious use of pesticides, USAID participates in the WHO Pesticide Evaluation Scheme task force. USAID also gives technical support to strengthen national programs to control malaria and other vector-borne diseases through surveillance, operations research, monitoring and evaluation, and more strategic collaboration with the manufacturers and distributors of public health pesticides. USAID also works closely with WHO on the global Roll Back Malaria initiative.

Integrated Ectoparasite Management

Ectoparasites are generally arthropods (insects, ticks and mites) that live on the surface of other animals. In African countries, development program managers will likely encounter ectoparasite problems on cattle, sheep, camels, goats, horses and other livestock and farm animals. Tick dips using pesticides are routinely used in pastoral communities such as those in Eritrea, Ethiopia, and the Sahel. Contact the International Livestock Research Center (http://www.cgiar.org/ilri/) to learn more about integrated ectoparasite management.

Migratory Plague Pest Species

Numerous species of animals become pests irregularly and then in massive quantities. The desert locust is probably the best known of this group. Other pests, such as the red locust, brown locust, migratory locust, tree locusts, armyworms, rodents, Quelea birds, and several species of grasshoppers, are capable of substantial outbreaks and plagues. In non-plague years, these pests are present in levels that do not cause concern, but when their numbers increase rapidly, during a plague, their effects can be devastating for some unlucky farmers. Control of these pests is generally attempted by farmers using indigenous knowledge. However, often the plagues build and move too fast and farmers require assistance. African MOAs are generally well versed in the management of these pests, but often require international support and coordination.

FAO maintains an African program, the Emergency Prevention System or EMPRES (www.fao.org/EMPRES), to coordinate MOAs' efforts in emergency pest management with those of the donors and regional organizations. Most European donors, including the European Union, cooperate in this program. The African Development Bank and several regional organizations, such as the Desert Locust Control Organization (DLCO), assist as well.

Conceived in 1987, USAID's AELGA (Assistance for Emergency Locust and Grasshopper Abatement) project pursues activities including environmental assessments, emergency assessments, bilateral train-the-trainer farmer training, regional training, research into novel IPM tactics, coordination with FAO, outreach, and obsolete pesticide disposal. Contact AELGA (see http://www.aelga.net/) if a plague appears imminent or if large quantities of dangerous old pesticides are located.

Issues Impacting International Pest and Pesticide Management Initiatives

Biotechnology and Genetically Modified Organisms (GMO) for Pathogen and Insect Resistance

Genetic engineering may offer new pest management tools, particularly through the existing model of host plant resistance. Transgenic crop plants exhibiting resistance to particular plant pathogens or insect pests are under development for a wide range of crops, including several important staple crops such as rice and cassava. Use of these new varieties may allow higher yields and/or drastic cuts in pesticide use, with attendant economic, health and environmental benefits.

However, potential benefits must be weighed against a range of problems. These include possible ecological impacts (e.g., harm to non-target species, creation of novel invasive weeds), lack of consumer acceptance, and uncertainties regarding access to seeds and seed saving.

In addition, there is great concern among experts that some transgenic crops will rapidly select for resistance in the target pest population. A GMO technology that increases yields dramatically for several years and then collapses due to the pest evolving to overcome the crop's genetic protection will not serve a long-term goal of reducing yield instability. Therefore, resistance management strategies appropriate to developing countries are essential to realize the potential benefits of Bt crops. One source of information and a site that rates biotech products is http://www.biotech-info.net/.

Invasive species

Non-native species may be introduced into countries on purpose, with the idea of cultivating or breeding them there, or by accident. Often, unfortunately, in the absence of their native natural enemies, the populations of these foreign species grow unregulated, and they may become new pests. Developing countries generally have neither the resources nor the technical talent to manage invasive species. Invasive species may also become barriers to trade with non-infested countries.

Trade Opportunities in Organic and Reduced Residue Products

Most agricultural development programs starting up in Africa and elsewhere now aim not only to increase the production and quality of food security crops, but also to grow crops that can be traded. Moreover, they clearly recognize and encourage the use of green and bio-intensive technologies**.** Worldwide, organic and ecological farming, begun in response to dangerous pesticide use and unwise soil management practices, has blossomed into a multi-billion-dollar mainstream business.

Factors that drive people to adopt sustainable practices include concern for the land and long-term nutrient cycling; consumer demand for environmentally sound practices; competitive advantages; cost reduction; and compliance with regulations. While laws affecting environmental and human health conditions have become stricter, the costs, risks and liabilities of pesticide use have increased. Green practices often help reduce these costs.

New, cutting-edge technologies include resistant crop varieties; pest predators, parasites, pathogens, antagonists and their enhancers; baited traps; pheromones for monitoring, mass elimination, and mating disruption; genetic techniques that cause natural populations to crash; botanical compounds; light oils, soaps, and various fatty acid compounds for arthropods and fungi; and many others. These types of technologies are opening new possibilities for trade in organic produce and other high-value clean plant products with developed countries, especially those in the European Union.

Cut flowers, green beans, vanilla, mangoes, peanuts, cassava, tomatoes, cabbage, plantain, tea, coffee, cocoa, and soybean are but a few well-known examples. Food security crops like maize, rice, millets, sorghum, and cowpea are benefiting from these programs, as well as from the new revolution in genetically modified organisms (see above). Ghana, Kenya, and South Africa, the regional economic engines for growth in Africa, are vigorously using and promoting green technologies, gaining access to lucrative overseas markets in the process.

One of the main obstacles to success is the continued influence of the old, chemical-intensive model of agriculture. The other is lack of information. It is important for projects to consider the possible niche markets for green products in developing IPM programs. GMO uses and cautions are discussed earlier in this section.

Valuable Indigenous Green Technologies

Ecologically based integrated production and pest management techniques were and are used in many indigenous and traditional agricultural systems. Many of these techniques are specially adapted to the unique environments in which they have been developed, and they focus on preventing pests before they reach damaging levels. It is important that programs not try to replace all of these valuable techniques with new ones. Rather, these centuries-old techniques should be carefully integrated with new ones, since many of the principles used in traditional systems remain relevant to this day. For example, soil biological activity and the resulting rich nutrient cycling are of primary importance to these traditional processes, yet they are often wiped out with pesticide use, necessitating additional costly inputs.

International Codes of Practice in the Horticulture Industry Governing ISO 14000 standards

Several groups, including some UN bodies and the International Development Research Center (IDRC), are working in East and Southern Africa on horticulture, floriculture and organic foods products and growers. They are using and implementing International Organization for Standardization (ISO) sets of environmental management standards and rules (ISO 14000) critical to facilitating trade. The standards focus on social and environmental standards, as well as standard economic factors. Specifically, they address sanitary and phytosanitary (SPS) issues, such as regulations on pesticide applications that maintain maximum pesticide residue levels for trade with EU countries. They also address organic standards, certification, and institutional support for international trade. The UN groups and IDRC work to sensitize growers to these SPS issues and provide ready access to information needed for trade. Projects that link to these resources will be on the leading edge of organic and green production trade with Africa.

Botanical Pesticide Use

While some farmers in Africa use relatively safe botanical pesticides, most could use more (for a list of botanical pesticides regulated and registered by the USEPA, see the "Safer Pesticide Use" chapter of these guidelines). To date, NGOs and PVOs have been testing the efficacy of the botanical pesticides, but have lacked the means to test their toxicities. They could put together advisory panels composed of staff from academic institutions or the CGIAR centers to develop screening mechanisms or tests, review traditional uses, and related plants. USDA's Agriculture Marketing Service is looking into botanical pesticides for certification to use in organic agriculture in the United States. In addition, such a group could provide suggestions for mitigating potentially hazardous effects.

EPA has two documents on botanicals: one on the definition of biochemical pesticides and a list of biochemical active ingredients; and the other a list of active and inert ingredients that are exempt from FIFRA. They can be found on the EPA Web site. The Board on Science and Technology for International Development (BOSTID) has an excellent collection of publications (for example, booklets on uses and toxicity of neem tree extracts) already in use, and might therefore be interested in disseminating any materials that are developed.

Push-Pull Strategies for Managing Stem Borers and *Striga* in Maize Farming Systems in Eastern Africa

Stem borers and parasitic weeds are two major constraints to increased maize production in East Africa, creating yield losses of 20–40 percent and 30–100 percent respectively. Both are difficult to prevent, and chemical control is impractical for resource-poor farmers, most of whom are women. Recently, a novel bio-intensive technique called "push-pull" was developed by ICIPE (the International Center for Insect Physiology and Ecology, at http://www.icipe.org/icipe/index.shtml), in collaboration with the Kenya Agricultural Research Institute (KARI), the Kenyan Ministry of Agriculture, and the UK's Institute of Arable Crops Research, with support from the Gatsby Charitable Trust.

The strategy involves trapping stem borers by luring them to highly attractive trap plants at field edges ("pull"), while driving them away from the center of the maize field using repellent intercropped plants ("push"). Planted on the field edges, both Napier grass and Sudan grass attract (pull) stem borers. The grasses produce a gummy substance that traps and holds the stem borers there so that they cannot enter the maize field. Both grasses can also serve as fodder.

Meanwhile, silver leaf *Desmodium* legume and molasses grass intercropped in the middle of the maize fields repel stem borers. The *Desmodium* also binds nitrogen, helps soil retain moisture and prevents erosion, and can likewise be sold for fodder. But the most exciting result of using the *Desmodium* is that it also suppresses the growth of *Striga* parasitic weeds by a factor of 40 percent. In addition, farmers are now growing dairy cattle on the *Desmodium*, which gives them extra income. These techniques are now being adapted and extended to Ethiopia, Tanzania, Uganda, Malawi and South Africa.

Economic Tradeoffs Between Agricultural Production and the Environmental Impacts of Agriculture

Economic tradeoffs between agricultural production and the resulting environmental impacts of agriculture have traditionally been difficult to ascertain. Now, Montana State University's "Tradeoffs" project, operated by the USAID Soil Management CRSP, has developed a decision support system (DSS) for assessing these tradeoffs in such areas as pesticide leaching, erosion and soil fertility decrease (see http://www.tradeoffs.montana.edu/ for details). Results of ongoing studies in Senegal and Kenya may be helpful to planning IPM programs in Africa.

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Internet Sites for Information on Pesticides and Pest Management

There are hundreds of Internet sites that provide information about pesticides and pest management. Not all are equally reliable or useful. National and international regulatory agencies are the best source of information about pesticides. Some of the best sites on IPM are sponsored by universities and international and national agencies with mandates to promote IPM. Below are sites identified by CARE (2003) as particularly useful and stable sites; many offer links to other sites. They are ranked:

*****	Not to be missed
****	Highly recommended
***	Very useful

Pesticides

http://www.who.int/ipcs/en/ This World Health Organization site includes The International Programme on Chemical Safety. The most authoritative site on human health effects of pesticides. Not all documents are online yet, but the WHO Recommended Classification is one of the most cited sources of acute toxicity information. *****

http://www.epa.gov/pesticides/ The U.S. Environmental Protection Agency's site on pesticides is a goldmine of information. Thousands of technical documents are available online, including the March 2000 edition of "Status of Chemicals in Special Review." *****

http://www.chem.unep.ch/irptc/ The joint UNEP and WHO site. A wealth of authoritative information on many international programs and agreements, such as PIC and POPs. *****

http://extoxnet.orst.edu/ EXTOXNET: The Extension Toxicology Network. An excellent source if you're looking for information by substance. ****

http://www.fao.org/documents/show_cdr.asp?url_file=/docrep/V8966E/V8966E00.htm For information on *Pesticide Storage and Stock Control Manual*. FAO.***

http://www.fao.org/ag/AGP/AGPP/Pesticid/Code/Download/label.doc See *Guidelines on Good Labeling Practice for Pesticides.* FAO.***

http://www.fao.org/documents/show_cdr.asp?url_file=/docrep/006/Y2766E/Y2766E00.HTM See *Good Practice for Ground and Aerial Applications of Pesticides* (1988). Food and Agriculture Organization of the United Nations. **

http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGP/AGPP/Pesticid/Code/Download/protect.doc *Guidelines for Personal Protection When Working with Pesticides in Tropical Climates* (1990). Food and Agriculture Organization of the United Nations, Rome. ****

- http://www.inchem.org/documents/pds/pdsother/class.pdf Pesticides in WHO class Ia and Ib: do not use chemicals in this list*****
- http://www.pic.int/en/Table7.htm Prior Informed Consent (PIC) list: do not use chemicals in this list*****
- http://www.chem.unep.ch/pops/alts02.html Persistent Organic Pollutants (POPs) Convention list: do not use chemicals in this list.*****

http://www.epa.gov/oppsrrd1/docs/sr00status.pdf To determine status of Chemicals in Special Review, to see if any of the chemicals you propose using are being reviewed for safety reasons*****

http://www.codexalimentarius.net/ For the United Nations CODEX pesticide residue limits for food and trade.****

http://www.ovid.com/site/catalog/DataBase/132.jsp?top=2&mid=3&bottom=7&subsection=10 PEST-BANK information. A guide to ordering information from two databanks covering all of the approximately 27,500 currently registered U.S. pesticides used in agriculture, industry, and general commerce as well as details on about 40,000 cancelled products.****

http://www.epa.gov/pesticides/safety/healthcare/handbook/handbook.htm For a pesticide poisoning handbook.*****

http://www.epa.gov/pesticides/ For U.S. Code of Federal Regulations, labels, restricted-use pesticides, etc. A guide to pesticides and those that are currently restricted, cancelled, and suspended for use in the United States. ****

http://www.epa.gov/pesticides/biopesticides/ For biological pesticide regulations. A list of biological pesticides currently registered for use in the USA. Includes lists of products that may replace synthetic pesticides if organic or 'green technology' choices are sought.*****

Pest Management

Thrupp, L.A (2002). Fruits of Progress: Growing sustainable farming and food systems. World Resources Institute. 85pp. Up-to-date information on organic and green technology advances, with case studies from U.S. producers using these techniques. Order at: http://www.ecampus.com/book/1569734720 *****

UC-Davis (2001). IPM in Practice: Principles and Methods of Integrated Pest Management. Publication 3418. Great source for the IPM professional and novice alike. Order at: http://www.ipm.ucdavis.edu/IPMPROJECT/ADS/manual_ipminpractice.html *****

http://www.communityipm.org/ An excellent source of information on the FAO Asia "Farmers' Field School" methodology. Many interesting and valuable downloadable documents. *****

http://ipmworld.umn.edu/ Radcliffe's IPM World Textbook. A great resource text constantly updated and improved. Excellent for students, teachers, extensionists who want a concise presentation of thematic areas or of the state of the art in IPM by crop. *****

http://www.ipmnet.org/ A very good portal to a host of IPM resources, including a searchable database of IPM resources, Radcliffe's IPM World Textbook, periodicals including back issues of IPMnet News, reviews of recent publications, a searchable database of IPM experts and more. Very well organized. Sponsored by the Consortium for International Crop Protection. *****

http://www.nysaes.cornell.edu/ent/biocontrol/ Biological Control: A Guide on Natural Enemies in North America. An excellent guide to natural enemies. Limited geographically, but great photos and summary of biology and ecology. ****

http://www.ipm.ucdavis.edu/PMG/crops-agriculture.html The University of California Pest Management Guide. Very complete and useful guides by crop. Some a bit dated. ****

http://www.epa.gov/oppfead1/pmreg/ U.S. EPA Pesticide Management Resource Guide. A guide to pesticide information resources at EPA and elsewhere designed to help national pesticide authorities find information for use in pesticide management decision-making. ***

http://www.who.int/heli/risks/vectors/vectordirectory/en/index3.html World Health Organization guidelines for disease vector management.****

Chapter 13
Pest Management II: Safer Pesticide Use

Contents

Introduction	13-1
Pest Management Issues in Africa	13-3
USAID's Pesticide Procedures	13-9
Planning and Preparing for Pest Management Operations	13-22
Pesticide Use: The Practical Context	13-25
Calibration, Product Quantity, and Pesticide Application	13-34
Toxicity, Human Protection and First Aid	13-40
References and Resources	13-49
Annexes: Pesticide Use Checklist and Measurement Conversions	13-51

While pesticides usually succeed in their main purpose—killing pests—they should be used as a tool of last resort because of their unintended effects on health and environment. The "safer pesticide use" approach advocates considering, testing and integrating all options for pest management.

Introduction: "Safe Use" versus "Safer Use"

The "safe pesticide use" paradigm, particularly as promoted by the agrochemicals industry, has been a common approach in attempting to mitigate the health problems caused by pesticides. All too often, however, "safe use" fails to emphasize the array of pest management choices available to farmers—choices that include pesticides, but are not limited to them. Rather, the approach focuses only on pesticide-related matters, such as pesticide selection, new and correct application technologies and methodologies, registration issues, and use of personal protective equipment such as masks and protective clothing.[1] As a result, many stakeholders,

[1] The latter, ironically, are too expensive for most resource-poor farmers and are intolerably hot and uncomfortable under tropical conditions.

whatever their degree of education, see pesticides as the crop protection method of choice—a “silver bullet”—when, in fact, there may be many less toxic alternatives that are never even considered.

Protective Equipment: A Mixed Blessing?

Protective clothes and masks are commonly promoted as part of safe pesticide use.
But too often they fail to help, because:

- They are too costly for most African farmers to buy;
- They are often too hot to wear in tropical climates;
- When worn, they often accumulate pesticides because they are not thoroughly washed between uses, thus exposing the wearer to *more* toxins.

In reality, overwhelming evidence from around the developing world shows that “safe pesticide use” programs are not especially successful. This is true whether studies measure people’s adoption of safety gear and practices or their rates of exposure. Particularly disturbing is the paradoxical fact that the use of protective equipment often *increases* people’s exposure to pesticides. Poor user habits (due to lack of water, soap and initiative) allow pesticides to accumulate in protective clothing and masks. Users are then subject to more exposure and higher doses with every “safety equipment” use.

The new focus on “safer pesticide use” promotes the principle that all options for pest management should be considered, tested and integrated into strategies for sustainable and environmentally sound crop production. A longer-term view of production and pest prevention is favored over the short-term, reactive view. The strategy that provides farmers with the most choices is **integrated pest management (IPM).** Pesticides are not excluded from this equation: they are considered as yet another option or tool to be used, especially in short-term or emergency situations, but usually not as the primary (or only) focus. IPM recognizes that pesticides usually succeed in their main purpose—killing pests—but maintains that they should be a tool of last resort because of all their unintended effects on health and environment. The challenge is to maximize their effectiveness when they do have to be used, while reducing the risks of damage to human and environmental health as much as possible.

This chapter provides guidance on maximizing the safety of pesticide use when such use is unavoidable. But no pesticide use should be considered before preventive and alternative measures have been examined and, where possible, adopted. It is in this light that USAID’s pesticide procedures were formulated. Before analyzing the risks and benefits of pesticide use, the procedures specify that project planners must (1) consider all reasonable IPM alternatives, and (2) describe all measures to be taken.

Smallholder versus Larger-Holder Farmers

The information contained in this chapter is applicable to groups working with farmers in Africa. However, there are several different types of farmers, reflecting the size and intensity of their farms as well as the farmers’ education and training levels. The conditions for working with them may vary greatly.

Smallholder farmers—roughly speaking, those with 5 hectares or fewer—may have less training, use more diverse cropping systems, and be less familiar with pesticide use. Moreover, their goals often differ from those of larger-holder farmers. They may be producing for subsistence as well as for limited local market sales to generate income, and they may have less money to buy pesticides.

Larger-holder farmers may aim to sell their produce in local, regional and international markets, depending on the size of their land holdings, so they may be able to afford to buy pesticides. If they sell in international markets, however, their use of pesticides may be limited by residue restrictions. And although they are often better trained or educated, and thus more likely to understand the constraints and dangers of pesticide use, they may not transfer this knowledge to their hired farm laborers who may use pesticides.

A program aimed at improving crop production will need to define the types of producers encountered and the methods for working with each of them, depending on their knowledge and goals.

Pest Management Needs

Problem areas where pesticides might be applied according to safer pesticide use principles:

- Protecting both growing and stored crops from pests.
- Managing emergency migratory pest outbreaks.
- Protecting high-value and export crops from pests.
- Protecting livestock from parasites and insect infestation.
- Managing human disease vectors such as mosquitoes.

Pest Management Issues in Africa

African villagers and farmers are bombarded by pests, ranging from those that feast on their crops in the field to those that infest crops in storage, and from parasites and disease vectors affecting livestock to vectors of human diseases. More sporadic, but highly devastating, are massive pest plagues. This section briefly addresses these disparate but related issues.

Agricultural Crop Protection. In the field, legumes such as peanut and cowpea are attacked by insects that bore into pods, chew leaves, and roll and mine stems. Maize is attacked by stem-boring moth larvae that cause stems to lodge young stalk-cutting insects like armyworms, while ears are eaten by moth larvae known as earworms. Aphids, mealybugs and leafhoppers suck sap from all plants and transmit debilitating diseases to them. Grasshoppers eat almost every species of plant, chewing leaves, stems and seed heads completely. Cucumber beetles and squash bugs attack various melons and squashes, damaging the fruit and spreading plant diseases. Beetle larvae, called white grubs, and wire worms in the soil attack plant roots, weakening the plants, and chew holes through tubers like potatoes, yams and cassava. Millets and sorghum seed heads are attacked by blister beetle larvae and birds. Mammals such as elephants, monkeys, baboons, and rodents can also cause devastating losses under certain circumstances.

Africans who do use pesticides on their crops most often apply them with hand-pumped backpack sprayers, with ultra low volume (ULV) sprayers, or by hand, using powder formulations. These sprayers may be purchased individually by larger holders or shared through smallholder farmer cooperatives. Unless development projects are paying, there is generally no larger pesticide equipment, such as motorized backpack or truck-mounted sprayers: these are far too costly for most smallholder and even larger-holder farmers to buy and maintain.

Most farmers do not use safety equipment or gloves when applying these pesticides. Even if they do, toxic residues remain from previous sprayings because they have too little water for cleaning and lack cautionary training. They also usually do not know how to calibrate (adjust) the sprayers correctly so they will apply the right amount of pesticide. As a result, they often apply too much, wasting the pesticide and increasing the danger to humans and the environment.

Project managers should be alert to ways they can help clients to access lucrative overseas markets for organic and other high-quality crops—if they can eliminate pesticides and their residues.

In addition, backpack sprayers leak in various places—at the top loading end of the tank; where the outlet hose is connected; along the hose, especially where the hand-operated flow regulator attaches; and from the nozzle. Pesticides spill down the sides of the tank when filling and mixing and are not wiped off. If any of these leak or spill sources are not mitigated, and bare skin or clothing is exposed to the concentrated pesticide, the farmer will be poisoned.

The accompanying chapter on IPM contains lists of techniques and resources for controlling pests with few or no pesticides; this chapter contains lists of both chemical pesticides and botanical pesticides that may work to regulate pests by repelling or killing them. Projects should try to combine several techniques, in an integrated way, for optimal pest management at reduced cost and

Pesticides are sometimes necessary to maximize agriculture production or protect stored food. But they should always be handled with care.

risk. Experimenting with the “push-pull” technologies described in the IPM chapter should yield very useful pest management approaches. Project managers should not forget about opportunities for their clients to sell organic and lucrative overseas markets, if they can find ways to eliminate pesticides and their residues.

Stored Commodity Pest Management. Once crops are out of the field, they still are not safe. In storage and processing or during shipment a number of (often very tiny) beetle, weevil, and moth larvae, roaches, termites, ants, silverfish and mites feed on the grain, seed and processed products, causing losses of up to 100 percent. Rodents such as rats, gerbils and mice may not only eat much of the goods, but also compromise the rest by urinating on and defecating in the seed or product, thereby affecting quality and potentially transmitting deadly diseases to humans. Many beetle and moth larvae and mites enter the grain in the field and are brought into the storage within the grain.

Unfortunately, many farmers do nothing about the threat and find their granary filled with grain dust because the pests have chewed through it. Yet there are a number of ways to confront the pest problem. Cleanliness, reduction of moisture, and carrying over fewer materials from year to year help to reduce all stored product pests. Storage areas can be cleaned with a mixture of lye, water, and miscible (emulsifiable) oil. To deal with pests that infest stored grain, many smallholder farmers put pest-repelling plant parts like tobacco or neem leaves in with the grain. Larger-holder farmers may use pesticidal powders or toxic baits to repel and kill pests in storage. (Care must be taken so that children and pets to do not come into contact with toxic baits such as rat poison.) Some farmers have cats to control rodents. If farmers in a cooperative have enough resources, they may fumigate communal granaries with a toxic gas (“bug bomb”). Residual-spray pyrethrins also reduce insect pests. Heating (when outside temperatures are very high) and cooling techniques can also be used to kill pests if storage areas are relatively airtight. Botanical repellents, listed in Table 4 later in this chapter, may also be used to keep pests out of storage areas.

Defenses Against Pests in Storage Areas

- Keeping the area clean and keeping moisture low
- Carrying over fewer materials from year to year
- Putting pest-repelling plant parts or processed botanical repellents in with the grain
- Keeping cats
- Using pesticidal powders or toxic sprays
- Fumigating with toxic gas or pyrethrins
- Heating or cooling airtight storage areas

Emergency Migratory Pest Management. Migratory pests, whose populations may build rapidly into overwhelming plagues, can cause severe damage to the crops of unlucky farmers in their path. This does not occur every year, however. Most plagues, though unpredictable, strike in 3- to 10-year cycles. Moreover, they closely track sudden environmental changes, such as exceptionally rainy periods following several years of drought.

Migratory pests in Africa include several species of locust (desert, red, brown, migratory and tree), armyworms, rodents, grain-eating quelea birds, and several species of grasshopper. Desert locusts and certain species of grasshopper feed on most crops and plants; red and migratory locusts and armyworms feed on grasses and grain crops; and rodents and quelea birds feed primarily on grains.

Smallholder farmers generally try to manage these pests using indigenous techniques, such as trenching or beating with sticks, usually with little effect. Most ministries of agriculture (MOAs) are equipped to help farmers to manage migratory and outbreak pests. However, larger-holder farmers, who have more political clout and more crops at stake, tend to receive more attention and resources.

When outbreaks do occur, MOAs take charge of the situation and donate government resources, such as pesticides, to farmers. In addition, other ministries, such as the ministries of forestry and the environment, may be tapped for staff and vehicles to help out with monitoring and plague control. MOAs often request assistance from international, regional and bilateral sources, such as the United Nations Food and Agriculture Organization (FAO), the regional desert locust control organization, and such donors as USAID.

If enough resources are located, truck- and aircraft-mounted pesticide sprayers may be enlisted for locust, armyworm and grasshopper control. Farmers are often lent motorized backpack sprayers, ULV sprayers and safety equipment to spray their own fields. For rodent control, farmers may be given poisons to use. Unfortunately, these poisons are often intercepted by children, household animals and other non-target beneficial wildlife. Quelea bird control is even more problematic, being accomplished by controversial pesticides that are toxic to all bird species and/or by dynamite; thus most donors do not support it.

Protecting people and the environment during a pest plague

Competing interests may overstate crop losses and call for using too much pesticide—or the wrong kind. It is critical to:

- Ensure honest crop loss assessments
- Set "no pesticide" boundaries around villages, waterways and national parks
- Set up pre- and post-spraying environmental monitoring
- Continuously test pesticide users for overexposure

Expect to put many regular crop protection activities on hold if a pest plague occurs, because it will capture all of the affected country's attention, along with that of neighbor and donor countries, and many farmers will be concerned only with rapid crop protection. Further, many IPM schemes may temporarily fall by the wayside.

The human health and environmental concerns listed above, and more besides, become acute during a big plague control campaign. The difficulties may increase because of the chaotic nature of control campaigns and the competing interests trying to get a piece of the quick, and often very lucrative, action. Rival pesticide vendors and many different so-called experts with differing interests add to the cacophony. Often the wrong pesticides or formulations are sold, unknowingly and knowingly.

To forestall these problems, villages, waterways and national parks must have "no pesticide use" boundaries around them, and pesticide users must have continuous blood tests for pesticide overexposure. Environmental monitoring should be set up immediately to plan and carry out pre- and post-spraying testing. IPM-focused activities in the field can help with all the human health and environmental needs that arise during a control campaign, as well as the need for honest assessment of crops that have already been lost.

Pest Management for High-Value and Export Crops. High-value and export crops, like vegetables, fruits, fresh plants, ornamentals and flowers, spices, cacao, vanilla, cashew, cotton, sisal, tobacco, coffee and tea, are generally grown by larger-holder or commercial farmers. These are also menaced by a long list of pests. Thrips, aphids and whiteflies attack flowers and ornamental plants. Fruit flies can devastate mangoes and other tropical fruits. Pod-boring larvae attack vanilla and cacao pods. Spices are attacked by the few insects adapted to deal with these plants' strong smells and tastes (most others are repelled). Vegetables are attacked by many of the same insects as those listed above.

Little visible insect damage can be tolerated in these crops because of consumer demand for clean or "perfect" products. However, the word "clean" has begun to take on a new meaning, as European countries reject shipments of products that have unacceptably high pesticide residues on them; the "clean" requirement is now a double-edged sword for most growers. Production of organic crops takes this one step further by using revolutionary new green technologies in place of pesticides. Certification as organic gives access to important niche markets, but also entails extra costs.

Cotton receives the lion's share of pesticides applied in many countries**,** since it is both valuable and vulnerable to pest attack. Serious cotton pests include bollworms and boll weevils, along with grasshoppers, aphids, whiteflies, sucking and stinking bugs, and spider mites. Pests that enter the boll are difficult to control with pesticides, so cotton should be harvested as early as possible. Early-maturing varieties should be used, and all stalks and remaining bolls should be plowed under or destroyed at the end of the season. New, relatively safe toxic baits have been developed for use against bollworm adult moths, using synthetic pheromones to attract them to the poison. The use of genetically modified "Bt" cotton (discussed below) may drastically reduce the amount of pesticides required.

Tobacco is attacked by many worms (larvae of moths) such as cutworms and hornworms, along with beetles, sucking bugs, leaf miners, seedling worms and maggots. Its buds are attacked by budworms, and its roots are attacked by white grubs, wireworms and mole crickets. Several species of beetle and moths infest tobacco in storage. Again, several methods can be combined to manage this threat. In the field, crop stubble should be destroyed at the end of the season. Fields can be burned over before planting to destroy waiting pests. Large worms such as hornworms can be hand-picked easily from leaves. An innovative approach that is relatively safe is to lace poisoned baits into bran and other carriers for use against other worms—cutworms, for example. Adult moths can be attracted to traps laced with attractants and a pesticide with low toxicity for humans.

Ornamental plants, houseplants, flowers and fruit trees, often grown in greenhouses, hothouses and nurseries, generally receive relatively high amounts of pesticide sprays to reduce visible damage. Many biological techniques, such as Bt and relatively nontoxic soaps and oils, have been developed to counter these pests, complementing or replacing synthetic pesticides.

Combating Pests That Prey on High-Value Crops

Protecting against visible insect damage is important to ensure the "clean" product many consumers demand. Farmers may:

- Plant early-maturing varieties to give pests less time to grow
- Plant pesticide-resistant Bt strains
- Plow under or burn stubble in fields to destroy eggs and larvae
- Hand-pick large worms (e.g., hornworms) from leaves
- Use poisoned baits in bran and in traps with pheromone attractants
- Spray ornamentals and fruit trees with relatively non-toxic soaps and oils

Bear in mind that many European countries also define "clean" as "having low levels of pesticide residue." Meeting both definitions of "clean" is difficult—but may be necessary, if farmers want to capture the export market.

Management of Livestock Ectoparasites and Flies. Livestock are also a target of pests. Ectoparasites such as mites, ticks, chiggers, lice, fleas and certain flies bite or bore into the skin of farm animals, weakening them, causing weight loss, ruining hides, and in some cases transferring debilitating diseases. Biting flies such as black flies, sand flies, horn flies, mosquitoes and others suck blood and irritate animals, leading to weight loss, and transmit exotic diseases such as sleeping sickness, rinderpest and river blindness.

Tsetse flies, mosquitoes and flies that transmit river blindness have been controlled in the past through large spray campaigns using aerial and truck-mounted sprayers. Other biting flies are controlled with poisoned baits and sprays, while ectoparasites are controlled using cattle and livestock insecticide dips. These dips present several problems, however. The animal can absorb too much toxin, spills are likely, operators are often exposed to the poison, and the used dip water must be disposed of properly. The list of botanical products given below provides several less-toxic options for repelling and killing mites and ticks.

Management of Human Disease Vectors. Humans are susceptible to many insect-transmitted diseases, and in many parts of Africa, exposure is both widespread and intense. Malaria is the primary disease that debilitates and kills Africans. Mosquitoes of certain species transmit the plasmodium parasite that causes malaria. Along rivers in West Africa, black flies transmit a parasite that causes river blindness by destroying the victims' corneas. In East and Southern Africa, tsetse flies transmit sleeping sickness to both cattle and humans. Mosquitoes also transmit yellow fever, dengue fever, encephalitis and filariasis. Houseflies everywhere transfer bacteria from fecal and decaying sources to food, thus contributing to death, especially among children, from diarrhea and dehydration. Lice, too, infest many people.

Outdated Pesticides Spell Danger

Pesticides often degrade into chemical compounds even more dangerous and toxic than the original one. There were over 120,000 tons of obsolete pesticides in Africa as of 2002.

- Never use old pesticides in an IPM program.
- Strongly discourage using them for any purpose.

In many countries, malarial mosquitoes are controlled by indoor sprays on walls and ceilings, water management, screens, and pesticide-treated bednets (see Hirsch et al., 2002). Populations need to be warned when the sprays occur so they can take appropriate precautions, and operators may require blood testing to detect overexposure to pesticides. House inner-wall sprays require use of long-residual pesticides. Mosquito-breeding waters can be treated with conventional pesticides, biological pesticides such as Bt spores, and the introduction of mosquito-eating fish. Window screens should be used in houses to keep out mosquitoes and other flies, and mosquito repellents can be used on the skin. Body lice are controlled with insecticidal shampoos and soaps, and houseflies are controlled through sanitation, baiting, trapping and spraying.

Obsolete Pesticides in Africa. There were over 120,000 tons of obsolete pesticides in Africa as of 2002. Old pesticides came from many sources, including donors, the FAO, regional development banks and the user's own purchase. Often these now unusable and degraded pesticides were donated for emergency programs against plagues of locusts, grasshoppers, armyworms, rodents, birds, mosquitoes, ticks, tsetse flies and other disease vectors. Many of these are not being stored properly. Old deteriorating pesticide barrels leak, non-experts such as children have access to them, streams flow nearby, and some are being sold by unscrupulous or unknowing crop protection agents.

Pesticides often degrade into chemical compounds even more dangerous and toxic than the original pesticide. Be aware of this and beware of allowing use of these old pesticides in an IPM program; in fact, strongly discourage their use for any purpose.

USAID's Pesticide Procedures

USAID's pesticide procedures derive from the only Environmental Impact Statement (EIS) conducted thus far on USAID's programs. The result of a 1975 legal challenge to USAID's policies on provision of pesticides, this EIS also stimulated the agency to develop comprehensive regulations governing environmental assessment of all its activities. These rules are variously referred to as the USAID Environmental Procedures, 22 Code of Federal Regulations 216, CFR 216, or Reg 216. *If USAID's resources are proposed for any activities that involve assistance for the procurement or use, or both, of pesticides, planners must take these procedures into account.* "Use" is defined in the sidebar at right.

Remember that IPM is at the heart of USAID's intended pest management strategies. Other elements of USAID's strategy include:

- strengthening pest-management infrastructures in developing countries
- improving schemes to regulate pesticide usage
- monitoring the human and environmental effects of pesticides
- working to exert a greater degree of U.S. leadership among the international community.

Although USAID's pesticide procedures require that any proposed use of pesticides be limited to products registered, without restrictions, for the same or similar uses in the United States by the U.S. Environmental Protection Agency (USEPA), there are exceptions. Developing countries have crops, diseases, habitats and other pests not found in the United States, and pest problems do not exactly mirror those found in the United States. For instance, certain pesticides effective against tsetse flies, locusts or malarial mosquitoes might be ideal in Africa, yet in the United States they would never need to be used. As a consequence they would remain

What is pesticide "use" according to USAID?

It is important to note that USAID broadly interprets "use" to include all *direct or actual use or acquisition* of pesticides, including handling, transporting, storing, mixing, loading, applying and disposing of them, as well as cleaning up spray equipment. It also includes any *indirect support for pesticide use,* such as providing fuel for transporting pesticides and giving technical assistance to pesticide management operations. An environmental review is required when USAID supports any such actions.

In contrast, *support for limited pesticide research and pesticide regulatory activities* is not subject to scrutiny under the pesticide procedures. Likewise, USAID may provide *support to train people in safer pesticide use* without environmental review when the training does not involve actual application of pesticides.

unevaluated by USEPA. Any proposed pesticide use that cannot be shown to conform to U.S. standards should be subjected to an Environmental Assessment or Environmental Impact Statement.

Important Restrictions on USAID-Supported Pesticide Use

- USAID finances pesticides only on a case-by-case basis.
- USAID does not finance pesticides through non-project assistance.
- Pesticides canceled or suspended by USEPA are never approved for USAID use.
- Products classified as "Restricted Use Pesticides" by USEPA are almost never approved for USAID use.
- USAID-financed (approved) pesticides may not be used in combination with non-approved pesticides.
- USAID-funded equipment should not be used to apply non-USAID-approved pesticides.

However, the USAID Administrator may waive certain rules in an emergency.

USAID finances pesticides only on a case-by-case basis (not on the basis of an approved commodity list), and then only after specific additional evaluation that considers the potential benefits conferred by the proposed pesticide. Furthermore, USAID does not finance procurement of pesticides through non-project assistance (i.e., through USAID Commodity Import Programs such as Title II, described below).

The kinds of factors to be considered in assessments such as an Initial Environmental Examination or Environmental Assessment should include, but not necessarily be limited to, the following CFR 216 parts:

- the USEPA registration status of the requested pesticide(s);
- the basis for selecting the requested pesticide(s);
- the extent to which the proposed pesticide use is part of an IPM program;
- the proposed method or methods of application, including availability of appropriate application and safety equipment;
- any acute and long-term toxic hazards, either human or environmental, associated with the proposed use, as well as measures available to reduce such hazards, if not eliminate them;
- effectiveness of the requested pesticide(s) for the proposed use;
- compatibility of the proposed pesticide(s) with target and non-target ecosystems;
- the conditions under which the pesticide(s) are to be used, including climate, flora, fauna, geography, hydrology and soils;
- the availability and effectiveness of other pesticides or non-chemical management methods;
- the requesting country's ability to regulate or control the distribution, storage, use and disposal of the requested pesticide(s);
- provisions made for training users and applicators; and
- provisions made for monitoring the use and effectiveness of the pesticide(s).

The types of environmental studies required by USAID, depending on USEPA regulatory status, are provided as a guide in Table 1. Pesticides canceled or suspended by USEPA (Table 2) are never approved for use in a USAID project. Similarly, products classified as Restricted Use Pesticides by USEPA (Table 3) are almost never approved for use in USAID projects.

PERSUAPs. USAID Africa Bureau uses a relatively new concept for permitting safer pesticide use with development funds, while maintaining a reasonable level of control over pesticide choice and use. Targeted studies or evaluations during project or activity design produce documents called Pesticide Evaluation Report and Safer Use Action Plans, or PERSUAPs (see http://www.encapafrica.org/sectors/pestmgmt.htm). PERSUAPs:

- describe the particular circumstances of the programs in question,
- assess the hazards posed by the pesticides proposed for use,
- outline the risk management choices available, and
- recommend how a risk management plan can be carried out in the field.

These documents are produced by or for country programs or activities that wish to use pesticides for discrete activities and that are supported by USAID, by non-governmental organizations (NGOs) or by private voluntary organizations (PVOs). PERSUAPs accompany an Initial Environmental Examination (IEE) and address the key Regulation 216 concerns listed above, emphasizing use of the lowest-risk compounds.

Local-level PERSUAPs are needed because, even though the USEPA may consider a pesticide safe for use in the United States, many farmers and pesticide users in Africa cannot be expected to handle pesticides in the same ways as U.S. users. Literacy rates are much lower, so users cannot read labels; farmers/users do not use safety equipment; regulations are not enforced; inappropriate pesticides or formulations are used; and users often do not know how to properly calibrate sprayers or use them safely, leading to gross and dangerous overapplications of pesticide. PERSUAPs are intended to foresee and prevent many of these risks.

Commingling of USAID Pesticide Funds with Others' Pesticide Funds. If more than one donor or NGO is involved in an activity, care must be taken that no USAID funds are spent on USAID-approved pesticides that might be used in combination with non-approved pesticides provided by another donor or group. Likewise, pesticide application equipment bought with USAID funds should not be used to apply non-USAID-approved pesticides. Good communication and program field monitoring will prevent this, at least over the short term or for the life of a project.

Pesticide Evaluation Report and Safer Use Action Plan (PERSUAP)

PERSUAPs describe results of risk assessment studies for proposed pesticide use, describe possible plans to address the risks, and then recommend one of the plans. Country programs use them together with an Initial Environmental Examination. PERSUAPs help USAID maintain a level of control over pesticide use in local projects.

Title II Food Assistance and Natural Botanical Pesticides. U.S. Public Law 480 Title II development and emergency food assistance, administered by USAID's Office for Food for Peace, provides cereals and other foodstuffs to targeted vulnerable groups in developing countries. As part of this program, USAID funds grants from the Food Security Fund (FSF) through PVO/NGOs, like ACDI-VOCA. Pesticide training, procurement and use may be part of grantees' programs.

Administrator Authority/Waivers. Under certain circumstances, such as locust or rodent plagues or exotic introduced pest outbreaks (e.g., screwworm in cattle), the Administrator of USAID may write a waiver to authorize or approve

- using compounds not normally used, or
- expediting actions with minimum or no environmental review.

Generally, this requires that requesting countries or projects forward emergency requests for assistance through USAID's Office of Foreign Disaster Assistance (OFDA).

Listing of pesticides. On the following pages are three tables that may be of use in deciding which pesticides to use. Table 1 outlines the different levels of USAID evaluation required by different combinations of pesticides and uses. Table 2 lists pesticides whose use has been cancelled or suspended by USEPA or that USEPA has never registered for use. Table 3 lists pesticides whose use has been restricted by USEPA.

Two other sites have helpful lists of pesticides. The **Pesticide Action Network (PAN)** site has a comprehensive database of pesticides used in many places (particularly the United States), including insecticides, herbicides and more. Along with the database, the site has a pesticide poisoning diagnostic tool, an international pesticide registration page, information on aquatic ecotoxicity, notes about California pesticide use, a pesticide tutorial and reference guide, a discussion of least/non-toxic alternatives to dangerous pesticides, and a set of links to other resources.

PAN list: http://www.pesticideinfo.org/Index.html (if you have problems, go to the PAN home page at http://www.panna.org)
PAN's famous "Dirty Dozen" list of highly hazardous pesticides is at http://www.pesticideinfo.org/Docs/ref_toxicity7.html#DirtyDozen

The FAO's **Prior Informed Consent (PIC)** Web site lists only hazardous chemicals. Under the 1998 Rotterdam Convention, exporters trading in any hazardous substance found on the PIC list have to obtain the prior informed consent of importers before proceeding with the trade. The interim PIC list contains 22 pesticides, 9 industrial chemicals and 6 severely hazardous pesticide formulations. The site also has tables listing several classes of problematic chemicals proposed for the PIC list (“candidate chemicals”).

PIC list: http://www.pic.int/en/ViewPage.asp?id=231 (if you have problems, go to the PIC home page at http://www.pic.int/)

Table 1. Classification of Candidate Pesticides for Specific Evaluation

Categorization in terms of proposed use and USEPA regulatory status	**Review requirements in accordance with USAID Regulation 216**
1. Pesticide to be used for research or limited field evaluation purposes only, irrespective of its current regulatory status in United States	IEE[b]
2. Projects involving demonstration or use of pesticides for specified use:	IEE[b]
(a) Pesticide registered for same or similar uses[a] in United States without restrictions	IEE[b]
(b. Pesticide registered for same or similar uses[a] in United States, restricted on basis of user hazard	IEE and, if approved, user hazard warning to and certification of awareness from recipient[b]
(c) Pesticide registered for same or similar uses[a] in United States, restricted on basis of environmental hazard	IEE plus EA or EIS[c]
(d) Pesticide registered for same or similar uses[a] but currently under Special Review, notice of intent to cancel, or subsequent notice of intent to suspend issued by USEPA	IEE plus EA or EIS[c] and, if approved, notice of impending action to recipient
(e) Pesticide previously registered for same or similar uses[a] but cancelled for environmental hazard	IEE plus EA or EIS[c]
(f) Pesticide previously registered for same or similar uses[a] but cancelled for health reasons	IEE plus EA or EIS[c]
(g) Pesticide registered for a different use in United States	IEE plus EA or EIS[c]
(h) Pesticide not registered for any use in United States, but tolerances established	IEE plus EA or EIS[c]
(i) Pesticide not registered for any use in United States, no tolerances established	IEE plus EA or EIS[c]

[a] Similar use is defined to include the use of a substantially similar formulation in a comparable use pattern. The term “use pattern” includes target pest; crop or animals treated; application site; and application technique, rate, and frequency.

[b] Pesticides in this category are not ordinarily subject to further analysis; however, the decision to undertake such analysis is made on a case-by-case basis.

[c] Pesticides in this category, following the IEE, automatically trigger at least an EA or an EIS, the choice of which continues to be governed by USAID Regulation 216.

Abbreviations: IEE: Initial Environmental Examination; EA: Environmental Assessment; EIS: Environmental Impact Statement; USEPA: U.S. Environmental Protection Agency. Source: USAID 1976a in Tobin 1994.

Table 2. Pesticide Compounds with USEPA-Cancelled or Suspended Products

The following is a list of generic or accepted common chemical or compound names for problematic pesticides. At least half of the products made with each pesticide are suspended, cancelled, or not registered (i.e., they have no “Active” registrations) in the United States by the U.S. Environmental Protection Agency (USEPA). Note that thousands of trade names exist, few of which appear on this list. Carefully examine the label of any pesticide to ascertain whether the accepted common (or generic) name appears on this list.

acetamide-na
acrolein-cna
acrylonitrile-c
alachlor-cna
alar
aldicarb-dd
aldrin-dd-b
allyl alcohol-c
alpha chlorhydrin-c
aluminum phosphide
amitraz-cna
amitrole
arsenic acid
arsenic trioxide-s
arsenic pentoxide-cna
atrazine
avitrol-cna
azinphos methyl
bendiocarb-cna
benomyl
BHC-dd-b
bis (tributyltin) oxide
brodifiacoum-c
bromoxynil
bromoxynil butyrate-b
butylate-c
cadmium-b
cadmium chloride-c
calcium arsenate-b
calcium cyanide-c
captafol-b
captan
carbofuran-s
carbon tetrachloride-b-c
chloranil-b
chlordane-dd-b
chlordimeform-dd-b
chlorfenvinphos-c
chlorbenzilate-b
chlorophacinone-cna
chloropicrin
chlorothalonil
chromic acid
coal tar-cna
coal tar creosote
copper arsenate-b
copper oxychloride-c
coumaphos-na
creosote-c
creosote oil
cupric oxide-c
cyanazine-cna
cycloheximide-c
cyhalothrin-na
cyhexatin-b
cypermethrin
daminozide-s
DBCP-dd-b-c
DDD (TDE)
DDT-dd-b
demeton-c
diallate-c
dichloenil (2,4-D)
dichloropropene
diclofop methyl
dicofol
dicrotophos-cna
dieldrin-dd-b
diflubenzeron
dimethoate
dinocap
dinoseb-b
dioxathion-cna
diphacinone-c
disulfoton
dodemorph-c
E-mevinphos-c
endrin-dd-cna
EBDCs
EDB-dd-b
endrin-cna
EPN-c-b
EPTC
ethion-cna
ethoprop-cna
ethyl parathion-cna
ethylene dibromide-c
fenamiphos-cna
fenitrothion-cna
fensulfothion-c
fenthion
fenvalerate-cna
flucythrinate-c
flouroacetamide-c
fluvalinate-c
fluoroacetamide
fonofos-c
heptachlor-dd-s
hydrocyanic acid-c
hydrogen cyanamide-na
imazaquin-c
isazofos-c
isofenphos-c
kepone
lead arsenate-b
lindane-dd-b
magnesium phosphide
metaldehyde
methamidophos
methiocarb
methomyl-cna
methyl bromide-cna
methyl parathion-dd
mercury compounds-b
mevinphos-c-b
mirex-b
monocrotophos-c-b
niclosamide-cna
nicotine
nitrogen, liquid-na
oxamyl-na
oxidemeton methyl-cna
OMPA-b
10,10' oxybisphenoxarsine
oxyfluorfen
parathion-dd
paraquat-dd
PCBs
PCNB
pentachlorophenol-dd-cna
pentachlorophenol-sodium S-dd-cna
permethrin
phenarsazine chloride
phorate-cna
phosacetim-c
phosalone-c
phosphamidon-c
picloram-c
picloram, isooctyl ester-c
picloram, potassium salt-cna
picloram, triisoprpanolamine
polychlorinated terphenyls
potassium pentachlorophenate-c
pronamide
profenphos-na
propanoic acid
safrole-b
silvex-b
simazine
sodium arsenate-s
sodium arsenite-b
sodium cyanide
sodium dichromate
sodium fluoroacetate-cna
sodium fluoride
sodium methyldithiocarbamate
sodium monofluoroacetate
sodium pyroarsenate-c
strobane-b
strychnine
sulfotep-cna
sulfuric acid
sulfuryl fluoride
2,4,5-T-dd-b
2,4,5-TCP-b
tefluthrin
TEPP-c
terbufos-na
tergitol-c
TFM-na
thallium Sulfate-b
TOK (nitrofen)-b
toxaphene-dd-b
tributyltin fluoride-cna
tributyltin methacrylate
tributyltin-s
trifluralin-c
triphenyltin hydroxide
vinyl chloride-b
z-mevinphos-c
zinc phosphide
Wood Preservatives: calcium arsenate-b, creosote, pentachlorophenol-dd, sodium arsenate-b, and sodium arsenite-b

Source: USEPA 2002

na = chemicals with no active registered products
cna = chemicals with cancelled and no active registered products
c = chemicals with all products cancelled
b = chemicals with all products banned
s = chemicals with most uses strictly restricted
dd = "dirty dozen" pesticides as designated by PAN, in Boldface Type

Table 3. Pesticides Classified as "Restricted Use Products" (RUP) by USEPA

Note: This list contains only accepted common generic names; trade names are far more numerous. These products may be used *only* by a certificated pesticide applicator or under the direct supervision of a certified applicator. For detailed information on the RUP classification, consult 40 CFR Subpart I, 152.160. RUP lists are found at http://www.epa.gov/opprd001/rup/ (last updated June 27, 2003). The RUP lists provide information on the status (active or cancelled) of all of the different product names (names under which the products are sold) likely to be encountered for each chemical compound base name in the RUP list. Some compounds have up to 100 different names, so look carefully at this resource. For each compound, the RUP list also provides reasons why each product is so closely regulated, along with formulations, uses, EPA actions, and the last date that each was revised.

Note: All pyrethroid pesticides were classified as "restricted on 07/27/95 due to acute hazards." Pyrethrins, on the other hand, are listed due to chronic eye effects.

Key: DD = A chemical on the PAN "dirty dozen" list; EC = emulsifiable concentrate

Acetamide	Acetic acid	Acetochlor
Acrolein	Acrylonitrile	Alachlor
Aldicarb ^{DD}	Allyl alcohol	Alpha-clorohydrin
Aluminum phosphide	Amitraz	Amitrole
Arsenic acid	Arsenic pentoxide	Atrazine
Avermectin	Avitrol	Azinphos-methyl
Bendiocarb	Benzoic acid	Biphentrhin
Bis(tributyltin) oxide	Brodifacoum	Butylate
Cadmium chloride	Calcium cyanide	Carbofuran
Carbon dioxide	Carbon tetrachloride	Chlordane ^{DD}
Chlordane, technical	Chlordimeform ^{DD}	Chlorfenvinphos
Chlorobenzilate ^{DD}	Chlorophacinone	Chloropicrin
Chlorothalonil	Chlorothoxyfos	Chlorpyrifos (EC on wheat)
Chromic acid	Clofentezine	Coal tar
Coal tar creosote	Copper oxychloride	Coumaphos
Creosote	Creosote oil	Cube resins

Cupric oxide	Cuprous oxide	Cyanazine
Cycloheximide	Cyfluthrin	Cyhalothrin
Cypermethrin	DBCP [DD]	Deltamethrin
Demeton	Diallate	Diazinon
Dichloenil (2,4,D)	Dichloropropene	Diclofop methyl
Dicrotophos	Diflubenzuron	Dioxathion
Diphacinone	Disulfoton	Dodemorph
E-mevinphos	Emamectin benzoate	Endrin [DD]
EPN	EPTC	Ethion
Ethoprop	Ethyl parathion [DD]	Ethylene dibromide
Fenamiphos	Fenbutatin-oxide	Fenitrothion
Fenpropathrin	Fensulfothion	Fenthion
Fenvalerate	Fipronal	Flucythrinate
Fluoroacetamide	Fluvalinate	Fonofos
Hydrocyanic acid	Hydrogen cyanamide	Imazaquin
Isazofos	Isofenphos	Lambda-cyhalothrin
Lindane [DD]	Magnesium phosphide	Methamidophos
Methidathion	Methiocarb	Methomyl
Methyl bromide	Methyl isothiocyanate	Methyl parathion [DD]
Metolachlor	Mevinphos	Monocrotophos
Niclosamide	Nicotine	Nitrogen, liquid
Oxamyl	Oxidemeton methyl	Paraquat [DD]
Pentachlorophenol [DD]	Pentachlorophenol, Sodium S [DD]	Permethrin
Phorate	Phosacetim	Phosalone
Phosphamidon	Phostebupirim	Picloram

Picloram, isooctyl ester	Picloram, potassium salt	Picloram, triiosopropanolamine
Piperonyl butoxide	Potassium pentachlorophenate	Profenophos
Pronamide	Propanoic acid	Propetamphos
Pyrethrins	Resmethrin	Rotenone
S-Fenvalerate	Simazine	Sodium arsenate
Sodium cyanide	Sodium dichromate	Sodium fluoroacetate
Sodium hydroxide	Sodium methyldithiocarbamate	Sodium pyroarsenate
Starlicide	Strychnine	Sulfotepp
Sulfuric acid	Sulfuryl fluoride	Sulprofos
Tefluthrin	TEPP	Terbufos
Tergitol	TFM	Toxaphene [DD]
Tralomethrin	Tributyltin fluoride	Tributyltin methacrylate
Trifluralin	Triisopropanolamine	Triphenyltin hydroxide
Z-Mevinphos	Zinc phosphide	

Biopesticides: Microbials, Botanical Pesticides, Repellents and Baits

Lists of biopesticides regulated by USEPA may be found at http://www.epa.gov/pesticides/ biopesticides. These pesticides are derived from such natural materials as animals, plants, bacteria and certain minerals. For example, canola oil and baking soda have pesticidal applications and are considered biopesticides. At the end of 2001, there were approximately 195 registered biopesticide active ingredients and 780 products.

Plant-Derived Pesticides That Are Not Permitted. The use of plant-derived pesticides *not* registered with USEPA, such as nicotine-based commercial products or smallholder farmer concoctions, will not be promoted under a USAID-funded project without completing a pesticide review—for example, an IEE, EA, or PERSUAP. Suggestions for testing and determining the risk of botanical products are listed in these guidelines' IPM chapter. For example, some botanical infusions of ground "rope" tobacco and soap can result in a product that is highly toxic to people and should not be supported or extended to smallholder farmers. Table 4 shows a list of botanical pesticides, repellents and baits regulated and registered by USEPA.

Biopesticides, as outlined by USEPA, fall into three major classes:

1. Microbial pesticides consist of a microorganism (e.g., a bacterium, fungus, virus or protozoan) as the active ingredient. Microbial pesticides can control many different kinds of pests, although each separate active ingredient is relatively specific for its target pest(s). For example, there are fungi that control certain weeds and other fungi that kill specific insects.

The most widely used microbial pesticides are subspecies and strains of *Bacillus thuringiensis*, or Bt. Each strain of this bacterium produces a different mix of proteins and specifically kills one or a few related species of insect larvae. While some Bts control moth larvae found on plants, others are specific for larvae of flies and mosquitoes. Target insect species are determined by whether the particular Bt produces a protein that can bind to a larval gut receptor, thereby causing the insect larvae to starve.

2. Plant-Incorporated Protectants (PIPs) are pesticidal substances that plants produce from genetic material added to the plant. For example, scientists can take the gene for the Bt pesticidal protein and introduce it into the plant's own genetic material. Then the plant, instead of the Bt bacterium, manufactures the substance that destroys the pest. The protein and its genetic material, but not the plant itself, are regulated by USEPA.

3. Biochemical pesticides are naturally occurring substances that control pests by nontoxic mechanisms. Conventional pesticides, by contrast, are

Biopesticides

There are three major classes of biopesticides:

- **Microbial pesticides**, which contain micro-organisms as the active ingredient.
- **Plant-incorporated protectants**, such as Bt proteins that are genetically added to a plant
- **Biochemical pesticides**, such as essential oils (lemongrass, eucalyptus) or insect pheromones that control pests by non-toxic means.

Biopesticides have several advantages over synthetic pesticides:

- They are usually inherently less toxic.
- They generally affect only the target pests.
- They are often effective in small quantities and decompose quickly.
- They can be safely used by large- and small-scale farmers.
- They can reduce use of conventional pesticides while preserving high crop yields.

generally synthetic materials that directly kill or inactivate the pest. Biochemical pesticides include substances such as insect sex pheromones that interfere with mating as well as various scented plant extracts that attract insect pests to traps. Because it is sometimes difficult to determine whether a substance meets the criteria for classification as a biochemical pesticide, USEPA has established a special committee to make such decisions.

The Versatile Bt Protein

The common soil bacterium *Bacillus thuringiensis* (Bt) produces proteins that can poison insect larvae. Each Bt strain kills a specific insect or group of insects. Bt can be used whole to protect maize, cotton and potatoes from insects, or the protein from the appropriate strain of Bt can be engineered directly into each crop so that the plants themselves kill the pests that are eating them.

Examples of scented plant extracts include a relatively long list of **essential oils**, defined as any volatile oil that gives a distinctive odor or flavor to a plant, flower or fruit, that were first registered as pesticide active ingredients in 1947. Twenty-four distinct chemicals are covered under the heading "essential oils." USEPA now requires that registrants identify the particular oil(s) contained in their products, rather than naming "essential oils" as the active ingredient. Approximately 25 pesticide products that contain essential oils as active ingredients are currently registered by USEPA. These products are used as repellants, feeding depressants, insecticides and miticides as well as antimicrobials, and are marketed as liquid sprays, crystals and pellets.

The advantages of using biopesticides are many:

- Biopesticides are usually inherently less toxic than conventional pesticides.
- Biopesticides generally affect only the target pest and closely related organisms, in contrast to broad-spectrum conventional pesticides that may affect organisms as different as birds, insects and mammals.
- Biopesticides often are effective in very small quantities and often decompose quickly, lowering exposures and largely avoiding the pollution caused by conventional pesticides.
- Both larger-holder and smallholder farmers may be able to use biopesticides safely.
- When used in IPM programs, biopesticides can greatly decrease use of conventional pesticides, while crop yields remain high.

Table 4. Botanical Pesticides, Repellents and Baits Regulated by USEPA, As Listed by EPA

Anise Oil	*Pimpinella anisum*	Repels vertebrates	Low	004301
Azadirachtin, Dihydroazadirachti	*Azadirachta indica* Neem tree extract	Kills & repels insects	III-IV	121701, 121702
Bergamot	Lemon mint	Repels vertebrates		129029
Canola Oil	*Brassica napus* *B. campestris*	Kills many insects	Low	011332
Capsaicin	*Capsicum frutescans* Red pepper	Repels vertebrates	Low, III	070701
Castor Oil	*Ricinus communis*	Repels vertebrates	Low	031608
Cedarwood Oil	*Juniperus* & *Cedrus* spp	Repels moth larvae	Low	040505
Cinnamaldehyde	Ceylon & Chinese cinnamon oils	Kills insects, fungi & repels vertebrates*	Low	040506
Citronella Oil	*Cymbopogon fardus*	Repels insects & vertebrates	Low	021901
Cloves, Crushed	*Syzygium aromaticum*		Low	128895
Eucalyptus Oil	p-Methane-3,8 diol	Repels insects, mites fleas & mosquitoes	Low	040503
Eugenol	Oil of cloves	Kills insects**	Low	102701
Garlic	*Allium sativum* 'Garlic barrier' etc.	Repels insects	Low	128827
Geraniol	Oil of rose isomeric w/ linalool	Repels vertebrates**	Low	597501
Geranium Oil			Low	597500
Indole	from all plants	Trap bait: corn root-worm beetles	Low	25000-
Jasmine Oil	*Jasminum* sp.		Low	040501
Jojoba Oil	*Simmondsia* spp.	Kills & repels whitefly kils powdery mildew	Low	067200
Lavandin Oil	Lavender	Repels clothes moth	Low	040500
Lemongrass	*Cymbopogon citratus*	Repels vertebrates	Low	040502
Linalool	Oil of Ceylon isomeric w/ geraniol	Repels insects, ticks, mites & spiders	Low	128838
Maple lactone		Roach trap bait	Low	004049
Methyl salicylate	Oil of wintergreen	Repels moths, beetle & vertebrates	May be Toxic in large quantity	76601-
Mint, Mint oil	*Menthus* spp.	Kills aphids	Low	128892, 128800
Mustard Oil	*Brassica nigra* Allyl isothiocyanate	Repels insects, spiders & vertebrates	Low	004901
Neem Oil	[see azadiractin]	Kills whitefly, aphids	Low	025006
1-Octen-3-ol	From clover, alfalfa	Trap bait: mosquitoes	Low	69037-
Orange	*Citrus sinensis*	Repels vertebrates	Low	040517
Pepper, red	Chilli, capsaicin	Repels insects	Low	070703
2-Phenylethyl-propionate	From peanuts	Kills insects, ticks,	Low	102601

Planning and Preparing for Pest Management Operations

There is a detailed discussion of IPM in the chapter on integrated pest management in these guidelines. Refer to it for details. In brief, here are some essentials of IPM.

How Do IPM Programs Work?

IPM is an approach that integrates appropriate existing management methods (cultural, biological, chemical, physical) with mitigating factors, environmental concerns, climatic conditions, and ecosystem inter-relationships to assist in decision-making. IPM is thus not a single pest control method, but rather a series of pest management evaluations, decisions and controls. In practicing IPM, growers will follow an approach that includes the following elements:

1. Prevention: As a first line of pest management, IPM programs work to manage the crop, lawn or indoor space to prevent pests from becoming a threat. On a farm this may mean using methods like rotating between different crops, selecting pest-resistant varieties, and planting pest-free rootstock. These methods can be very effective and cost-efficient and present little or no risk to people or the environment.

2. Monitoring and identifying pests: Not all insects, weeds and other living organisms require control. Many are innocuous, and some even benefit the crop by preying on harmful organisms. IPM programs work to monitor for pests and identify them accurately, so that farmers can make appropriate management decisions using action thresholds (see next item). This monitoring and identification removes the possibility that pesticides will be used when they are not really needed or, worse, that the wrong kind of pesticide will be used.

3. Setting action thresholds: Before taking any pest management action, IPM sets an **action threshold**—a point at which pest populations or environmental conditions indicate that action must be taken. Sighting a single pest does not always mean action is needed. Knowing the level at which pests become an economic threat is critical to pest control decisions.

4. Management: Once monitoring, identification, and action thresholds indicate that pest control is required, and preventive methods are no longer effective or available, IPM programs evaluate possible management methods for both effectiveness and risk. Effective, lower-risk pest controls are chosen first, including highly targeted chemicals (such as pheromones to disrupt pest mating) or mechanical controls (such as trapping or weeding). If

Basic Steps for Pest Management

- *Practice prevention first,* by managing crops or households to prevent pest problems before they occur.
- *Monitor and identify pests*. Not all insects, weeds and wild animals around the farm are harmful; some may even help.
- *Set an action threshold*—the point where a pest problem must be dealt with. Sighting a single pest may not justify a campaign.
- *Identify and evaluate proper controls,* once pest management is indicated.

further monitoring, identification and action thresholds indicate that less-risky controls are not working, then additional pest control methods are used, such as targeted spraying of the least toxic pesticides. Broadcast spraying of nonspecific pesticides is generally a method of last resort.

Many kinds of organisms can be pests, including different species of insects, mites, nematodes, mollusks, plant pathogens, vertebrates and weeds. It is vital to identify a pest correctly—as well as its natural enemies—before deciding whether and how to manage it.

Preparing for Crop Protection Actions

Before the growing season(s), any crop protection service (CPS) field bases supporting village farmers should ensure that farmers are ready, technically and materially, to face the coming season. Farmers should first prepare the farm to face a pest infestation with preventive action. In addition to the methods mentioned in (1) above, examples of prevention include destroying last season's crop refuse and having planting material ready to plant at the optimum time. Farmers should also prepare:

- plans of action or IPM strategies for different pest scenarios;
- working spray equipment;
- clean protective clothing and safety equipment;
- and a basic supply of least-toxic pesticides carefully stored and ready for use.

In addition, if pest problems do develop, it is important to assess the vulnerability of crops threatened by the pest species, the relative importance of the crops, and the crops' stage of development. This information will help the farmer decide when and where a pesticide spray treatment may be needed.

Pest Monitoring and Survey

To help keep pest numbers below levels where economic damage from crop loss can occur and to reduce the environmental impact of pesticide use, it is important for both farmers and extension agents to survey the crops regularly. Pest surveying should begin early in the season and continue on a regular basis throughout the growing season. When necessary, control activities should be carried out promptly and in a carefully targeted way. Knowledge of the pest and crop ecology, along with equipment in good working order, help to accomplish this. *A monitoring-based approach typically will reduce the number of pesticide treatments required by 40–60 percent during a regularly scheduled control scheme.*

The main elements to be included in pest survey programs are (1) knowledge of pest distribution in time and space and (2) monitoring of environmental conditions and changes that might lead to increased numbers of pest species. This will require some knowledge of pest species' biology, current environmental conditions, and how these conditions can encourage or limit the spread of pests.

Village Brigades

A village brigade is a unit responsible for a village's pest monitoring and control needs. Brigades are being formed in many African countries as self-help units and to decentralize the activities the national CPS often conducts.

Village Brigades

A village brigade typically includes 10 interested villagers who can mobilize their neighbors for such anti-pest activities as:

- Baiting rats area-wide
- Removing pest and disease reservoirs
- Hand-picking egg masses of large pests

Ideally the members receive three days of intensive training in pest management. They can then train their entire village during the year.

Appropriate, well-maintained equipment is critical for safe pesticide use.

These brigades are formed with the assistance of rural extension agents and the national CPS. A village brigade typically includes 10 interested and enthusiastic villagers. Brigade activities should include coordination of area-wide rat-baiting programs, removal of pest and pathogen reservoirs (such as crop stubble containing pests), timely hand-picking of egg masses of large pests, and implementation of other useful non-chemical management techniques requiring effective community mobilization.

To the extent that village brigades assume a significant role in pest management, they should be encouraged to understand and promote adoption of non-chemical control options as much as possible and discouraged from becoming overly dependent on pesticides. Participants ideally receive three days of intensive pest and pesticide management training and then are responsible for pest management at the village level, with the help of the other local farmers. Investment in participant training has the potential for a dramatic multiplier effect, as the members of a village brigade can train an entire village during the year.

Pesticides at the User Level

Safer pesticide use involves the following key components, which are discussed in three sections. The first section (below) covers the practical context of pesticide use, including pesticide selection, understanding the pesticide label, pesticide transport, mixing and loading pesticide, pesticide storage, container disposal and obsolete pesticides. The second section covers the actual process of using pesticides, including calibration of application equipment, determining the amount of chemical to use, and applying pesticides. The third section covers pesticide toxicity, human protection, and basic first aid for pesticide overexposure.

Note that many smallholder farmers will not use the methods discussed in these three sections, regardless of the amount of training they receive, while some larger-holder farmers who do understand these principles may not emphasize their importance sufficiently to laborers who use the pesticides. Medium- to larger-holder farmers who do their own crop protection are apt be the most likely to use appropriate precautions. If project monitoring shows that farmers or farm laborers are not using appropriate precautions, a spraying service may need to be provided.

Pesticide Use: The Practical Context

Pesticide selection

Once the decision is made to use a synthetic pesticide, the correct product must be selected.

Here are some factors to consider:

- Is the product registered and recommended for managing the pest on the specific crop being grown? (Do not use a pesticide on a crop for which it is not registered or recommended.)
- What is the cost of the chemical, based not only on the initial unit cost but also on the cost per application and the number of applications required?
- What is the pesticide's availability?
- What is the pesticide's relative toxicity, and how hazardous is its use?

Ensuring Proper Pesticide Management and Safety

The following list presents the main issues to be understood and remembered when using chemicals to manage pests:

- Use the recommended chemical, rate and application method.
- Good coverage of all plant parts is essential if spraying is done on a "wet to runoff" basis—i.e., the plants are sprayed to the point that the spray just begins to drip from the foliage.
- Some insecticides kill beneficial insects as well as harmful ones, so do not use them indiscriminately.
- Always read the directions on the container.
- Buy and store pesticides in their original container. Keeping pesticides in containers that originally held food or drink has resulted in many accidental poisonings. Likewise, never reuse an empty pesticide container for any purpose, especially for storing food or water.

- What are the possible harmful effects of using the product?
- What is one's past experience in using the chemical for the pest and crop in question?

Pesticides can be grouped or classified by several different methods, as seen in the following table.

According to function (action against a specific pest category)	
Pesticide	***Pest Group***
Acaricide/miticide	Mites, ticks
Bactericide	Bacteria
Fungicide	Fungi
Herbicide	Weeds
Insecticide	Insects
Molluscicide	Mollusks
Nematicide	Nematodes
Rodenticide	Rodents
According to chemical makeup	
Groups	***Examples***
Organochlorines	DDT, dieldrin, aldrin, heptachlor, lindane (most of these are banned in most countries)
Organophosphates	actellic, acephate, chlorpyrifos, dimethoate, endosulfan, malathion
Carbamates	carbaryl, methomyl, propoxur
Synthetic pyrethroids	bifenthrin, cyfluthrin, permethrin, cypermethrin, deltamethrin, fenvalerate
Botanicals	pyrethrum, rotenone, nicotine, azadirachtin (neem)

Microbials	*Bacillus thuringiensis*, *Heliothis* nuclear polyhedrosis virus, *Nosema locustae*, *Metarhizium* spp.
Petroleum oils	mineral oil
Insect growth regulators	diflubenzuron, methoprene, fipronil
According to formulation	
Liquid	Emulsifiable concentrates (EC or E) Flowables (F or L) Solutions (S) Ultra low volume concentrates (ULV)
Dry	Dusts (D) Granules (G) Pellets (P) Wettable powders (WP) Soluble powders (SP) Dry flowables (DF)
Other	Aerosols Fumigants Baits

Understanding the Pesticide Label

The label is the printed material attached to the pesticide container. If possible, pesticides without an approved label attached to the container should not be purchased. The ability to read or understand the information on the label is essential, and vendors and farmers should understand the value of an adequate label. Even those who cannot read need to be helped to grasp the information on the label or to understand the pesticides they are selling or using. Users will find the label and other product documentation helpful:

Vendors and farmers need to understand the pesticides they are selling or using. Even those who cannot read must be helped to grasp the information on the label—for safety and for effective use of the product.

- before purchasing the pesticide, to determine if the chemical will manage the pests on the crop in question and can be used safely for their specific conditions;
- before mixing the pesticide, to determine if users have the necessary protective clothing, how much pesticide to use, and how to mix it;
- before applying the pesticide, to learn the safety measures required, when to apply the pesticide, how to apply it, when it is safe to reenter the treated area, when it is safe to harvest the treated crop, and what restrictions would prohibit its use under current conditions;
- before storing the container, to ensure safe and proper storage; and
- before disposing of the container, to ensure safe and proper disposal.

The pesticide label should include:

- *USEPA or other registration number*
- *Brand name*: Name assigned by the manufacturer
- *Common name*: Short name approved for the chemical's active ingredient (the material that actually kills the pest)
- *Chemical name*: Full name of the active ingredient, presented according to the rules of nomenclature used in *Chemical Abstracts*
- *Ingredient statement*: Lists the active ingredient or ingredients, along with the percentage of inert or inactive ingredients

- *Amount of active ingredient*: For powders, this is listed as a percentage. For instance, “50% WP” means that the powder consists of 50 percent active ingredient and 50 percent inert ingredient. For liquids, it is measured as pounds of active ingredient per gallon. For example, ”2 EC” means that the compound contains 2 pounds of active ingredient per gallon of product.

- *Net contents*: Shows the actual amount of product in the container

- *Name and address of the manufacturer*

- *Signal words and symbols*: Quick reference to product’s relative toxicity to humans

- *Precautionary statements*: Given to protect users, others, animals, and the environment from damage resulting from using the pesticide

- *Route of entry*: Possible ways the pesticide can harm or enter a handler’s body

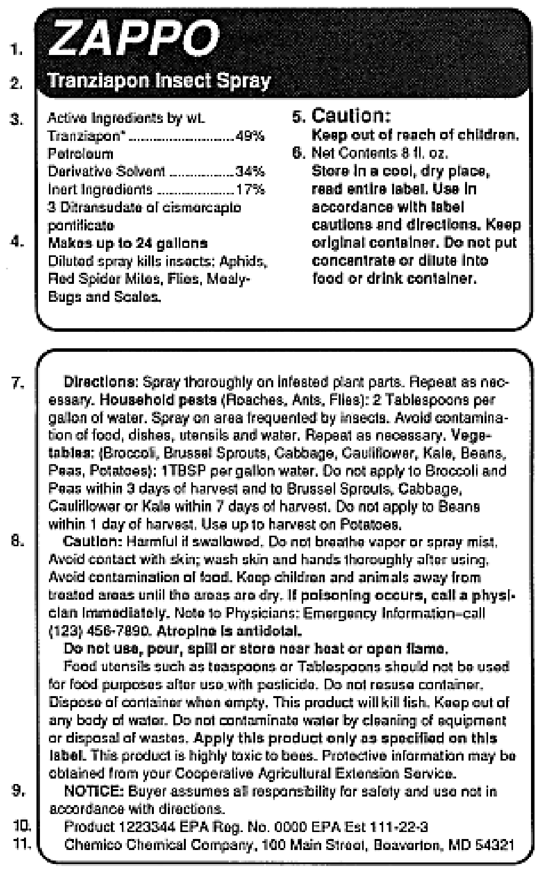
- *Specific action*: Actions that help the handler protect the routes of entry specified above

- *Protective clothing and equipment*: Lists any that are needed to prevent overexposure to the pesticide

- *Practical treatment*: Specifies the recommended first aid in case of overexposure

- *Environmental hazards*: Explains how misuse of the product can harm the environment

Pesticide Label Example



1. ZAPPO
2. Tranziapon Insect Spray
3. Active Ingredients by wt.
Tranziapon* 49%
Petroleum
Derivative Solvent 34%
Inert Ingredients 17%
3 Ditransudate of cismercaplo pontificate
4. **Makes up to 24 gallons**
Diluted spray kills insects: Aphids, Red Spider Mites, Flies, Mealy-Bugs and Scales.

5. **Caution:**
Keep out of reach of children.
6. Net Contents 8 fl. oz.
Store in a cool, dry place, read entire label. Use in accordance with label cautions and directions. Keep original container. Do not put concentrate or dilute into food or drink container.

7. **Directions:** Spray thoroughly on infested plant parts. Repeat as necessary. **Household pests** (Roaches, Ants, Flies): 2 Tablespoons per gallon of water. Spray on area frequented by insects. Avoid contamination of food, dishes, utensils and water. Repeat as necessary. **Vegetables:** (Broccoli, Brussel Sprouts, Cabbage, Cauliflower, Kale, Beans, Peas, Potatoes): 1TBSP per gallon water. Do not apply to Broccoli and Peas within 3 days of harvest and to Brussel Sprouts, Cabbage, Cauliflower or Kale within 7 days of harvest. Do not apply to Beans within 1 day of harvest. Use up to harvest on Potatoes.
8. **Caution:** Harmful if swallowed. Do not breathe vapor or spray mist. Avoid contact with skin; wash skin and hands thoroughly after using. Avoid contamination of food. Keep children and animals away from treated areas until the areas are dry. **If poisoning occurs, call a physician immediately.** Note to Physicians: Emergency Information–call (123) 456-7890. **Atropine is antidotal.**
Do not use, pour, spill or store near heat or open flame.
Food utensils such as teaspoons or Tablespoons should not be used for food purposes after use with pesticide. Do not resuse container. Dispose of container when empty. This product will kill fish. Keep out of any body of water. Do not contaminate water by cleaning of equipment or disposal of wastes. **Apply this product only as specified on this label.** This product is highly toxic to bees. Protective information may be obtained from your Cooperative Agricultural Extension Service.
9. **NOTICE:** Buyer assumes all responsibility for safety and use not in accordance with directions.
10. Product 1223344 EPA Reg. No. 0000 EPA Est 111-22-3
11. Chemico Chemical Company, 100 Main Street, Beaverton, MD 54321

Be sure to read and understand the label instructions for each pesticide that is in use.

- *Special toxicity*: Explains how to use the product without harming non-target organisms, such as honeybees, fish, birds, and other wildlife

- *Physical or chemical hazards*: Explains any special fire, explosion or chemical hazards the product can pose during transportation or storage

- *Reentry statement*: Gives the time that must pass between application of the pesticide and when it is safe to reenter the treated area

- *Storage and disposal*: Outlines recommended methods

- *Directions for use*: Occupies a large area of the label. Lists crops, sites and target pests for which the product is registered, along with recommended application rate, method of application, timing, any known compatibility or phytotoxic (plant-poisoning) problems, and other information about use. The period between application and when the crop is safe to eat ("days to withhold") is sometimes listed here.

Reasons It Is Vital to Measure Pesticide Exactly

- Using too little pesticide usually fails to manage the pest.
- Using too much pesticide:
  - wastes money.
  - could harm the user.
  - could harm the environment.
  - could make the crop unsafe to eat because of the toxic residues.

Signal words, symbols and color codes. A label may display a signal word such as "Danger—poison," "Warning" or "Caution," depending on how toxic the product is. The most poisonous products will also have a skull and crossbones on the label. Various measures are used to find the category to which a pesticide belongs. See the discussion below under "Pesticide Toxicity and Human Protection," including Table 8, as well as Tables 13 and 14 at the end of the chapter.

Pesticide label "color coding" schemes have been developed by the FAO and others. For example, in Zimbabwe the pesticide registration officer of the Plant Protection Research Institute collaborates with the Hazardous Substances and Articles Control Board to assign a color code to a pesticide. The color reflects the size of the pesticide's acute oral lethal dose (LD50), the concentration of its formulation, and the length of time it persists in the ecosystem after application. The colors green, amber, red and purple represent pesticides with LD50 ranges of >2,001; 500–2,000; 101–500; and 0.1–100 mg/kg body weight, respectively. In addition, the color coding system signals the hazards the chemical possesses; who, by law, may handle or use it; and the type of protective clothing a person must wear when handling or using the pesticide. See the Web site http://www.ifgb.uni-hannover.de/ppp/ppp_s01.pdf for more information on this concept.

Pesticide Transport

Pesticides should be transported where people are the least likely to be exposed to them. They should be placed inside another container or bag and kept as far from passengers as possible. Check the transporting surface to be certain that there are no nails, bolts, screws, or other sharp objects that could puncture pesticide containers. Never transport pesticides with persons or animals. Never transport pesticides where they could come into contact with groceries, livestock feed, seed or other products that might become contaminated. Pesticide containers should be well sealed and secured during transport to prevent spillage or loss in case of sudden starts, stops or turns.

Mixing and Loading Pesticide

Most pesticides are sold as concentrates that require dilution with a “carrier” (usually water) before application. Always read the label before mixing a pesticide; it will tell how much to dilute the formulated product and how much of the mixture to apply per unit of area.

It is essential to measure the exact amount of pesticide recommended. Applying smaller amounts usually does not manage the pest. Applying more than is recommended not only needlessly increases production costs but could also be harmful to the applicator and the environment. It could also make the crop unsafe to eat and/or hard to sell abroad due to excessive pesticide residues. Pour the specified quantity of pesticide into the water. If stirring is necessary, use a stick, never hands.

Make sure all the protective clothing specified on the label is available and is used. Soap and water for washing should be accessible as well. **If a pesticide spills or splashes onto the farmer during mixing, the next two minutes are critical.** Immediately remove clothing and wash affected areas thoroughly with soap and water.

Following the mixing process, close the containers securely and return them to storage. Wash all measuring and mixing containers and store. Wash all protective clothing, and store any that is not required for application.

Pesticide Storage

The success of pest management campaigns depends on pesticides being available in the areas that need treatment. Pesticides should be placed in a safe and secure storage area as close as possible to agricultural areas that are likely to need treatment. Pesticide stocks must be securely in place at the crop protection service’s bases and in villages before the rainy season, when transportation often becomes much more difficult.

A good storage facility should have a fenced and covered area for the pesticides. (A thorn-branch fence will do if other materials are unavailable or too expensive.) The facility should:

- be secure against illegal entries, as well as children and livestock, and locked when not in use;
- be constructed in a site not exposed to flooding during rainy season;

Management System for Pesticide Storage

A good management system is vital for storing pesticides safely. The system should ensure that people:

- Record dates of arrival and use for each pesticide.
- Post and teach storage requirements for each pesticide.
- Have stored pesticides tested periodically.
- Dispose of used/obsolete pesticides safely, as well as their containers.

- be isolated from dwellings, to avoid fire, leakage and water contamination;

- be supplied with water, to clean spills and fight fires;

- be well ventilated (aerated) to avoid concentration of toxic fumes;

- have a current inventory list of pesticide stocks;

- have protection gear such as suits, boots, gloves, goggles and breathing masks;

- have a first aid kit with antidotes; and

- be serviced by trained personnel familiar with measures to take in cases of poisoning.

The following considerations are also of vital importance:

- The pesticides must be kept dry; if they get wet, they lose their power to control pests. Therefore, the roof should be waterproof (zinc sheeting is good), and pesticides should be placed on a shelf or pallet—never directly on the floor or ground.

- Plants should not be allowed to grow around the storage area, because they will attract domestic animals to feed. Animals can be poisoned by eating plants that have been contaminated with pesticides.

A management system is needed to record the date each pesticide arrived at the facility, how long it stays in storage, and when it is removed for use. In addition, storage requirements for each pesticide must be posted and known by the management staff. Stored pesticides must be tested periodically to insure that the active ingredient is as described on the label and that the formulation concentration is correct. Also, disposing of unused and obsolete pesticides, and destroying their containers, must be part of the management system.

If no village storage facility is available, farmers may decide to keep pesticides on their farms for their own use. As far as possible, they should store pesticides in accordance with the principles described above. Place special stress on keeping the pesticides covered and dry; well ventilated; secure from thieves, children and animals; and isolated from the rest of the farm, with no plants growing around the pesticide area. Smallholder farmers, in particular, are often unaware of these principles, which should be carefully explained to them. Larger-holder farmers may have this information already, and may have a safe building where pesticides are stored.

Container Disposal

All empty pesticide containers must be destroyed and never reused. It is extremely dangerous to use them for anything else. Consult the pesticide label, the manufacturer, or the manufacturer's representative for specific recommendations regarding container cleanup and disposal. The following are general guidelines.

There are two basic methods for cleaning pesticide containers before disposal. Both require that the container be turned upside down and allowed to drain into the spray tank for at least 30 seconds, followed by adding water to the container and rotating it well to wet all surfaces, then draining it again into the spray tank as an additional dilutent.

- *Triple Rinse Method:* Add a measured amount of water or other specified dilutent so the container is one-fifth to one-fourth full. Rinse container thoroughly, pour into a tank, and allow to drain for 30 seconds. Repeat three times. The water rinsate (rinsewater) can be used to mix with or dilute more of the same pesticides, or it can be sprayed on the target crop.

- *Pesticide Neutralization Method:* Empty organophosphate and carbamate containers can be neutralized by washing with alkaline substances, though the wash water and rinsate are still dangerous. The following procedure is recommended for 200-liter barrels; use proportionally less material for smaller containers.

    1. Add 20 liters of water, 250 milliliters of detergent, and one kilogram of flake lye or sodium hydroxide.

    2. Close the barrel and rotate to wet all surfaces.

    3. Let stand for 15 minutes.

    4. Drain completely and rinse twice with water. The rinsate should be drained into a shallow pit in the ground located far away from wells, surface water or inhabited areas.

Containers cleaned by any of the above methods are still not safe to use for any other purpose. Glass containers should be broken; plastic or metal ones should be punctured or crushed. Containers can then be buried in an isolated area at least 50 cm below ground surface.

Safely Disposing of Containers

All empty pesticide containers must be destroyed and never reused.

- Clean the containers first (it is still unsafe to reuse them for any other purpose).
- Break glass containers; puncture or crush plastic ones.
- Bury the destroyed containers in an isolated area at least 50 cm underground.

Obsolete pesticides

As discussed above, obsolete pesticides are a major problem in most African countries. Many of these are not being properly stored: old, deteriorating pesticide barrels leak, non-experts such as children have access to them, streams flow nearby, and some are sold for use by unscrupulous or unknowing crop protection agents. Pesticides often degrade into chemical compounds even more dangerous and toxic than the original pesticide. Be aware of this and beware of allowing these old pesticides to be used in an IPM program. In fact, strongly discourage their use for any purpose.

Calibration, Product Quantity and Pesticide Application

Calibration of application equipment

Calibration of spray equipment is the process of adjusting the sprayer to deliver the correct amount of pesticide to manage the target pest, according to the rates recommended by the manufacturer. Pesticides are generally mixed with water, and the resulting mixture is applied using some type of sprayer. Water is used to dilute and "carry" the pesticide so the sprayer can deliver it to the plant or other target area. A sprayer *must* be properly equipped, maintained and calibrated for pesticides to be effective.

An adequately equipped, maintained and calibrated sprayer is essential for using pesticides effectively.

Determining the application rate**:** Three factors determine the rate at which many sprayers deliver the spray mixture to a given area: (1) the size of the orifice (opening) in the nozzle tip through which the spray mixture passes, (2) the pressure used to force the spray mixture through the nozzle, and (3) the speed at which the sprayer travels over the area being sprayed.

Nozzle tips. The nozzle regulates the flow rate, breaking up (atomizing) the mixture into droplets and dispersing them in a specific pattern. Nozzles come in different types and orifice sizes. As orifice size increases, so does the amount of spray mixture that passes through it in a given period. It is important to check the sprayer's calibration before each application involving a different spraying situation. If the orifice becomes badly worn, the nozzle will deliver the wrong amount of pesticide. In this case, the nozzle tip should be replaced.

Cone nozzles are preferred for applying fungicide and insecticide sprays where penetration and complete coverage of the plant foliage is important. These produce small, lightweight droplets that drift readily, so spraying should be done when the weather is calm. Cone nozzles are named for the spray pattern they produce, some producing a hollow cone, others a solid cone.

Pressure. The rate of spray application increases with the pressure. Gauges that measure the pressure created by the spray pump are available for many backpack sprayers, but few such sprayers actually have gauges. Pressure gauges are not as important for insecticide and fungicide application as they are for herbicide use.

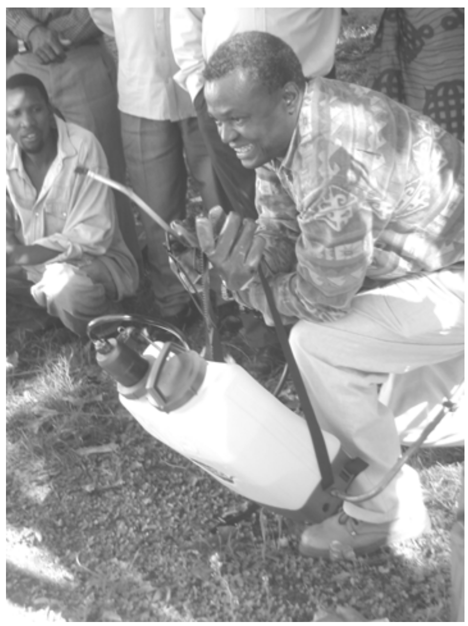
Speed of movement. The time the user will need to spray a given area must be determined when calibrating a sprayer. For applying fungicides and insecticides to row crops, this is the time the user will take to spray the crop plants thoroughly for a predetermined length of a row. Usually it is recommended that crops be sprayed to the "wet to runoff" point, when the spray just begins to drip from the foliage. Alternatively, one could determine the time required to spray a certain area, for example, two hectares. This method is useful for crops planted broadcast (i.e., not planted in rows).

Calibration**:** To calculate how much insecticide or fungicide material should be added to a given amount of water, one must first know how much water will be applied to a given area. Spray volume and pesticide rates are often expressed in terms of amounts required per hectare. In the following example, we will assume we are planning to use a chemical that is in liquid form. We will spray water over a small area to calibrate the sprayer and then convert this to liters per hectare.

To calibrate a sprayer *for crops planted in rows*:

1. Determine the space between rows (in cm) for the crop to be sprayed. Using this distance and Table 5, select the length of row to be used in calibrating the sprayer. For example, if the row spacing is 90 cm, use a row length of 11.1 m.

2. Select a section of a row with plants that best represent the average size of the crop to be sprayed. Then measure and mark off the distance obtained in Table 5.



Ensuring that a sprayer is working properly helps reduce environmental damage from pesticides and can prevent dangerous accidents.

3. Make sure the sprayer is clean and in good working order. Fill the sprayer with clean water only. Do not use any spray chemicals for the calibration test.

4. Using a watch, determine how long it takes to spray the plants in the section of row that you marked off, working at the same pace you would normally use when spraying a crop.

5. Next, while standing still in a convenient location, spray in the same way as before and for the same length of time, but now collect the water by spraying it into a suitable container. Then measure the water collected to determine how many ml were sprayed. If a cup to measure ml is not available, you may substitute an empty cold drink (soft drink) can. Measure the amount to the nearest 1/4 can. *Note: For this step, do not use containers that will be used to prepare food, since small amounts of poisonous chemicals may remain in sprayers even after cleaning.*

6. If you measured the water you collected in ml, then the number of ml collected is equal to the number of liters per hectare. Example: If you collected 475 ml, the amount of the total spray you will need to apply (water plus chemical) is 475 liters/ha.

   If you used a cold drink can to measure the water collected, you can use Table 6 to determine the spray volume per hectare. Example: If about 1.5 cans were collected, we can see from Table 6 that the rate per hectare would be approximately 510 liters/ha.

To calibrate *crops not planted in rows*:

1. Select an area that best represents the average topography to be sprayed. Measure and mark a section 2 by 10 meters in size.

2. Follow step 3 above.

3. Determine the time (in seconds) it takes to spray the entire area (see step 4), and follow steps 5 and 6 above.

To calibrate without use of a watch:

1. Follow steps 1 through 3 in the appropriate section above. If the crop to be sprayed is planted in rows, follow section (a). If the crops are not in rows, use section (b).

2. With this method, have the sprayer full when starting so it can be refilled to the same level. Spray the plants in the section marked off, being careful to cover the plant surfaces well just until the spray begins to drip from the leaves.

3. Measure the amount of water you need to use to refill the sprayer to the same level as before.

4. If you measured the water in ml, then the number of ml collected is equal to the number of liters required per treated hectare. If you used a cold drink can to refill the sprayer, go to Table 6 to determine the spray volume per hectare. For examples, see step 6 above.

Table 5. Select Calibration Distance to Use Based on Row Spacing of Crop to Be Sprayed

Row spacing (cm)	**Calibration distance (m)**
40	25.0
60	16.7
90	11.1
150	6.7

Table 6. Determine Liters per Hectare to Apply Based on Number of Cold Drink Cans of Water Collected

Note: 1 can holds 12 fl. oz. = 355 ml

No. of cans collected	**Volume/hectare (liters)**
½	170
¾	255
1	340
1¼	425
1½	510
1¾	595
2	680
2¼	765
2½	850

Determining the Amount of Chemical to Use

Adding the correct amount of chemical to each sprayer is as important as correctly calibrating the sprayer.

Adding the correct amount of chemical to each sprayer full of water is as important as correctly calibrating the sprayer. Various extension publications for particular crops list recommended rates of chemical products that should be used to control important diseases and insects. These publications often give the amount of chemical to be added to 5 liters of water or to one spray tank. Some publications list the amount of material to be applied per hectare. In this case, additional calculation is needed to determine the amount to be added to one sprayer tank. Two methods of doing this are given below:

Method 1: To find out what fraction of a hectare can be covered by one tankful of spray, divide the capacity of the sprayer tank by the number of liters needed to cover a hectare, as calculated in step 6 (previous page).

Example: If the sprayer holds 15 liters and it takes 475 liters to cover a hectare, then: 15 liters @ 475 liters/ha = .032 ha per tank (that is, one tankful will cover .032 ha).

Then, find the recommended application rate per hectare for the fungicide or insecticide you are using. If you multiply this by the fraction of a hectare covered by one tankful, you will obtain the amount of chemical to add to one spray tank.

Example: If the recommended rate for the chemical is 2 kg per hectare and one tankful will cover .032 ha, then: 2 kg/ha X .032 ha/tank = .064 kg (or 64 g). In other words, you will add only 64 g of chemical to one sprayer full of water.

Method 2: Table 7 lists the amount of product to add to a 15-liter spray tank for various recommended rates per hectare of chemical product and for several calculated spray volumes. For spray volumes not listed in the table, use the one nearest to your calculated amount.

Table 7. Number of Tablespoons (1 level matchbox) of Chemical to Add to 15-Liter Spray Tank for Recommended Chemical Rates and Spray Volumes

Recommended chemical use (kg/ha and liters/ha)	**Recommended chemical rate for calibrated spray volume (liters/ha)**					
	250	300	400	500	600	700
Kg of powder/ha	**Number of tablespoons or level matchboxes of chemical to be added to a 15-liter spray tank**					
1	6	5	4	3	2.5	2
2	12	10	8	6	5	4
3	18	15	12	9	7.5	6
4	24	20	16	12	10	8
5	30	25	20	15	13	10
Liters of liquid/ha	**Number of tablespoons or level matchboxes of chemical to be added to a 15-liter spray tank**					
1	3	2.5	2	1.5	1	1
2	6	5	4	3	2.5	2
3	9	7.5	6	4.5	4	3
4	12	10	8	6	5	4
5	15	12.5	5	10	7.5	6

Example: Two kg per hectare of chemical are recommended, and in your calibration you have determined that your spray volume is 475 liters per hectare. Using Table 7, you find that 475 liters per hectare is not listed. Since 500 liters is the closest amount, you look under that column and find that to get 2 kg of chemical per hectare, 6 matchboxes (tablespoons) of the chemical should be added to each 15-liter spray tank.

DON'Ts for Pesticide Safety

Do NOT:

- ✖ Buy more pesticide than you'll need for a single season.
- ✖ Mix more pesticide than you'll need to treat the desired area.
- ✖ Apply sprays or dusts when leaves and small plants are continually moving because of the wind (this means a wind speed of 4 m/second).
- ✖ Apply pesticides during the hottest part of the day.
- ✖ Apply pesticides if you think it will rain within 12 hours.
- ✖ Eat, drink, smoke, or chew tobacco while applying pesticide.
- ✖ Carry tobacco, food or drinks with you while spraying.
- ✖ Get into the path of any spray drift, or let others get in its path.
- ✖ Try to blow out a plugged nozzle with your mouth.
- ✖ Keep working if anyone shows signs of pesticide poisoning (start first aid immediately).
- ✖ Wash contaminated clothes with any other clothing.
- ✖ Let water from washing contaminated clothes or equipment get into streams, ponds or wells.

Applying Pesticides: Important Cautions

Avoid applying pesticide spray or dust if you see leaves and small plants continually moving and fluttering in the wind (i.e., when the wind is moving at about 4 meters/second). If too much pesticide drifts away from the treatment area, there is a good chance the pests will not be managed well. In addition, the drifting pesticide can harm the environment in other areas: it can affect human settlements, pollute waterways, and contaminate adjacent crops that are close to being harvested.

Refrain from applying pesticides during the hottest part of the day. As a general rule, do not apply between 10 a.m. and 6 p.m. Avoid applying pesticides if you think it will rain within 12 hours, rain is likely to wash the pesticide away. This wastes the pesticide, and it may run off into bodies of water or other inappropriate places.

Disposing of unwanted pesticides, a potentially dangerous undertaking, is difficult to do safely. Avoid this problem by buying only the amount needed for a single season and mixing only the amount needed to treat the desired area.

Recommended protective clothing must be worn at all times. Do not eat, drink, or smoke or chew tobacco while applying pesticides; tobacco absorbs them. Do not carry tobacco, food or drinks with you while spraying. Keep out of any spray drift and keep all others away from the area. If the nozzle gets plugged, do not try to blow it out with your mouth; use a small brush or soft stick. ***If you or a co-worker show signs of pesticide poisoning, stop spraying immediately and begin first aid.***

After applying pesticides, wash all equipment and protective clothing and store them in a secure area. Wash face, hands and other exposed parts of the body with soap and plenty of water. Wash all contaminated clothing separately from other clothing. As always, do not contaminate streams, ponds or drinking water wells during cleanup. Fish are very susceptible to most pesticides (that is why you should never eat fish found dead).

Toxicity, Human Protection and First Aid

Toxicity is the inherent capacity of a substance to poison living beings. A pesticide's toxicity is measured by performing **oral** (mouth), **dermal** (skin) and **inhalation** studies on test animals. The term *hazard* refers to the risk or danger of intoxication (poisoning) when a toxic substance is used. Pesticides vary in their toxicity to humans and are grouped into three categories. The relative toxicity of a pesticide is noted on its label by a **signal word**, as shown in Table 8. Two more detailed labeling systems are shown in Tables 13 and 14 at the end of the chapter.

Table 8. Relative Pesticide Toxicities Noted by Signal Word on Pesticide Label
Source: U.S. Environmental Protection Agency

Signal word	**Toxicity**	**Lethal oral dose** (for a 70 kg person)*
Danger **	Highly toxic	A few drops to 1 teaspoon (5 ml)
Warning	Moderately toxic	1 teaspoon to 1 tablespoon (15 ml)
Caution	Low toxicity	1 ounce (28 g or ml) to more than1 pint (473 g or ml)

*Lethal doses are less for a child or a person weighing less than 70 kg.
**Skull and crossbones symbol included.

Farmers who use pesticides are being exposed to poison, and it is crucial to keep such exposure to an absolute minimum. The danger can be reduced by following proper safety procedures. Most pesticide poisonings result from carelessness or a lack of knowledge about the safer handling of pesticides. The time spent learning about safer procedures is an investment in the health and safety of oneself, one's family, and others.

Time spent learning about safer procedures and how to use them is an investment in the health and safety of oneself, one's family, and others.

Pesticides can enter the body through four major paths: the skin, the mouth, the nose, and the eyes. The checklist below will help users to avoid these various routes of overexposure to pesticides.

To avoid dermal (skin) exposure:

- Check the label for special instructions or warnings regarding dermal exposure.
- Use recommended protective clothing and other equipment as listed on the label.
- Do not reenter the treated area until the sprayed-on pesticide has dried or the *reentry interval* (waiting period) is past.

To avoid oral (mouth) exposure:

- Check the label for special instructions or warnings about oral exposure.
- Never eat, drink, or smoke or chew tobacco while working with any pesticide.

Basic First Aid for Pesticide Exposure

Get medical advice quickly; provide first aid to victims while medical help is on the way.

Follow the first aid instructions on the pesticide label. Take the pesticide can or label to the doctor or medical practitioner.

For poison on skin:

- Act quickly
- Remove contaminated clothing and drench skin with water
- Cleanse skin and hair thoroughly with detergent and water
- Dry victim and wrap in blanket

For chemical burns:

- Remove contaminated clothing
- Wash with large amounts of running water
- Cover burned area immediately with loose, clean soft cloth
- Do NOT apply ointments, greases, powders or other medications to burn

Poison in Eye:

- Wash eye quickly but gently
- Hold eyelid open and wash with gentle stream of clean running water for 15 minutes or more
- Do NOT use chemicals or medicines in the water; they may worsen the injury

Inhaled Poison:

- Carry victim to fresh air immediately
- Open all windows and doors
- Loosen tight clothing
- Apply artificial respiration if the victim is not breathing or victim's skin is gray or blue. If the victim is in an enclosed area, do not enter without proper protective clothing and equipment. If proper protection is not available, call for emergency equipment from your fire department.

Poison in mouth or swallowed:

- Rinse mouth with plenty of water.
- Give victim large amounts (up to 1 liter) of milk or water to drink.
- Induce vomiting only if the label instructs you to do so. See "Procedure for Inducing Vomiting" on p. 44 (sidebar).

- Wash thoroughly with soap and water before eating, drinking, smoking or chewing tobacco.
- Do not touch lips to contaminated objects (such as nozzles).
- Do not wipe mouth with contaminated hands or clothing.
- Do not expose food, beverages, drinking vessels or cigarettes to pesticides.
- Wear a face shield when handling concentrated pesticides.

To avoid respiratory (breathing) exposure:

- Read the label to find out if respiratory protection is required.
- If respiratory protection is required, use only an approved respiratory device.
- Stay upwind during application.

To avoid eye exposure:

- Read the label to find out if eye protection is required.
- If eye protection is required, use goggles to protect eyes or a face shield to protect eyes and face.
- Keep pesticide container below eye level when pouring.

Table 9 contains a list of recommended protective clothing and equipment based on a product's formulation and the signal word on its label. Table 10 defines different types of toxicity based on how long symptoms take to develop, and Tables 11–12 list symptoms for various types of pesticide poisoning.

Basic First Aid for Pesticide Overexposure

Get medical advice quickly if you or any of your fellow workers have unusual or unexplained symptoms during work or later the same day. Do not let yourself or anyone else get dangerously sick before calling a health care provider or going to a hospital. It is better to be too cautious than too late.

First aid is the initial effort to help a victim while medical help is on the way. If you are alone with the victim, make sure the victim is breathing and is not being exposed further to the poison before you call for emergency help. Apply artificial respiration if the victim is not breathing.

Procedure for Inducing Vomiting

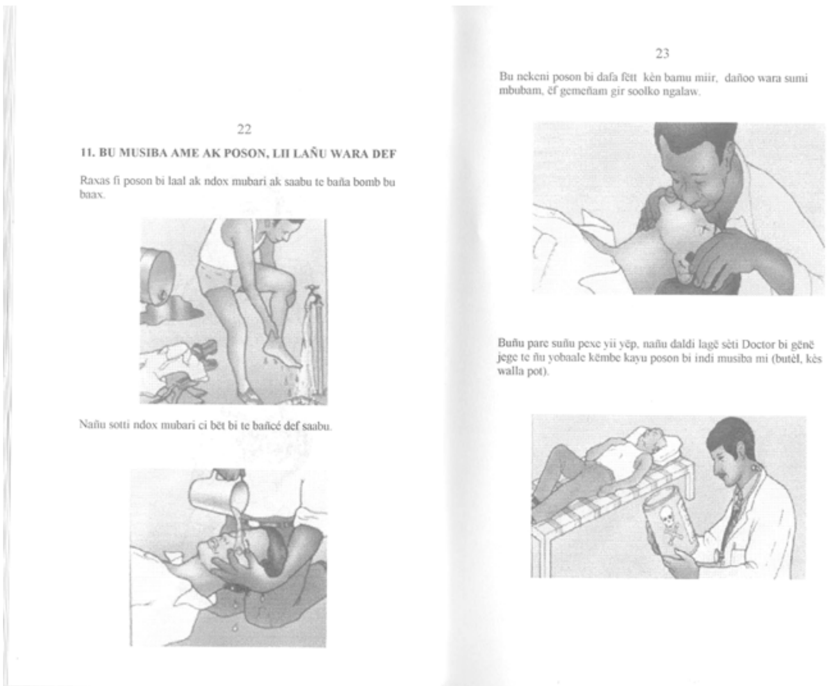
Induce vomiting *only* if the label instructs you to do so.

- Position the victim face down or kneeling forward; do not allow the victim to lie on his or her back, because vomit could enter the lungs and do additional damage.
- Put a finger or the blunt end of a spoon at the back of victim's throat or give syrup of ipecac.
- Collect some of the vomit for the physician if you do not know what the poison is.
- Do not use salt solutions to induce vomiting.

When *Not* to Induce Vomiting

- If the victim is unconscious or is having convulsions.
- If the victim has swallowed a corrosive poison—a strong acid or alkali. Such a poison will burn the throat and mouth as severely coming up as it did going down. It may also get into the lungs and burn them as well.
- If the victim has swallowed an emulsifiable concentrate or oil solution. These may cause severe damage to the lungs if inhaled during vomiting.

Read the first aid instructions on the pesticide label, if possible, and follow them. The information on page 43 may also be helpful. Do not expose yourself to poisoning while you are trying to help the victim. Take the pesticide container (or the label) to the physician. However, do not carry the pesticide container in the passenger space of a car or truck; put it in the trunk (boot), on the truck bed or up on the roof rack.



22

11. BU MUSIBA AME AK POSON, LII LAÑU WARA DEF

Raxas fi poson bi laal ak ndox mubari ak saabu te baña bomb bu baax.

Nañu sotti ndox mubari ci bët bi te bañcé def saabu.

23

Bu nekeni poson bi dafa fëtt kèn bamu miir, dañoo wara sumi mbubam, ëf gemeñam gir soolko ngalaw.

Buñu pare suñu pexe yii yëp, nañu daldi lagë sèti Doctor bi gënë jege te ñu yobaale këmbe kayu poson bi indi musiba mi (butèl, kès walla pot).

Get first aid to a victim of pesticide poisoning as fast as possible. Booklets, like this one used by USAID's AELGA program, can help farmers and workers respond quickly to an emergency.

Table 9. Protective Clothing and Equipment Guide

	Signal Words on Pesticide Label		
Formulations	**Caution**	**Warning**	**Danger**
Dry	Long-legged trousers and long-sleeved shirt; shoes and socks	Long-legged trousers and long-sleeved shirt; shoes and socks; wide-brimmed hat; gloves	Long-legged trousers and long-sleeved shirt; shoes and socks; wide-brimmed hat; gloves; cartridge or canister respirator if dust is in air or if precautionary statement on label says: "Poisonous *or fatal* if inhaled"
Liquid	Long-legged trousers and long-sleeved shirt; shoes and socks; wide-brimmed hat	Long-legged trousers and long-sleeved shirt; shoes and socks; wide-brimmed hat; rubber gloves. Goggles if required by label precautionary statement; cartridge or canister respirator if label's precautionary statement says: "Do not breathe vapors or spray mists" or "Poisonous if inhaled"	Long-legged trousers and long-sleeved shirt; rubber boots, wide-brimmed hat; rubber gloves, goggles or face shield. Canister respirator if label's precautionary statement says: "Do not breathe vapors or spray mists" or "Poisonous if inhaled"
Liquid (when mixing)	Long-legged trousers; long-sleeved shirt; shoes and socks; wide-brimmed hat; gloves; rubber apron	Long-legged trousers and long-sleeved shirt; shoes and socks; wide-brimmed hat; rubber gloves; goggles or face shield; rubber apron. Respirator if label's precautionary statement says: "Do not breathe vapors or spray mist" or "Poisonous [*or* fatal *or* harmful] if inhaled"	Long-legged trousers and long-sleeved shirt, rubber boots, wide-brimmed hat, rubber gloves, goggles or face shield. Canister respirator if label's precautionary statement says: "Do not breathe vapors or spray mists" or "Poisonous if inhaled"

Liquid (when mixing the most toxic concentrates)	Long-legged trousers; long-sleeved shirt; boots, rubber gloves, waterproof wide-brimmed hat	Water-repellent, long-legged trousers and long-sleeved shirt; rubber boots, rubber gloves, rubber apron; waterproof wide-brimmed hat; face shield; cartridge or canister respirator	Waterproof suit, rubber gloves, and waterproof hood or wide-brimmed hat.

Table 10. Types of Toxicity

Type	Number of Exposures	Time for Symptoms to Develop
Acute	Usually 1	Immediate (minutes to hours)
Subchronic	A few	2 days to 1 week
Chronic	More than a few	1 week to years
Delayed	1 or more	Long after exposure (often years later)

Table 11: Toxicity Categories with Common Symptoms

Category	System Affected	Common Symptoms
Respiratory	Nose, trachea (windpipe), lungs	Irritation, coughing, choking, tight chest
Gastrointestinal	Stomach, intestine	Nausea, vomiting, diarrhea
Renal	Kidney	Back pain, urinating more or less than usual, discolored urine
Neurological	Brain, spinal cord	Headache, dizziness, confusion, depression, coma, behavior change, convulsions
Hematological	Blood	Anemia (tiredness, weakness)

Dermatological	Skin, eyes	Rashes, itching, redness, swelling of skin (cutaneous swelling)
Reproductive	Ovaries, testes, fetus	Infertility, miscarriage, birth defects

Table 12. Symptoms of Acute Organophosphate Poisoning

Mild Poisoning	Moderate Poisoning	Severe Poisoning
Fatigue	Inability to walk	Unconsciousness
Headache	Weakness	Severe constriction of pupil
Dizziness	Chest discomfort	Muscle twitching
Blurred vision	Constriction of pupil	Secretions from mouth, eyes and nose
Too much sweating and salivation	Earlier symptoms are more severe	Breathing difficulty
Nausea and vomiting		Coma and death

Table 13. USEPA Toxicity Categories for Labels According to Hazard Indicator

Categories	Signal word	Oral Toxicity LD_{50}	Inhalation Toxicity* LD_{50}	Dermal Toxicity LD_{50}	Eye**	Skin
I	DANGER—POISON	Up to and incl. 50 mg/kg	Up to and incl. 0.2 mg/liter	Up to and incl. 200 mg/kg	Corrosion; corneal opacity not reversible within 7 days	Corrosion
II	WARNING	From 50 through 500 mg/kg	From 0.2 through 2 mg/liter	From 200 through 2,000 mg/kg	Corneal opacity reversible within 7 days; persisting for 7 days	Severe irritation at 72 hours
III	CAUTION	From 500 through 5,000 mg/kg	From 2 through 20 mg/liter	From 2,000 through 20,000 mg/kg	No corneal opacity; irritation reversible within 7 days	Moderate irritation at 72 hours
IV	CAUTION	Greater than 5,000 mg/kg	Greater than 20 mg/liter	Greater than 20,000 mg/kg	No irritation	Mild or slight irritation at 72 h

Categorie s	**Signal word**	**Oral Toxicity LD_{50}**	**Inhalation Toxicity* LD_{50}**	**Dermal Toxicity LD_{50}**	**Eye****	**Skin**
						hrs

*Based on 1-hour exposure: divide by 4 to reflect four-hour exposure
**The duration of the eye observation period now routinely extends to 21 days.

Table 14. WHO Classification System According to Acute Toxicity

Class	**Hazard Level**	**Oral Toxicity***		**Dermal Toxicity***	
		Solids*	***Liquids****	***Solids****	***Liquids****
Ia	Extremely Hazardous	5 or less	20 or less	10 or less	40 or less
Ib	Highly Hazardous	5–50	20–200	10–100	40–400
II	Moderately Hazardous	50–500	200–2,000	100–1,000	400–4,000
III	Slightly Hazardous	over 500	over 2,000	over 1,000	over 4,000

*Mg/kg body weight (based on LD_{50} for a rat)

**The terms “solids” and “liquids” refer to the physical state of the product or formulation being classified.

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Annex 1: Pesticide Use Checklist for PVOs and NGOs

The following checklist is intended to assist in identifying potential environmental problems with pesticide use. It will also help in guiding project management to ensure that pesticides are not used inappropriately. Since pesticide use is mainly an issue with agricultural projects involving trees or food production, livestock projects, and health projects (control of mosquitoes, schistosomiasis pathogens, tsetse fly, etc.), particular care should be taken with those sectors. The same caution should be used any time pesticides are used as part of project activities in any sector.

1. Check off all ways in which pesticides will be used:

	By Project Staff	*By Project Recipient*	*Others (Specify)*
Demonstration	________	________	________
Research	________	________	________
Training	________	________	________
Vector control	________	________	________
Others (list)	________	________	________

2. Check the technical expertise of the people to be handling pesticides:

	Project Staff	*Project Recipient*	*Others (Specify)*
Well-trained	________	________	________
Moderately trained	________	________	________
Not trained	________	________	________
Other (explain)	________	________	________

3. Pesticides are needed to manage pests on (check one or more):

______ Crops

______ Livestock

______ Others; please specify: ______________________________

4. Can your staff identify the main pest organisms?

_____Yes _____No

5. Do you know which pesticides are needed?

_____Yes _____No

6. List pesticides needed, indicating each commodity (crop type, livestock type, tree, etc.) and specify pests (name of specific insects, diseases, weeds, storage pests, etc.) needing control, using the format shown below.

Commodity	*Pest*	*Pesticide Common Name*	*Trade Name*

7. Pesticide Storage Facilities

a. Do you have a storage facility on the project site designated solely for pesticides?

______Yes. Describe:

______No

b. Is the storage shed well lit, well ventilated, and safe from flooding?

_____Yes _____No

c. Are pesticides kept away from food, feed and water?

_____Yes _____No

d. Are storage facilities secure and kept locked when not in use?

_____Yes _____No

e. Are all pesticides kept in their original, labeled containers?

_____Yes _____No

f. Are warning signs posted outside the storage sheds?

_____Yes _____No

g. Are pesticides stored away from flammable/combustible materials?

_____Yes _____No

h. Is there a well-established procedure for cleaning up spills?

_____Yes. Describe:

_____No

8. Safe Use of Pesticides

a. Do you have a place to mix the pesticides safely?

______Yes. Describe:

______No

b. Do you have protective clothing (e.g., rubber boots, coveralls, gloves, masks, eye protection)?

______Yes. Describe:

______No

c. Do you have measuring and mixing equipment?

______Yes. Describe:

______No

d. Do you have a supervisor in the project designated to oversee all pesticide operations?

______Yes. Name:____

Level of training: ____

______No

e. Is your staff familiar with appropriate pesticide disposal procedures?

_____Yes _____No

f. Describe how you plan to dispose of pesticide containers:

Metal: ____

Glass: ____

Plastic: ____

Paper: ____

Cardboard: ____

g. Is your staff familiar with first aid procedures for pesticide poisoning?

______Yes ______No

h. Are emergency procedures in place in case of accidental poisonings?

_____Yes. Briefly describe:

_____No

i. Are there procedures for observing restricted-entry intervals after applications?

_____Yes _____No

9. Application Equipment

a. Describe equipment you will use to apply the pesticide.

b. Is there a trained person on the project whose job is to maintain application equipment, including nozzles and sieves?

______Yes ______No

c. Are spare parts available in local stores?

______Yes ______No

10. General Pest Management Concerns

a. Have you identified pesticide-related risks in your project area and analyzed whether pesticide use is justified, is affordable, and can be managed and supervised adequately?

______Yes ______No

______N/A

b. Will your staff be training other people in pest management and pesticide use?

______Yes (whom?)

______No

c. Are available funds for necessary materials, training methods, and follow-up included in your project paper?

______Yes. Estimated costs: ____

______No

11. IPM approach

a. Is the project promoting adoption of preventive, nonchemical management measures?

_____Yes _____No

If yes, indicate which measure (crop rotation, biocontrol, use of resistant cultivars, crop diversification, no-till or reduced tillage, sanitation, manual weed destruction, etc.):_____________________

____

b. Are pesticides being applied only as a last resort and based on action threshold criteria? Are pest monitoring procedures being used to determine the need for pesticide treatments?

_____Yes _____No

c. Can farmers and project extensionists readily distinguish pest from nonpest organisms? Can they recognize common beneficial species (pollinators, predators, parasitoids)?

_____Yes _____No

12. Environmental Impact

a. Are there wildlife sanctuaries, preserves or any other protected habitats in or near the project implementation area that might be affected by pesticide use?

_____Yes. Describe:

_____No

b. Are there water bodies (lakes, lagoons, reservoirs, rivers, streams, estuaries, etc.) near the project areas that might be subject to pesticide contamination through drift, runoff or spills?

_____Yes. Describe:

_____No

c. Are wildlife and domestic animals protected from poisoned baits?

_____Yes. Describe how:

_____No

13. Pesticide Monitoring

Is there a system in place for tracking pesticide use activities, including frequency of application, techniques, chemicals used, doses, target pests, effectiveness, criteria for applying, and safe use practices?

_____Yes

_____No

14. Literature Needs

Have you included needed literature on pesticide safety and IPM techniques and technologies in your activity?

_____Yes

_____No

15. Check off areas where additional assistance may be needed:

	Consultancy	*Training*
Pest identification	____________	_________
Pesticide selection	____________	_________
Handling pesticides (transport, mixing, loading, application, equipment cleanup, disposal)	____________	_________
Application equipment	____________	_________
IPM	____________	_________
Pesticide storage	____________	_________
Protective clothing	____________	_________
Measuring & mixing equipment	____________	_________
Training (designate activity)	____________	_________
Literature	____________	_________
Training materials	____________	_________
Other (specify)	____________	_________

Annex 2: Measurement Conversions

English to Metric

Multiply	By	To Get
Acres	0.405	Hectares
Feet	30.48	Centimeters
Feet	0.305	Meters
Inches	2.54	Centimeters
Ounces*	28.35	Grams
Pints	0.473	Liters
Pounds	453.592	Grams
Quarts	0.946	Liters
Tons**	907.185	Kilograms
Yards	0.914	Meters
Pounds per acre	1.121	Kilogram per hectare
Pounds per gallon	119.826	Grams per liter

* Ounces shown here are avoirdupois. Multiply troy ounces by 31.104 to get grams.
**Tons shown here are short tons. Multiply long tons by 1,016.047 to get kilograms. Multiply metric tons by 1,000 to get kilograms.

Metric to English

Multiply	By	To Get
Grams	0.035	Ounces (dry)
Hectares	2.47	Acres

Multiply	By	To Get
Kilograms	2.205	Pounds
Kilometers	3281	Feet
Kilometers	0.621	Miles
Liters	0.264	Gallons
Liters	2.113	Pints
Liters	1.057	Quarts
Meters	3.281	Feet
Meters	39.37	Inches
Meters	1.094	Yards
Kilograms per hectare	0.89	Pounds per acre

English

Multiply	By	To Get
Acres	43,560	Square feet
Acres	4,840	Square yards
Cups	8	Ounces (fluid)
Cups	16	Tablespoons
Feet	12	Inches
Feet	0.333	Yards
Gallons	128	Ounces (fluid)
Gallons	8	Pints

Multiply	**By**	**To Get**
Gallons	4	Quarts
Miles	5,280	Feet
Miles	1,760	Yards
Miles per hour	88	Feet per minute
Miles per hour	1.467	Feet per second
Miles per minute	88	Feet per second
Miles per minute	60	Miles per hour
Ounces (dry)	0.063	Pounds
Ounces (fluid)	0.063	Pints
Ounces (fluid)	0.031	Quarts
Pints	0.125	Gallons
Pints	0.5	Quarts
Pints	2	Cups
Pints	16	Ounces (fluid)
Pounds	16	Ounces (dry)
Quarts	2	Pints
Quarts	0.25	Gallons
Quarts	32	Ounces (fluid)
Quarts	2	Pints
Tablespoons	3	Teaspoons
Yards	3	Feet
Yards	36	Inches

Metric

Multiply	**By**	**To Get**
Grams	0.001	Kilograms
Grams	1,000	Milligrams
Kilograms	1,000	Grams
Meters	0.001	Kilometers
Meters	100	Centimeters
Meters	1,000	Millimeters
Square meters	0.0001	Hectares
Hectares	10,000	Square meters
Hectares	0.01	Square kilometers
Square kilometers	100	Hectares

Chapter 14

Rural Roads

Contents

Brief Description of the Sector	14-1
Potential Environmental Impacts	14-1
Sector Program Design-Specific Guidance	14-4
Mitigation and Monitoring Issues	14-10
Resources and References	14-24
Annex A: Sample Environmental Matrix	14-27

Road improvements can bring substantial economic and social benefits to both rural communities and national economies. But they may also lead to significant and long-lasting environmental damage.

Brief Description of the Sector

USAID support for rural roads is generally confined to the development or rehabilitation of non-asphalt roads, with one- or two-lane unpaved surfaces. These may be constructed to provide farmers with access to markets or to increase community access to services, such as health care or schools. In some cases USAID may also provide support to improve roads leading to protected areas, or within them, in order to encourage tourism.

Road improvements can bring substantial economic and social benefits to both rural communities and national economies. But they may also lead to significant and long-lasting environmental damage. That is why USAID's environmental procedures typically require an Environmental Assessment before any major new road construction. This section briefly summarizes a few of the major impacts and outlines key mitigation measures, in order to familiarize project developers and mangers with these issues.

Practitioners are also referred to *Low-Volume Roads Engineering Best Management Practices Field Guide* (Keller and Sherar 2003 [forthcoming]), developed for the USDA Forest Service's International Programs and USAID. Many other excellent references are listed in the Resources and References section of this briefing; these offer technical guidance on best practices for road improvements. Almost all of these are drawn from Keller and Sherar's bibliography.

Rural Roads

In this chapter, you will learn about:

- Common types of environmental damage from road projects
- Proper planning of road projects to avoid environmental degradation
- Putting operation and maintenance programs into effect to prevent and mitigate environmental impacts
- Best means of decommissioning roads to prevent erosion and loss of resources

Potential Environmental Impacts of Development Programs in the Sector and Their Causes

Many of the most common adverse environmental impacts associated with road improvements are summarized in Annex A, "Sample Road Improvements Environmental Impact Matrix." Of these, some of the most significant may include:

Soil erosion. Soil erosion is often caused by failing to keep water off road surfaces. Roads that cross hilly or steep terrain without following contours

Potential Environmental Impacts

Some impacts of road projects are:

- Soil erosion
- Degradation of water quality
- Adverse effects on quantities of water
- Altered hydrology and flooding
- Deforestation
- Damage to valuable ecosystems and habitats
- Damage to scenic quality and tourism
- Adverse impacts on human health and safety
- Changes to local culture and society

or minimizing grades are especially susceptible to erosion, as are roads that collect water and do not have enough side drainage to handle heavy precipitation or abnormal flooding.

Roads may also contribute to soil erosion through the development of multiple tracks, as travelers try to avoid standing water and ruts. Multiple track development occurs wherever inadequate attention is paid to keeping standing water off the road surface. These effects may be particularly pronounced where roads pass through "black cotton" heavy clay soils (vertisols) or across wetlands. Abandoned roads, if not properly decommissioned, can also become gulleys, with severe erosion impacts. Other barren areas associated with roads can contribute to soil erosion, including building material sources, work areas, temporary routes, excessively wide shoulders, and turnout or parking areas.

Degradation of water quality. Water quality may be damaged by soil erosion and the siltation of nearby rivers, streams, lakes and wetlands. The chief indirect cause of siltation is agricultural development. Such development tends to increase significantly with the expansion of new roads into previously inaccessible areas, but can also occur with the rehabilitation or upgrading of existing roads. Siltation also occurs as a secondary effect of soil erosion resulting from road improvements.

Adverse impacts on water quality may also be associated with poor management of fuel and lubricants at road camps, vehicle maintenance depots and fueling areas.

Borrow pits associated with road construction and maintenance fill with water during rains, creating safety hazards and pools that attract mosquitoes and other disease vectors

Adverse effects on water quantity. Large quantities of water are needed to help prepare and compact the road surface during road construction and maintenance. Although this demand for water is temporary, it may significantly affect local water supplies. In arid and semi-arid areas, drawing water for road improvements may harm aquatic species and farm production, especially if the water is taken during dry seasons.

Roads and quarries or "borrow pits" may also create artificial ponds and lakes (impoundments) that breed mosquitoes or harbor water-borne diseases. Road builders may create such ponds inadvertently, by damming gullies or other small catchment areas or streams, or intentionally, by constructing retention basins and settling ponds to minimize erosion and sedimentation.

Altered hydrology. Roads crossing areas with high water tables or wetlands may act like dams to block surface and sub-surface water flows. This is especially true where large quantities of initial material must be added to raise the road above the land surface, and where new material must be added annually to keep the road elevated. Under these circumstances, land on one side of the road can become much wetter than it was before the improvement, while land on the opposite side may be drier. This may adversely affect crop production, the composition of species in the local ecosystem, and road stability.

Alternatively, poorly installed culverts in wet or meadow areas may concentrate water and then form gullies upslope and/or downslope of the road. These gullies can subsequently drain the area and contribute to drying up the wetland.

Deforestation. Opening up new roads for expanded agricultural development puts adjacent forests at risk, especially where no effective forest management systems are in place. Typically, the most significant impact on forests results from the clearing of land for farms. However, once a road is in place, it also provides access to people wanting to supply urban or peri-urban charcoal and fuelwood markets.

Damage to valuable ecosystems and habitats. International concern over the protection of biodiversity continues to grow. Inadequate attention to biodiversity issues in road improvement projects can lead to the loss of species locally and to significant adverse effects on threatened or endangered species. New roads, or the rehabilitation of existing roads, may disrupt the integrity of plant and animal populations and permanently alter sensitive ecosystems.

The construction of new roads may also lead to the introduction of exotic or non-indigenous flora and fauna that may severely destabilize local plant and animal communities. Road access can also contribute to poaching and the trapping of exotic species. High-speed roads can significantly raise animal mortality (road kill).

Declines in scenic quality. Construction of new roads or the realignment of existing roads may adversely affect viewsheds (scenic vistas). Under some circumstances, such damage can lower tourism revenues. The cumulative effects of poorly located and poorly managed quarries and borrow pits supplying building materials for road projects may also cause significant loss in scenic values.

Adverse impacts on human health and safety. Potential concerns include:

Dust and noise. Depending on local conditions and the vicinity of houses and communities, dust and noise may damage human health during construction and, especially, once the road is in use. The health of road construction and maintenance staff may also be adversely affected by noise and dust produced from construction, road rehabilitation and maintenance.

Spread of communicable diseases. Road improvements increase communication among rural and urban populations. This in turn increases the potential for exposure to sexually transmitted diseases (including HIV/AIDS) and other communicable diseases such as tuberculosis. Road construction crews are often the first sources of such infections in an area.

Spread of water-borne diseases. Where poor road design and maintenance result in poor drainage and areas of standing water, the risk of water-borne disease such as cholera or malaria increases. The same is true for standing water found in open quarries and borrow pits.

Traffic hazards. Road improvements, especially those that allow increased vehicular speed, can lead to significant increases in accident rates for both human and animal populations.

Road works hazards. The operation of road works machinery often endangers both operators and laborers during construction and road maintenance. Poorly planned borrow pits and quarries for road works can also pose threats, ranging from falls from quarry faces to drowning in quarry pits that have become standing water reservoirs.

Change local culture and society. The development of new roads, or rehabilitation of existing ones, often improves personal livelihoods. Access to educational opportunities and to social services, including health care, is often a key rationale for road improvements. However, socio-cultural values may also be altered and the stability of communities adversely affected by exposure to rapid social change or tourism.

Road construction and maintenance may also provide income for local laborers and farmers. However, under some circumstances it could compete with farms for labor during harvest and planting seasons.

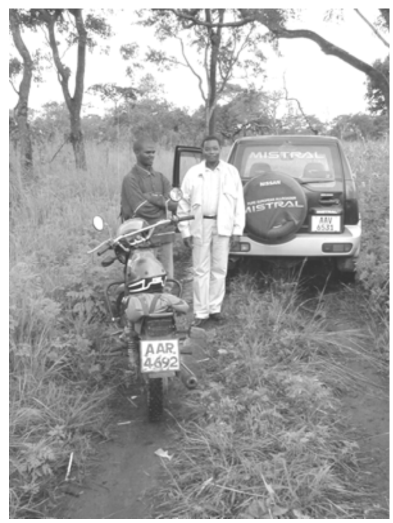
Planning and Design Elements

It is particularly important to assess the need for, and purposes of, a new road. Some ways of accomplishing this are to:

- Estimate future demand for transport and road use
- Assess the long term impact of limiting building or reconstruction of a road
- Use professional hydrologists, engineers and social scientists in planning and assessing a project
- Follow land contours in road building
- Provide specifications for designing and maintaining drains
- Properly assess the need for construction and road-building materials from quarries, forests and "borrow pits"
- Train equipment operators and maintenance personnel
- Develop and erosion control plan for every project

Sector Program Design—Some Specific Guidance

If your organization plans to undertake rural road improvement activities, engineering, ecological and social science expertise should be engaged, at a minimum, and the references listed at the end of this section should be reviewed in depth.



One important aspect of road building is anticipating future development consequences. Here a road was built in a forested area, leading to in-migration and indiscriminant cutting for charcoal production

Many of the impacts summarized above can be avoided or minimized through careful attention in the initial planning and design stage. Specifications can be incorporated into construction contracts or road works procedures for governments or communities, and appropriate training in mitigation can be provided during construction, operation and maintenance.

Planning and design

For this sector it is particularly important to evaluate the **need** for the road by assessing the **purposes** it will serve. For example, if the primary purpose is to transport produce from farm to market, approximate tonnages and seasonal transport patterns need to be identified. Then the costs and benefits of **potential alternatives** should be weighed. In some cases, transport by water, rail, bicycle or footpath may prove more practicable and desirable from an economic and environmental standpoint.

Similarly, if the primary purpose is tourism, then road construction or rehabilitation should be weighed within the context of overall plans for the transportation network. In some cases tourist roads can be re-routed to improve effects on viewsheds (for example, by following contours, avoiding straight, highly visible stretches, creating more pleasing meandering tracks through woodlands, etc.). In other cases, building walking trails instead of roads can improve visitors' experiences and also provide greater protection to sensitive resources and ecosystems in protected areas.

Planning and design suggestions include:

- Estimate future demand in order to decide on the type and size of road to be provided. It is important to decide how many vehicles can be expected to move on the road and the approximate tonnage they will carry seasonally. This information is needed both to design the road to last and to balance environmental sustainability with human needs.

- Assess the long-term impact of the road against the "no-action" alternative, since road improvements can have many direct and indirect effects on the environment. Over a 20- or 30-year period, these impacts, such as increased agricultural expansion or deforestation, may prove cumulative and highly significant. Ancillary developments can be expected, including gas stations, restaurants, hotels, markets, shops, retail stores and bars. In the case of road improvements associated with protected areas, a long-term benefit can be an increase in revenues for the protected area management systems from consumptive uses (e.g., getting food and shelter) and non-consumptive ones (e.g., sightseeing). However, these must be balanced against the potential damage to sensitive ecosystems and biodiversity.

A rural road in Zambia. Upgrading the road will require elevating the roadbed across a wetland area, adversely affecting local water flow. Could USAID funds still be used for this project?

- In siting roads, ensure that professional hydrologic and engineering studies are done first, to avoid potentially adverse impacts on soils; to minimize possible effects on surface or sub-surface water resources; to ensure correct design of drainage structures and systems; and to reduce the potential for damage from unusually heavy rains and floods, including the rare but catastrophic kind known as "100-year floods." Avoid problematic areas such as springs, wetlands, landslides, steep canyons, flood plains and large rock outcrops. Be sure to involve hydraulic and geotechnical specialists in planning expensive and high-risk structures such as bridges, retaining walls and slide stabilization structures.

- Require that road designs follow contours and minimize harm to viewsheds where feasible.
- Provide specifications for road design and maintenance that keep water off road surfaces, such as use of camber and turnout drains.
- Ensure that specifications cover the quantity of road construction material needed and its potential sources, based on the quantity and quality of material at various sites. Prepare quarry and borrow pit management plans that identify locations, specify amounts to be removed from each site, and provide specific instructions for reclamation at each site. Quarries and pits are often left unclosed because the planners never decided how much of each resource should be used and thus never prepared a plan for phased closure. Develop these plans in consultation with affected stakeholders. (**Note:** The maintenance of a rural unpaved road for 20 years or more can require extensive use of road material, and unplanned use of quarries and borrow pits can cause very significant harm over time.)
- Provide for training of equipment operators and road works crews in environmentally sound road construction and maintenance.
- Develop a Project Erosion Control Plan for every construction or reconstruction project.

Special areas for consideration

Maintenance and operation are the areas where most adverse of road projects impacts occur. Be sure to train all equipment operators in the environmentally sound operation of their machinery. Maintenance personnel should be trained to maintain the roadway in a manner that prevents erosion and damage to water and natural resources.

Decommissioning is also an important aspect of a road project. Old roads should be blocked, to prevent their continued use, or "ripped" to encourage revegetation.

Operation and Maintenance

The main goal of environmentally sound road maintenance is to keep the road in working condition and minimize environmental damage. Good road maintenance practices that keep the road usable and durable, such as clearing drainage structures and restoring camber, will minimize much of the environmental damage the road might cause. Other practices, such as proper management of petrol and oil from equipment, are also necessary for optimal environmental protection.

The day-to-day work of road maintenance involves adjusting road surface and drainage structures to control the flow of water over and alongside the road, clearing vegetation, maintaining vehicles, and managing road use and user behavior.

Accomplishing these tasks effectively requires a good management plan and well-trained and equipped road works personnel. *When adequately funded,* these elements together can ensure that roads remain in good condition and minimize environmental damage.

Poor or inadequate maintenance—a primary cause of environmental damage from unpaved roads

Environmental damage from unpaved rural road construction frequently stems from insufficient or poor quality maintenance. These in turn derive from poorly or incompletely trained maintenance personnel, broken or incorrect equipment, and lack of regular maintenance schedules. To succeed, a maintenance program for rural unpaved road must therefore:

- *Provide timely, comprehensive, regular training to equipment operators.* For example, well-trained grader operators are key to the proper shaping of road surfaces that will direct water away from vehicle tracks and keep it from accumulating on road surfaces. Equipment operators rarely receive adequate training and frequently fail to perform even basic standard procedures, such as keeping logbooks on equipment use. Operators should be given good training and frequent refresher courses on correct and environmentally sound use of their equipment.

- *Purchase appropriate, maintainable equipment, apply preventive maintenance, and keep mechanics trained and equipped; consider using manual labor as an alternative.* In the average road maintenance operation in Africa, most of the heavy road equipment is broken. If the equipment is not available when needed, roads may incur heavy, costly damage. To keep equipment in working order:

    1. Only purchase equipment in good working condition and suited to the types of tasks it will be used for. It should be of the correct size, purpose and durability and of a brand and model for which replacement parts are readily available.

    2. Carry out regular preventive maintenance by keeping records on use, stocking a full array of tools, hoists, spare parts, etc., and hiring mechanics who can read and understand foreign technical equipment manuals. Alternatively, if possible, contract with a private firm to perform preventive maintenance.

    3. Provide sufficient funding for operation and repair. Try to account for expected recurring costs and assign funds to cover them in the annual budget.

    4. An alternative approach is to use local manual labor and hand tools for road maintenance instead of heavy equipment. In some cases this may be both practical and economical, and it avoids the problems associated with heavy equipment. Hand labor–based methods also create employment opportunities, often enhance workers' skills, and can improve economic conditions in their home towns and nearby communities. Building local capacity in this way may make sustained maintenance of the road truly achievable.

- *Develop and follow a good management plan.* A good management plan, and the annual work plans derived from it, should encompass a number of elements, including timetables for maintaining sections of the road network; a schedule for introductory and refresher training for equipment operators and mechanics, as well as a list of topics to be covered in the training; and, possibly, a schedule and instructions for routine maintenance of equipment.

Other sources of environmental damage

The overall management plan must also address other sources of environmental damage associated with building and maintaining rural roads, including spilling and dumping of solid waste, hazardous fluids and solvents; off-road driving and use of roads in the rainy season; the spread of invasive non-native plants; adverse impacts from extracting murram and other road repair materials; and the spread of HIV and other diseases.

- *Maintaining vehicles.* Dumping and spillage of hazardous fluids generated during vehicle maintenance, such as used oil, petrol and solvents, is a common problem. It can be avoided by training staff in sound practices and installing correctly designed maintenance structures such as concrete pads for vehicle servicing. Equipment operators and mechanics should receive training in the safe storage, use and disposal of fuel, lubricants, solvents and other chemicals.

    - *Off-road driving and out-of-season road use.* Much off-road driving near existing roads results from drivers' attempts to avoid deep ruts and flooding in the official roadway. Regular, correct maintenance of the road surface and drainage system will minimize the problem by preventing the flooding and the growth of ruts. Wet-season traffic on roads designed only for dry-season use can severely damage the road surface and promote erosion. Closure and enforcement are the recommend management measure, but they often provoke off-road driving. The best solution, if there is a significant demand during the rainy season, is to upgrade the road for wet use.

- *Invasive plants.* Attention also needs to be paid to ensuring that crews are trained in the early removal of exotic plant species and preservation of native plants, especially when roads pass near or within protected areas.

- *Quarries and borrow pits.* Extraction of road materials from quarries and borrow pits must be **closely supervised,** and procedures for reclamation, which should have been prepared during the planning and design stage, must be carefully followed.

- *HIV/AIDS and other diseases.* Road crew members from other geographic areas can spread various health problems, especially HIV/AIDS and other sexually transmitted infections (STIs), to local populations. To protect both employees and local residents, road maintenance projects should implement HIV-prevention programs that focus on changing risky behaviors and the parts of organizational culture that encourage them, by encouraging condom use, by teaching how HIV is spread and how to reduce STIs, by promoting tolerance of HIV-infected individuals, and by encouraging voluntary testing. Three common and relatively inexpensive first steps are to provide regular HIV/STD awareness training, condom use education, and easily accessible free condoms. Sources of more detailed guidance can be found in this guide's *References and Useful Resources* section.

A well-designed decommissioning plan helped a Zambian landowner and a road construction company convert a construction camp into a hotel complex.

Decommissioning

Re-alignment of an existing road is not uncommon in rural road improvement programs. When this occurs, old roads may need to blocked off with stones, mounds of earth, or other devices to prevent continuing use. In some cases the old surface must be scraped for drainage or "ripped" to encourage revegetation.

Table 1: Environmental Mitigation and Monitoring Issues for Rural Roads Projects

Activity	**Impact** *The activity may. . .*	**Mitigation** Note: Mitigations apply to specified project phase: *Planning and Design (P&D), Construction (C), or Operation and Maintenance (O&M)*
Planning and Design in General (New and Existing Roads)		
Identification and weighing of alternatives		• Identify known and potential areas of ecological, archeological, paleontological, historic, religious or cultural significance and ecologically sensitive areas such as tropical forests, wetlands, and other areas of high biodiversity or threatened species along possible routes (P&D)
Establishing design standards	Damage valuable ecosystems and habitats Damage valuable historic, religious, cultural, and paleontological resources Change local culture and society Cause soil erosion Degrade water quality and/or alter hydrology Mar scenic views Lead to injury, disease, or death of workers, and local residents	• Choose or develop design standards for each facet of construction and related activities, e.g., road bed, road surface drainage, culvert installation, erosion control, revegetation, stream crossing, sensitive areas, steep slopes, material extraction, transport and storage, construction camps, decommissioning, etc. (P&D) • Provide plans to identify and protect sensitive habitats (P&D) • Take patterns of local weather and natural phenomena into account, e.g., fog, flooding, earthquakes, heavy rain, mudslides, drought, etc. (P&D) • Develop an Erosion Control Plan for all projects (P&D)

Activity	Impact *The activity may. . .*	Mitigation Note: Mitigations apply to specified project phase: *Planning and Design (P&D), Construction (C), or Operation and Maintenance (O&M)*
Planning route	Damage valuable ecosystems and habitats Damage valuable historic, religious, cultural, and paleontological resources Change local culture and society Cause soil erosion Degrade water quality Alter hydrology Contribute to deforestation Mar scenic views	• Have a multidisciplinary team involved in planning new routes. Ideally the team will include an ecologist, geotechnical and road engineer, soil scientist, hydrologist and other relevant professionals, such as an archeologist or tourism specialist (P&D) • Avoid routing road through sites of known paleontological, archeological, historic, religious or cultural significance (P&D) • Avoid routing across agriculturally productive soils (P&D) • Take problem areas involving soil and slope stability into account. Note seasonal and long-term (50- and 100-year) flooding patterns (P&D) • Whenever possible, site roads to follow hill contours (P&D, C) • Avoid creating road grades of greater than 10% as well as long straight downhill stretches (P&D) (C) • Identify sites for temporary/permanent storage of excavated material and construction materials. If excavated material will not be reused, decide how it will be disposed of or shaped (P&D) (C) • Keep the route a safe distance from river and stream banks (P&D) • Avoid environmentally sensitive areas, such as wetlands, and places near protected areas or relatively undegraded forests. Explore possible “compromise” alternatives such as building a narrow, improved trail across protected area lands to provide access on foot, bicycle or motorcycle, with construction of main access roads around these areas (P&D) (C) • Avoid constructing roads through forest areas, especially tropical forest, if possible. If clearing is unavoidable, protect or restore forests elsewhere within the drainage basin as close as possible to those that were lost (P&D) • Minimize impacts on viewsheds (scenic landscapes) by avoiding planning roads that cut long straight paths across valleys and plains. Instead, hide roads beneath forest cover to minimize aesthetic damage, and provide meanders where feasible (P&D) • Avoid siting roads where they may disturb animal behavior such as feedin, mating, and migration patterns (P&D) • If sensitive areas cannot be avoided, involve ecologists and engineers in designing road, construction camp, quarries and other areas. (P&D) (C)

Activity	**Impact** *The activity may. . .*	**Mitigation** Note: Mitigations apply to specified project phase: *Planning and Design (P&D), Construction (C), or Operation and Maintenance (O&M)*
Constructing road surface	Increase sedimentation Cause discomfort to road users	• Stabilize the road surface with gravel/murram and other rocky surfacing material (P&D) (C) • Elevate road surface (measure from base of wheel tracks) above side channel water (see figure 3-1.2) (P&D) (C) • Clearly define the type of road surface shape and drainage method—insloped, outsloped, or cambered/crown roadway—to be used for each section of roadway (see figures 3-1.2 - 3-1.5 for examples of cambered roadway) (P&D) (C)
Drainage	Cause soil erosion Degrade water quality Alter hydrology Damage valuable ecosystems and habitats	• Install drainage structures during construction instead of after construction. Most erosion associated with roads occurs in the first year after construction. Delaying installation of the drainage features greatly increases the extent of erosion and damage during the first year (P&D) (C) • Clearly define the type of road surface shape and drainage method—insloped, outsloped, or crown roadway—to be used for each section of roadway. Use outside ditches to control surface water when necessary, but avoid general use, as they concentrate water flow and require the road to be at least a meter wider. Install frequent structures, such as berms or ditches , to divert water off the road before it directly reaches live stream channels (see figure 3-1.2 and 3-1.4) (P&D) (C) • Install frequent diversion structures, such as cross drains, drivable, rolling dips or water bars, to move water off the road frequently and minimize concentration of water (P&D) (C) • Install drainage crossings to pass water from the uphill to the downhill side. If using culvert pipes, at least roughly design them before or during construction. Use either the Rational Formula or back-calculation using Manning's Formula and high-water mark data to determine the anticipated flow. This will allow you to roughly determine the correct pipe sizes. Where flows are difficult to determine, use structures such as fords, rolling dips, and overflow dips that can accommodate any volume of flow and are not susceptible to plugging (P&D) (C) • Stabilize outlet ditches (inside and outside) with small stone riprap and/ or vegetative barriers placed on contour, to dissipate energy and to prevent the creation or enlargement of gullies (P&D) (C) • Extend runout drains far enough to allow water to dissipate evenly into the ground (P&D) (C) • Visually spot-check for drainage problems by looking for accumulation of water on road surfaces. Do this immediately after first heavy rains and again at the end of the rainy season. Institute appropriate corrective measures as necessary (C)

Activity	Impact *The activity may. . .*	Mitigation Note: Mitigations apply to specified project phase: *Planning and Design (P&D), Construction (C), or Operation and Maintenance (O&M)*
Perennial and intermittent rivers and streams	Risk destruction of bridge by 50-or 100-year flood Cause damming and resultant meandering of stream which destroys neighboring sections of roadway, dwellings and/or native flora and fauna	• Construct drifts rather than bridges, where feasible and cost-effective. Since periodic replacement or reconstruction of damaged bridges and culverts can be costly, involve hydraulic engineers in bridge designs (P&D) (C) • When constructing a bridge, consider using a design, such as a Bailey Bridge, that can be erected and dismantled so if the waterway meanders, the structure can be moved to another site (P&D) (C) • Try "training" rivers and streams to follow desired channels by selectively removing debris. However, any channel changes should be minimized. Use a combination of hand labor and small machinery. Careful and selective bulldozing may be feasible in some cases. However, bulldozer tracks can easily expose soil to erosion and do more harm than good (P&D) (C)
Wetlands	Degrade wetland, damaging the valuable ecosystems and habitats Alter hydrology	• Avoid routing through these areas (see "Planning route" above for additional guidance) (P&D) • Minimize cuts and/or fills and compensate for impact by protecting other wetlands (P&D) (C) • Take special precautions to prevent release or dumping of debris, oil, fuel, sand cement and similar harmful materials (C) • Use elevated porous fills (rockfills) and/or multiple pipes to maintain natural flow patterns of groundwater and near-surface water (C)
Sloped areas and raised roads	Cause soil erosion Degrade water quality Alter hydrology Damage valuable ecosystems and habitats	• Stabilize slopes by planting vegetation. Work with agronomists to identify native species with the best erosion control properties, root strength, site adaptability, and other socially useful properties. Set up nurseries in project areas to supply necessary plants. Do not use non-native plants. Use soil-stabilizing chemicals or geotextiles (fabrics) where feasible and appropriate (P&D) (C) • Minimize use of vertical road cuts (even though they are easier to construct and require less space than flatter slopes). The majority of road cuts should have no more than a ¾:1 to 1:1 slope to promote plant growth. Vertical cuts are acceptable in rocky material and in well-cemented soils (P&D) (C) • Install drainage ditches or berms on up-hill slope to divert water away from road and into streams (see figure 3-1.4) (P&D) (C) • Install drainage turnouts at more frequent intervals and check dams to reduce ditch erosion (P&D) (C) • If possible, use higher-grade gravel, which is much less prone to erosion (P&D) (C) • If very steep sections cannot be avoided, provide soil stabilizers or surface with asphalt/concrete (P&D) (C)

Activity	Impact *The activity may. . .*	Mitigation Note: Mitigations apply to specified project phase: *Planning and Design (P&D), Construction (C), or Operation and Maintenance (O&M)*
Construction contracts	Cause all types of damage mentioned	• Select or develop guidelines and procedures to be applied to each facet of road construction, and incorporate them into contracts with construction companies. These will apply, for example, to site clearing; bed and surface construction; drainage; fuel and materials usage; quarry site management; and procedures for operating construction camp and work site, including procedures addressing worker safety • Include incentives for adhering to guidelines and penalties for violating them
Maintenance agreements	Cause all types of damage mentioned	• Finalize maintenance agreements with local communities **before** beginning construction. All parties must clearly understand and be committed to the terms of the agreement, such as who will do what work, when, how frequently, for what compensation, and within what limits
Planning and Design—Existing Roads (Reconstruction/Repair/Realignment)		
All projects		• Use a "clean slate" approach, i.e., consider realigning all existing minimal/informal roads to follow contours and avoid sensitive areas (P&D)
Road surface is below grade of surrounding road	Cause soil erosion Degrade water quality Alter hydrology	• Raise road surface with stable fill material. Grade with inslope, outslope or cambered shape. Install sufficient cross-drains, ditches and settling ponds (Figure 3-1.1 and 3-1.2) (P&D) (C) (O&M)
Road is steeply sloped and eroding	Cause soil erosion Degrade water quality Alter hydrology	• Consider realigning the road section so that it conforms to preferred design parameters described above. Decommission original road sections after realignment (see "Decommissioning" below) (P&D) (C) (O&M)
Deteriorated road surface	Cause erosion Damage vehicles	• Determine cause of deterioration. If the cause is heavy use, either find a means of reducing traffic or upgrade road to a more durable surface (gravel, asphalt, or concrete) (figure 3-1.6) (P&D) (C) (O&M)
Drivers drive at excessively high speeds	Cause injury and death of people and animals	• Realign road sections to meander; curving roads deter speeding (P&D) • Add speed bumps in villages or populated areas (C)
Sections have multiple tracks/off-road driving	Cause soil erosion Degrade water quality Alter hydrology Damage valuable ecosystems and habitats	• Generally caused by either muddy/flooded roadway or highly deteriorated roadway. Maintain or upgrade road so road section no longer floods or becomes muddy (P&D) (O&M) • Raise the road bed or define the roadway with rocks. Realign the road to a better area. Avoid very flat terrain (P&D) (O&M)
Road section must be realigned		• Remove surface if necessary and loosen soil of previous track (to accelerate regeneration of vegetation). Block access with rocks, branches, roadblocks and signs. Narrow tracks will usually revegetate naturally with no noticeable scars or impact on the environment. Wider roads may require active planting and reseeding (C) (O&M)

Activity	Impact *The activity may. . .*	Mitigation Note: Mitigations apply to specified project phase: *Planning and Design (P&D), Construction (C), or Operation and Maintenance (O&M)*
Construction		
Construction camp and crew	Damage local habitat, compact soil and create erosion via building and occupation of construction camp Contaminate surface water and spread disease via solid waste and feces generated by camp Spread communicable diseases including malaria, tuberculosis, and HIV/AIDS via construction crew members who come from outside the region Introduce alcohol or other socially destructive substances via construction crew Generate trash due to lack of solid waste management Adversely effect local fauna and flora (especially game and fuelwood) via poaching and collection by construction crews	• Explore off-site accommodation for crew. Avoid wet, muddy sites (P&D) (C) • Keep camp size to a minimum. Require that crew preserve as much vegetation as possible, e.g., by creating defined foot paths. Define areas of use (with rocks or fencing) (P&D) (C) • Provide potable water for crew (O&M) • Provide temporary sanitation on site, e.g., VIP latrine (assuming the water table is low enough and soil and geology is of appropriate composition) (also consult “Water Supply and Sanitation” in this volume). Where this is not possible, instruct road crews to employ soil mining (digging a pit for human waste and covering with soil immediately after use) (P&D) (C) • Use local or regional labor, if possible. Provide hygiene and public health training to road crews, including information about transmission of HIV/AIDS and other sexually transmitted diseases (P&D) (C) • Collect all solid waste (metal, glass, and burnable materials) from all work and living areas. Dispose of waste in local dump or landfill. If this is not possible, sell recyclables for reuse/recycling, place organic wastes in well-screened waste pits, covering with soil weekly, bury the remainder (excluding toxic materials). (Also consult “Management of solid waste from residential, commercial and industrial facilities” in this volume) • Set guidelines prohibiting the poaching and collection of plants/wood, with meaningful consequences for violation, such as termination of employment. Provide enough food and cooking fuel; both should be of good quality (C) • Restore site through revegetation and similar measures after camp is broken down (C) • Test grade drivers’ ability to follow grade, slope, and contour design standards. Train if necessary (P&D) (C) • Test the ability of bulldozer drivers and other equipment operators to properly maintain drainage structures. Train if necessary (P&D) (C) • Test road crew’s ability to keep roads clear of vegetation with least adverse environmental impacts. Train if necessary (P&D) (C) • Provide workers with appropriate safety equipment, e.g., earplugs or headgear to mute noise from very loud equipment; masks for workers exposed to large amounts of dust; safety glasses for workers doing jobs that may generate sharp projectiles

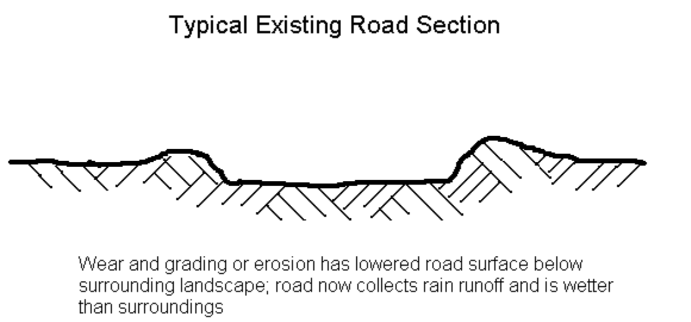
Activity	Impact *The activity may. . .*	Mitigation Note: Mitigations apply to specified project phase: *Planning and Design (P&D), Construction (C), or Operation and Maintenance (O&M)*
Use of heavy equipment and hazardous materials	Cause erosion due to machinery tracks, damage to roads, stream banks, etc. Compact soil, changing surface and groundwater flows and adversely affecting future use for agriculture Contaminate ground or surface water when (1) machinery repairs result in spill or dumping of hydraulic oil, motor oil or other harmful mechanical fluids; and (2) hazardous construction materials are spilled or dumped Put workers at risk from exposure to hazardous materials	• Minimize use of heavy machinery (P&D) (C) • Set protocols for vehicle maintenance, such as requiring that repairs and fueling occur elsewhere or over an impervious surface such as plastic sheeting. Prevent dumping of hazardous materials. Capture leaks or spills with drop cloths or wood shavings. Burn waste oil **if** it is not reusable/readily recyclable, does not contain heavy metals and is flammable. Prohibit use of waste oil as cooking fuel (P&D) (C) • Investigate and use less toxic alternative products (P&D) (C) • Prevent fuel tank leaks by (a) monitoring and cross-checking fuel levels deliveries and use, (b) checking pipes and joints for leaks, (c) tightening generator fuel lines, and (d) preventing over-filling of main storage and vehicle tanks (C) (Also consult "Activities with Micro and Small Enterprises (MSEs)" in this volume)
Materials extraction: Quarrying, logging	Damage aquatic ecosystems through erosion and siltation Harm terrestrial ecosystems via harvesting of timber or other natural products Spread vector-borne diseases when stagnant water accumulates in active or abandoned quarries or borrow pits and breeds insect vectors Take land out of other useful production The quarry may become a safety hazard	• Identify the most environmentally sound source of materials that is within budget (P&D) (O&M) • Use material from local road cuts first, but only if it produces a fairly suitable, durable aggregate for either embankment fill or surface stabilization material. Local borrow material can be very cost-effective. Upon removal of material, the area should be restored and receive erosion control measures (P&D) (C) • Develop logging, quarrying and borrowing plans that take into account cumulative effects (P&D) • Take photos of site before initiating excavation, so that restoration can match original site characteristics as much as possible (C) (O&M) • Site quarries and gravel pits so that they are not visible to travelers on the roads (P&D) (C) (O&M) • Monitor adherence to plans and impacts of extraction practices. Modify as necessary (C) (O&M) • Decommission/restore area so it is suitable for sustainable use after extraction is completed (C) • Install drainage structures to direct water away from pit (C) (O&M) • Implement safety protocols to minimize risks from falling rock or debris, collapsing quarry walls, or accidental falls from cliffs (P&D) (C) (O&M) • Develop specific procedures for storing topsoil, as well as for phased closure, reshaping and restoration when extraction has been completed. Include plans for segregating gravel and quarry materials by quality and grade for possible future uses. Where appropriate, include reseeding or revegetation to reduce soil erosion, prevent gulleying and minimize visual impacts (P&D) (C) (O&M) • Discuss with local community the option of retaining quarry pits as water collection ponds for watering cattle, irrigating crops or similar uses. Highlight issues of disease transmission and the need to prohibit its use for drinking, bathing, and clothes washing (P&D) (C) (O&M)

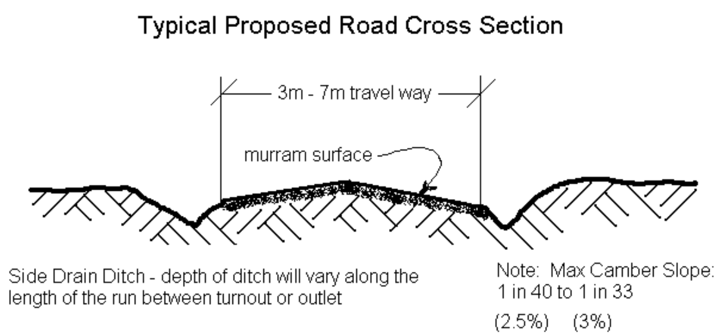
Activity	Impact *The activity may. . .*	Mitigation Note: Mitigations apply to specified project phase: *Planning and Design (P&D), Construction (C), or Operation and Maintenance (O&M)*
Storing materials	Deplete water resources Damage valuable ecosystems and habitats	• Pre-wet gravel when water is more available (i.e., not during dry season) and store gravel in a way that will keep it wet, e.g., covered with plastic sheeting (P&D) (C) • When siting storage areas, avoid using sensitive areas or sites that drain directly into a sensitive area (P&D) (C)
Site clearing and/or leveling	Damage or destroy sensitive terrestrial ecosystems Produce areas of bare soil which cause erosion, siltation, changes in natural water flow, and/or damage to aquatic ecosystems	• Minimize disturbance of native flora (vegetation) during construction. Minimize the amount of clearing. Clear small areas for active work one at a time (P&D) (C) • Avoid use of herbicides. Any use should follow health and safety procedures to protect people and the environment. At a minimum, herbicides should be used according to manufacturer's specifications (C) • Where possible, remove large plants and turf without destroying them, and preserve them for replanting in temporary nurseries (P&D) (C) • Move earth and remove vegetation only during dry periods. Store topsoil for respreading. If vegetation must be removed during wet periods, disturb ground only just before actual construction (P&D) (C) • Install temporary erosion control features when permanent ones will be delayed. Use erosion control measures such as hay bales, berms, straw or fabric barriers (C) • Revegetate with recovered plants and other appropriate local flora immediately after equipment is removed from a section of the site (C)
Excavation	Cause erosion, siltation, changes in natural water flow, and/or damage to aquatic ecosystems when excavated soil is piled inappropriately Expose inhabitants and crew to risk of falls and injuries in excavation pits Deprive down-gradient populations and ecosystems of water if upper regions of aquifer are blocked	• Cover pile with plastic sheeting; prevent run off with hay bales,or similar measures (P&D) (C) • Place fence around excavation (P&D) (C) • Investigate alternatives, such as shallower excavation and no excavation (P&D) • Have construction crews and supervisors be alert for buried historic, religious and cultural objects and provide them with procedures to follow if such objects are discovered. Provide incentives for recovery of objects and disincentives for their destruction or theft.(P&D) (C) • Ensure that excavation is accompanied by well-engineered drainage (P&D) (C)
Filling	Block water courses when fill is inappropriately placed Destroy valuable ecosystems when fill is inappropriately placed Cause later land subsidence or landslides when fill is inappropriately placed, causing injuries and damages.	• Do not fill the flow line of a watershed. Even in arid areas, occasional rains may create strong water flows in channels. A culvert may not supply adequate capacity for rare high-volume events(P&D) • Design so that filling will not be necessary. Transplant as much vegetation and turf as possible (P&D) (C) • Use good engineering practices. For example, do not use soil alone; first lay a bed of rock and gravel (P&D) (C) • Balance the cuts and fills (to minimize earthwork movement) whenever possible.

Activity	Impact *The activity may. . .*	Mitigation Note: Mitigations apply to specified project phase: *Planning and Design (P&D), Construction (C), or Operation and Maintenance (O&M)*
Cutting and filling	Cause soil erosion Degrade water quality Alter hydrology Damage valuable ecosystems and habitats	• Test grade driver's ability to follow design standards for grades, slopes, and contours. Train if necessary (P&D) (C)
Compacting to improve road materials performance	Deplete freshwater resources	• Water the road immediately before compacting it to strengthen the road surface. (Otherwise, traffic will soon beat back the road surface to pre-bladed condition) (P&D) (C) • When possible, delay compaction activities until the beginning of the wet season or when water becomes more available (P&D) (C)
Blasting	Cause soil erosion Degrade water quality Alter hydrology Damage valuable ecosystems and habitats	• Minimize blasting (P&D) (C) • Take safety precautions to protect workers and others from being injured by flying or falling rock and avalanches (P&D) (C)
Design verification Quality control		• Conduct independent inspections of work periodically to see that it conforms to original plan and design specifications. Provide incentives and disincentives to ensure conformance (C) • Drive roads after moderate rains to identify areas that collect or gully water. Mark and redesign/rehabilitate as necessary (C)
Operation and Maintenance		
Road maintenance to remove ruts, potholes, washboarding, standing water and materials blocking road	Create gulleys and standing pools Create mud holes, potholes Breed disease vectors in settling basins and retention ponds	• Monitor and maintain drainage structures and ditches, including culverts. Clean out culverts and side channels/runout (leadoff ditches) when they begin to fill with sediment and lose their effectiveness (O&M) • Fill mud holes and potholes with good quality gravel; remove downed trees and limbs obscuring roadways (O&M) • Use water from settling basins and retention ponds for road maintenance (O&M)
Construction camp and crew	(See "Construction camp and crew" above)	• (See "Construction camp and crew" above)
Use and maintenance of equipment	(See "Use of heavy equipment and hazardous materials" above)	• (See "Use of heavy equipment and hazardous materials" above) • Install concrete pads, drains and oil/water separators in areas where vehicle and equipment maintenance and fueling will occur regularly

Activity	Impact *The activity may. . .*	Mitigation Note: Mitigations apply to specified project phase: *Planning and Design (P&D), Construction (C), or Operation and Maintenance (O&M)*
Decommissioning		
Decommissioning	Cause soil erosion Degrade water quality Damage valuable ecosystems and habitats	• Break up old road surface and soil. Remove and dispose of surfacing material (e.g., asphalt) if necessary, and loosen soil of previous track (to accelerate regeneration of vegetation) • Reshape eroded or culled surfaces with outsloping, or add cross-drains or water bars so that water will no longer follow the course of the roadway (See fig. 3-1.1) • Revegetate as needed. Narrow tracks will usually revegetate naturally with no noticeable scars or impact on the environment. Wider roads may require active planting and reseeding (O&M) • Block access with rocks, branches, roadblocks, waterbars and signs.

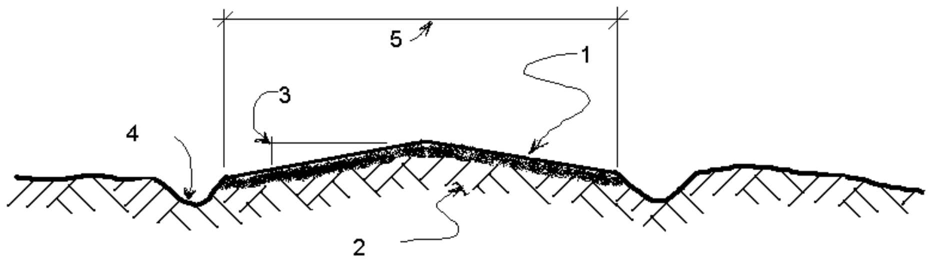
Figures 3-1.1 and 3-1.2





Figures 3-1.3 and 3-1.4

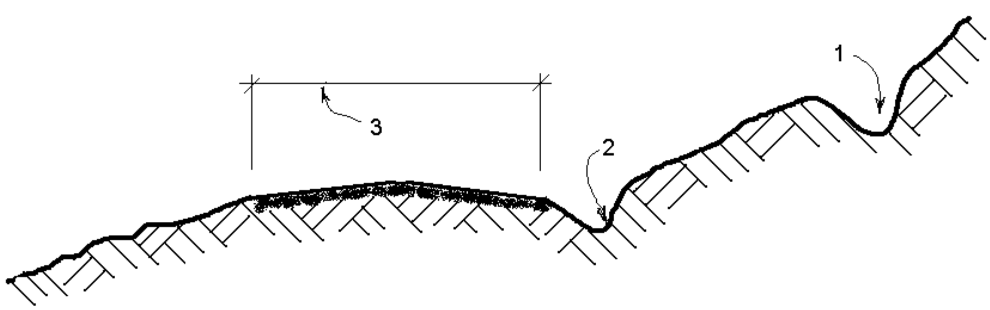
Cross Section of a Gravel Road



KEY
1 - Layer of murram; thickness of murram layer depends on soil type at site
2 - Subgrade
3 - Cross-slope 1 in 33 to 1 in 40
(3%) (2.5%)
4 - Side drain ditches
5 - Traveled way; width depends on the class of road

Drainage in Hilly Roads Cross Section

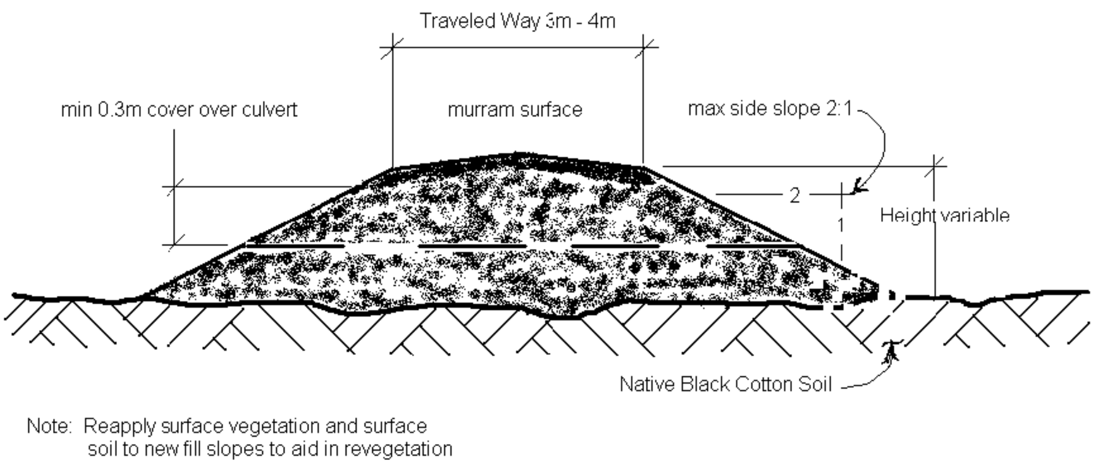
Key
1 - Water catchment ditches/drains
2 - Side ditch drain
3 - Traveled way



Figures 3-1.5 and 3-1.6

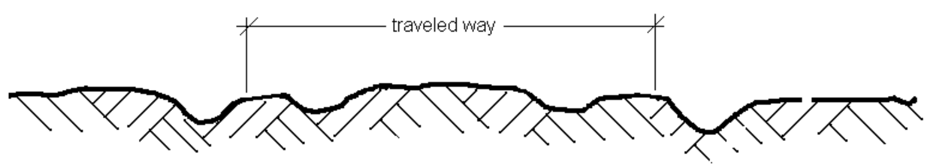
Raised Road Embankment

Typical proposed Black Cotton fill cross section

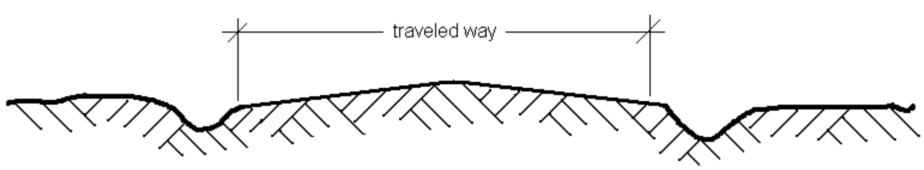


Longitudinal Ruts Correction

Typical road cross section with longitudinal ruts caused by vehicle tyres



Typical road cross section after filling up the longitudinal ruts by reshaping the road



References and Useful Resources

Almost all references here are taken from:

Keller, G., and James Sherar (2003). *Low-Volume Roads Engineering: Best Management Practices and Field Guide*. Washington, DC: USAID, USDA, and Virginia Polytechnic Institute and State University. http://ntl.bts.gov/lib/24000/24600/24650/Index_BMP_Field_Guide.htm

The guide also has an extended bibliography for readers in need of more depth or detail regarding specific issues and applications. In addition to the topics listed below, the extended bibliography offers references for hydrology for drainage crossing design; tools for hydraulic and road design including Manning's Formula, riprap, filters, and the use of geosynthetics; general considerations for drainage of low-volume roads; fords and low-water crossings; physical, vegetative and biotechnical methods of erosion control; and stabilization of gullies.

Best Management Practices—General

- Environmental Protection Agency (2005). *National Management Measures to Control Nonpoint Source Pollution from Forestry*. EPA Contract No. 68-c7-0014, Work Assignment #2-20. Prepared for the U.S. Environmental Protection Agency's Office of Water by Tetra Tech, Fairfax, Virginia. http://www.epa.gov/nps/forestrymgmt/

  A comprehensive guide to measures for reducing water pollution from roads and logging activities.

- Vermont Department of Forests, Parks and Recreation (1987). *Acceptable Management Practices for Maintaining Water Quality on Logging Jobs in Vermont*. http://www.vtfpr.org/pdf/waterq.pdf

- *Wisconsin Department of Natural Resources (1995).* Wisconsin's Forestry Best Management Practices for Water Quality: Field Manual for Loggers, Landowners and Land Managers. *Publication No. FR093. http://www.dnr.state.wi.us/org/land/forestry/usesof/bmp/bmptoc.htm*

- World Bank, Transport Division of the Environmentally Sustainable Development Vice-Presidency and Transportation, Water & Urban Development Department. Washington, D.C. http://www.worldbank.org/transport/r&h_over.htm

  Links to tools and literature covering many dimensions of road construction, including planning, financing, institutional management, safety, construction and maintenance, environment, and tolls, among others.

- World Bank (1997). *Roads and the Environment: A Handbook.* World Bank Technical Report TWU 13, and update WB Technical Paper No. 376. World Bank, Washington, D.C. (Part II details specific environmental, social, and other impacts). Online: http://www.worldbank.org/transport/publicat/reh/toc.htm

Planning Issues and Special Applications

- Dykstra, D. and R. Heinrich (1996). *FAO Model Code of Forest Harvesting Practice*. Food and Agriculture Organization of the United Nations, Rome. http://www.fao.org/documents/show_cdr.asp?url_file=/docrep/V6530E/V6530E00.htm

- Keller, G., G. Bauer and M. Aldana (1995). *Minimum Impact Rural Roads* ***(Caminos Rurales Con Impactos Minimos)***. Training manual written in Spanish for the USDA Forest Service

International Programs, USAID, and Programa de Caminos Rurales, Guatemala City, Guatemala. (Manual is currently being rewritten in English.)

- Oregon Department of Forestry (2000). *Forest Roads Manual*. Forest Engineering Coordinator, State Forests Program, Oregon Dept. of Forestry, Salem, OR (503-945-7371). http://www.oregon.gov/ODF/STATE_FORESTS/Roads_Manual.shtml

  This manual provides basic information about logging road design, construction and maintenance.

- PIARC World Roads Association (1999). *Natural Disaster Reduction for Roads, Final Report*. 72.02B, Paris, FR. PIARC Working Group G2. 275p. (ISBN2-84060-109-5) (Also see Comprehensive Report 72.01B, 1995.) Available to order at http://www.piarc.org/exec/publication.htm?objectId=253 .

- Tanzania National Parks, et al. (2001) *TANAPA Programmatic Environmental Assessment for Road Improvements in Tanzania National Parks.* Four volumes, including Environmental Management Guidelines for Road Improvements. September. Available at http://www.encapafrica.org/download/tanapa-pdf.zip [10MB download]

Basic Engineering Considerations for Low-Volume Roads

- American Association of State Highway Transportation Officials (1994). *Guidelines for Geometric Design of Very Low-Volume Local Roads (ADT •400).* Available for purchase: http://www.aashto.org or http://www.normas.com/AASHTO/pages/VLVLR-1.html .

  Covers the design standards for local road and street design**.**

- Australian Road Research Board Limited (1993). *Unsealed Roads Manual: Guidelines to Good Practice.* Vermont, South Victoria, Australia. Available to order at http://www.arrb.com.au/index.php?option=content&task=view&id=328&Itemid=294

  A useful manual for gravel road design and maintenance, particularly in semi-arid regions.

- Casaday, E. and B. Merrill (2001). *Field Techniques for Forest and Range Road Removal*. Eureka, California. California State Parks, North Coast Redwoods District. 63p. http://www.parks.ca.gov/?page_id=23071

  A useful field guide to road closure and obliteration, with great photos and figures.

- Geunther, K. (1999). *Low Maintenance Roads for Ranch, Fire and Utility Access*. Wildland Solutions Field Guide Series, Clyde, CA: Wildland Solutions. 48p Available to order for $12.50 at http://www.wildlandsolutions.com/orderfrm.htm

Culvert Use, Installation, and Sizing

- Normann, J.M., R.J. Houghtalen and W.J. Johnston (1985) (Reprinted 1998). *Hydraulic Design of Highway Culverts*. Hydraulic Design Series No. 5. Tech. Rep. No. FHWA-IP-86-15 HDS 5. September. McLean, VA: Department of Transportation, Federal Highway Administration, Office of Implementation. 265 p. http://www.fhwa.dot.gov/engineering/hydraulics/pubs/hds5si.pdf

  Includes a comprehensive design for both conventional culverts and culverts with inlet improvements.

Bridge Location and Design Factors

- American Association of State Highway and Transportation Officials (2002). *Standard Specifications for Highway Bridges (17^{th} Edition)*. ISBN Number: 1-56051-171-0 Available for purchase at: https://bookstore.transportation.org/item_details.aspx?ID=51

  Covers the design of wood, steel, and concrete bridges, as well as structural plate structures.

Slope Stabilization and Stability of Cuts and Fill

- Mohney, J. (1994). *Retaining Wall Design Guide*. 2d ed. Tech. Rep. No. EM-7170-14. Washington, DC: U.S. Department of Agriculture, Forest Service, Engineering Staff. Also, Pub. No. FHWA-FLP-94-006. September. Washington, D.C.: Department of Transportation, Federal Highway Administration, Federal Lands Highway Program. 537 p. http://www.ntis.gov/search/product.asp?ABBR=PB97194401&starDB=GRAHIST

  Covers the analysis and design of a wide variety of retaining walls.

Roadway Materials

- ARRB Transport Research Ltd. (1996). *Road Dust Control Techniques: Evaluation of Chemical Dust Suppressants' Performance*. Spec. Rep. 54. Victoria, Australia**.** Available to order from http://www.arrb.com.au/

  Covers the products available, how they work, selecting the product, and the product's environmental impacts.

HIV/AIDS Prevention

- HEARD – Health Economics and HIV/AIDS Research Division, University of Natal, Durban, RSA. http://www.heard.org.za/

  Provides toolkits, presentations, publications, links, statistics and more.

- Rau, B. 2002. *Workplace HIV/AIDS Programs: An Action Guide for Managers*. Family Health International. 85 p. http://www.fhi.org/en/hivaids/pub/guide/workplace_hiv_program_guide.htm

Annex A: Sample Road Improvements Environmental Impact Matrix

Legend

Adverse Impact Level		Beneficial Impact Level
	Low	
	Medium	
	High	

Impact Category ⇒	**Physical Resources**													**Ecological Systems**										**Landscape**					**Socio-Economic**													
Activities ⇓	Soil Erosion	Debris Deposition	Siltation	Soil Compaction	Surface Runoff	Hydrology	Topography	Drainage	Wetlands	Surface Water Quantity	Surface Water Quality	Ground Water Quantity	Ground Water Quality	Habitat Change	Species Diversity	Alien Species	Vegetation	Poaching	Wildlife Movement	Animal Harassment	Ecological Function	Exceptional Resources	Tropical Forest	Scenic Quality	Wilderness Quality	Viewshed	Carrying Capacity	Visitor Experience	Human Settlement	Compatibility w/ Policies	Cost to Agency	Benefit to Agency	Costs to Communities	Benefits to Communities	Health	Disease Vectors	Noise Levels	Dust Levels	Risks/Hazards	Employment	Local Economy	Tourist Industry
Construction																																										
Vegetation clearing																																										
Construction camp																																										
Quarry management																																										

Impact Category ⇒	Physical Resources													Ecological Systems										Landscape					Socio-Economic													
Activities ⇓	Soil Erosion	Debris Deposition	Siltation	Soil Compaction	Surface Runoff	Hydrology	Topography	Drainage	Wetlands	Surface Water Quantity	Surface Water Quality	Ground Water Quantity	Ground Water Quality	Habitat Change	Species Diversity	Alien Species	Vegetation	Poaching	Wildlife Movement	Animal Harassment	Ecological Function	Exceptional Resources	Tropical Forest	Scenic Quality	Wilderness Quality	Viewshed	Carrying Capacity	Visitor Experience	Human Settlement	Compatibility w/ Policies	Cost to Agency	Benefit to Agency	Costs to Communities	Benefits to Communities	Health	Disease Vectors	Noise Levels	Dust Levels	Risks/Hazards	Employment	Local Economy	Tourist Industry
Trucking gravel																																										
Cutting & filling																																										
Blasting																																										
Construction material use																																										
Management of spoil																																										
Storage of diesel/oils																																										
Waste management																																										
Water use																																										
Operation																																										
Vehicle Traffic Movement																																										
Road maintenance																																										
Maintenance of machinery																																										

Impact Category ⇒	**Physical Resources**													**Ecological Systems**										**Landscape**					**Socio-Economic**													
Activities ⇓	Soil Erosion	Debris Deposition	Siltation	Soil Compaction	Surface Runoff	Hydrology	Topography	Drainage	Wetlands	Surface Water Quantity	Surface Water Quality	Ground Water Quantity	Ground Water Quality	Habitat Change	Species Diversity	Alien Species	Vegetation	Poaching	Wildlife Movement	Animal Harassment	Ecological Function	Exceptional Resources	Tropical Forest	Scenic Quality	Wilderness Quality	Viewshed	Carrying Capacity	Visitor Experience	Human Settlement	Compatibility w/ Policies	Cost to Agency	Benefit to Agency	Costs to Communities	Benefits to Communities	Health	Disease Vectors	Noise Levels	Dust Levels	Risks/Hazards	Employment	Local Economy	Tourist Industry
Tourist activities																																										
Waste management																																										
Off-road driving																																										
De-commissioning																																										
Ripping old road																																										
Shaping																																										
Revegetation																																										

Chapter 15

Solid waste: generation, handling, treatment and disposal

Contents

Brief Description of the Sector	15-1
Potential Environmental Impacts	15-3
Sector Design-Specific Guidance	15-4
Environmental Mitigation and Monitoring	15-16
Resources and References	15-26

Brief Description of the Sector

Thousands of tons of solid waste are generated daily in Africa. Most of it ends up in open dumps and wetlands, contaminating surface and ground water and posing major health hazards. Generation rates, available only for select cities and regions, are approximately 0.5 kilograms per person per day—in some cases reaching as high as 0.8 kilograms per person per day. While this may seem modest compared to the1–2 kg per person per day generated in developed countries, most waste in Africa is not collected by municipal collection systems because of poor management, fiscal irresponsibility or malfeasance, equipment failure, or inadequate waste management budgets.

Though high- and low-value recyclables are typically recovered and reused, these make up only a small proportion of the total waste stream. The great majority of the waste (~70 percent) is organic. In theory, this waste could be converted to compost or used to generate biogas, but in situations where rudimentary solid waste management systems barely function, it is difficult to promote innovation, even when it is potentially cost-effective to do so. In addition, hazardous and infectious materials are discarded along with general waste throughout the continent. This is an especially dangerous condition that complicates the waste management problem.

Throughout most of sub-Saharan Africa solid waste generation exceeds collection capacity. This is in part due to rapid urban population growth: while only 35 percent of the sub-Saharan population lives in urban areas, the urban population grew by 150 percent between 1970 and 1990. But the problem of growing demand is compounded by broken-down collection trucks and poor program management and design. In West African cities, as many as 70 percent of trucks are always out of service at any one time, and in 1999 the City of Harare failed to collect refuse

The adverse impacts of waste management are best addressed by establishing integrated programs where all types of waste and all facets of the waste management process are considered together. The long-term goal should be to develop an integrated waste management system and build the technical, financial, and administrative capacity to manage and sustain it.

For more information…

These guidelines are intended to be a starting point for developers and managers of solid waste projects. They are designed to highlight key issues, questions to consider, and technical options. More detailed resources are cited at the end of this document. Solid waste project developers and managers should pay particular attention to *The International Source Book on Environmentally Sound Technologies for Municipal Solid Waste Management,* produced by the International Environmental Technology Centre of the United Nations Environment Programme.

from nearly all of its residents because only 7 of its 90 trucks were operational.

For health reasons, waste in tropical regions should actually be collected daily. This makes the challenges and costs of solid waste management in much of Africa even more daunting. It is generally the city center and the wealthier neighborhoods that receive service when it is available. In poorer areas, uncollected wastes accumulate at roadsides, are burned by residents, or are disposed of in illegal dumps which blight neighborhoods and harm public health. Where present, manual street sweeping by municipal employees or shopkeepers may help reduce these effects in the most public areas. Nonetheless, roadside accumulation in many cities has reached levels resembling those that spawned epidemics in European cities 500 years ago. Unless more effective urban waste management programs and public water supply systems are put in place, outbreaks of cholera, typhoid and plague may become increasingly common.

Recommended Frequency of Waste Collection

Tropics	Daily
Temperate regions	
Summer	Every 2 days
Winter	Every 3 days
Cool climates	
Summer	Twice a week
Winter	Once a week

Only a small amount of the region's waste is disposed of in sanitary landfills; most is deposited in open dumps or semi-controlled unlined landfills with no groundwater protection, leachate recovery, or treatment systems. The larger dumps are located on the edges of cities, towns, and villages, sometimes in ecologically sensitive areas, or areas where groundwater supplies are threatened. They serve as breeding grounds for rats, flies, birds and other organisms that serve as disease vectors. Smoke from burning refuse may be damaging to the health of nearby residents and the smell degrades their quality of life.

While the recovery and reuse of materials is generally for personal use, there are also many professional waste pickers. They are seriously threatened by disease organisms, sharp objects and other hazards in the waste, especially since they generally lack protective equipment. The high level of reuse of non-organic waste reflects the extent of poverty in the region.

Separation and treatment of organic waste is very rare. Municipal composting programs exist in some South African cities, but the few large-scale composting facilities built elsewhere are no longer operating. Anaerobic digestion to produce methane is not widely applied, and then usually uses manure, not organic waste.

While solid waste collection is generally a municipal function, some countries and municipalities are now experimenting with limited privatization of these services, with some success. Because of the poor levels of collection, many residents—from impoverished to wealthy—pay for private collection of their wastes where these services are legalized.

Municipal waste incinerators are too expensive for most communities and are not used. In any case, they are generally not practical, since most paper that can be reused from the waste stream is removed, leaving behind an organic waste that is too wet to burn. Some hospitals and municipalities have incinerators for medical waste, but these are often not operated correctly. The HIV/AIDs epidemic has raised concerns about reuse of syringes, and efforts are being made to construct low-cost, high-temperature two-chamber incinerators to destroy syringes along with other medical wastes.

Potential Environmental Impacts from Solid Waste Management Activities

The typical municipal solid waste stream will contain general wastes (organics and recyclables), special wastes (household hazardous, medical, and industrial waste), and construction and demolition debris. Most adverse environmental impacts from solid waste management are rooted in inadequate or incomplete collection and recovery of recyclable or reusable wastes, as well as codisposal of hazardous wastes. These impacts are also due to inappropriate siting, design, operation, or maintenance of dumps and landfills. Improper waste management activities can:

An open refuse dump in downtown Segou, Mali. During the rainy season part of the dump is submerged in water, threatening the health and water supply of the surrounding area.

- **Increase disease transmission or otherwise threaten public health.** Rotting organic materials pose great public health risks, including, as mentioned above, serving as breeding grounds for disease vectors. Waste handlers and waste pickers are especially vulnerable and may also become vectors, contracting and transmitting diseases when human or animal excreta or medical wastes are in the waste stream. (See the discussion on medical wastes below and the separate section on “Healthcare Waste: Generation, Handling, Treatment, and Disposal” in this volume.) Risks of poisoning, cancer, birth defects, and other ailments are also high.
- **Contaminate ground and surface water.** Municipal solid waste streams can bleed toxic materials and pathogenic organisms into the

leachate of dumps and landfills. (Leachate is the liquid discharge of dumps and landfills; it is composed of rotted organic waste, liquid wastes, infiltrated rainwater and extracts of soluble material.) If the landfill is unlined, this runoff can contaminate ground or surface water, depending on the drainage system and the composition of the underlying soils.

Many toxic materials, once placed in the general solid waste stream, can be treated or removed only with expensive advanced technologies. Currently, these are generally not feasible in Africa. Even after organic and biological elements are treated, the final product remains harmful.

- **Create greenhouse gas emissions and other air pollutants.** When organic wastes are disposed of in deep dumps or landfills, they undergo anaerobic degradation and become significant sources of methane, a gas with 21 times the effect of carbon dioxide in trapping heat in the atmosphere.

  Garbage is often burned in residential areas and in landfills to reduce volume and uncover metals. Burning creates thick smoke that contains carbon monoxide, soot and nitrogen oxide, all of which are hazardous to human health and degrade urban air quality. Combustion of polyvinyl chlorides (PVCs) generates highly carcinogenic dioxins.

- **Damage ecosystems.** When solid waste is dumped into rivers or streams it can alter aquatic habitats and harm native plants and animals. The high nutrient content in organic wastes can deplete dissolved oxygen in water bodies, denying oxygen to fish and other aquatic life form. Solids can cause sedimentation and change stream flow and bottom habitat. Siting dumps or landfills in sensitive ecosystems may destroy or significantly damage these valuable natural resources and the services they provide.

- **Injure people and property**. In locations where shantytowns or slums exist near open dumps or near badly designed or operated landfills, landslides or fires can destroy homes and injure or kill residents. The accumulation of waste along streets may present physical hazards, clog drains and cause localized flooding.

- **Discourages tourism and other business**. The unpleasant odor and unattractive appearance of piles of uncollected solid waste along streets and in fields, forests and other natural areas, can discourage tourism and the establishment and/or maintenance of businesses.

Sector Design—Some Specific Guidance

Experience and study of solid waste collection programs in various parts of the developing world have identified a set of program elements and common pitfalls as well as a number of operations strategies to meet operational requirements and avoid commonn problems. Successful program:

- Apply an integrated holistic approach that takes into account key factors affecting waste generation, storage, and final disposition;
- Securing or establish stable financing and ensure funds are used appropriately;
- Carefully design, develop and implement privatization schemes after weighing the potential costs and benefits;
- Involve the community in waste-management decision making; and
- Build capacity of administrative and technical staff in government, NGOs and/or the private sector.

An illegal dump site south of Sumbe, Angola. A well-designed waste management plan can minimize illegal dumping and mitigate severe environmental damage.

Integrated waste management

The adverse impacts of waste management are best addressed by establishing integrated programs where all types of waste and all facets of the waste management process are considered together. Despite their importance, limited resources may prevent these programs from being implemented, and only a piecemeal solution may be possible. However, the long-term goal *should* be to develop an integrated waste management system and build the technical, financial, and administrative capacity to manage and sustain it.

Whether pursuing a holistic approach or a piecemeal one, managers should ensure that the program is appropriately tailored to local conditions and that practical environmental, social, economic, and political needs and realities are balanced. Answering the following key questions will help achieve this goal:

- Are adequate financial and human resources available to implement the policy, program, or technology?
- Is this the most cost-effective option available?
- What are the environmental benefits and costs? Can the costs be mitigated?
- Is the policy, program, or technology socially acceptable?
- Will specific sectors of society be adversely affected? If so, what can be done to mitigate these impacts?

For a detailed discussion of key objectives and issues to be addressed in municipal solid waste management strategies, see the UNDP *Conceptual Framework for Municipal Solid Waste Management in Low-Income Countries* listed under references in this document.

Financing

Sources of Funding

Possible sources of funding for construction and operations are:

- Communal or municipal funds.
- Taxes. Problem: Incorporation within local tax systemsInclusion in local taxes will not work if tax collection is deficient, or if the transfer to management committees is not secured. This form of general taxation method also dissociates waste management costs and revenues.
  - User charges (flat or graded rate). Block rate pricing could be used in solid waste— too: a low rate for a basic amount of garbage (the poor usually produce less waste) and higher rates for subsequent blocks.
  - Mixed systems and water or electricity metering provides opportunities for cross-subsidies. Water metering can be compared to measuring the amount of solid waste produced (in volume or weight). Because electricity consumption is closely correlated with waste generation, fees for waste collection can be tied to electricity use and integrated into the electrical bill. The utility company may charge an administrative fee for handling such billing.
  - Vending arrangements, such as:
    - Shared private connections and sanitary blocks serving clusters of households. In this system, users pay in cash for each use. This system combines well with garbage collection depots.
    - Metered group connections paid for by a user group with its own group committee. This system is comparable to

a community or group paying a private operator to collect solid waste in its area. In this case, the group is sold service from the municipal government at a bulk rate and determines its own systems for distribution and fee collection. The municipality can offer additional benefits—, for example, like exemption from certain local taxes, or a subsidy to buy equipment.

  - Concession system. A system where local private operators of solid waste collection systems (micro-enterprises) obtain a license or concession from the local government. This may or may not involve community management.

- Local revolving funds or credit circles. However, voluntary funds, however, often do not generate enough money for effective solid waste management. Other communal funds that require a communal production base may not be effective in cities.
- Lotteries and auctions.
- Raffles, bazaars, or entertainment (such as movie showings).
- Donations from prominent individuals.
- Launching community-based organizations.

Fee Collection

Willingness to pay, combined with ability to manage, are good measures to assess the feasibility of a community-based project. A service is considered affordable when a community perceives it as valuable. While this strategy will lead to the desired level of service, is not necessarily the simplest or cheapest approach from an operator perspective.

Ways to generate more revenue from fee collection include:

- Change way of payment.
- Change tariff system to reflect:
  - Level of service. Different rates could be used for collection from communal collection points, curbside or house-to-house collection..
  - Type of users (domestic, institutional, commercial, industrial and gender). If men and women have their own sources of income and take part in financing arrangements as individuals, programs should avoid askingthat the same contribution from women as is asked from men and women..
  - Income level.

    - Property value or characteristics.
    - Amount of waste to dispose (measured by size or weight of bin).
  - Educate people on benefits and financial obligations. Use community meetings to review billing rate, fee collection plan, and encourage regular payment.
  - Give fee collectors more personal benefit.
  - Establish/enforce sanctions for non-payment.
  - Fee collection by operators or respected community members rather than by government officials. Small user groups or operators can collect fees via house-to-house collection, via community meetings, via deposits on bank accounts, at government offices, or through payment in cash directly at waste disposal location. For women, payment at central places may be culturally less appropriate than home collection of fees. Payment on a savings account is also an effective strategy because women can make small deposits and poor people can join projects that require larger deposits or tariffs.
  - Set fees with the assistance of community organizations. (See section on community based management of solid waste.)

Accountability and Reporting

Accountability and reporting are also aspects of financing a solid waste management project. Means of improving accountability are reporting include:

- Provide bookkeeping training, account books, water fee collection cards, etc., and employ teachers or women as treasurers.
- Avoid misuse of funds by requiring two or three committee member signatures of committee members, or one signature from someone with of the assisting NGO, to withdraw money from the bank.
- Sign a contract between the management committee and the community detailing rights and responsibilities, including reporting, for both parties. (See section on community- based management of solid waste.)
- Communicate financial reports through
  - Bulletins distributed to households.
  - Oral reports given by the treasurer at community meetings followed by questions and answers.

    - Written reports on large sheets of paper and posted on walls in public places, particularly where people come to pay their bills.
    - Waste committee meetings dealing with financial matters and open to the community.

- Provide training in accountability to
    - Treasurers, on how to make simple summaries of costs and expenditures, and how to present these to committee and general user assemblies.
    - Committees, on how to account to the users for their performance.
    - Users, on their rights and how they can arrange for accountability (e.g., through statutory annual meetings and an independent audit committee for checking the books.)

Privatization

Privatization is the gradual process of disassociating state-owned enterprises or state-provided services from government control and subsidies, and replacing them with market-driven entities. In the context of municipal services, privatization generally implies reducing local government activity within a given sector by:

- involving participation from the private sector; or
- reducing government ownership, through divestiture of enterprises to unregulated private ownership, and commercialization of local government agencies.

Private sector participation leaves municipal resources available for urban infrastructure and equipment. Privatization of urban services also can reduce the cost of public services to consumers; relieve the financial and administrative burden on the government; increase productivity and efficiency by promoting competition; stimulate the adoption of innovation and new technology; improve the maintenance of equipment; and create greater responsiveness to cost control measures.

There are five basic modes of privatization:

1. **Concessions:** a contractual arrangement whereby a private operator is selected and awarded a license to provide specified services over a discrete period of time in return for a negotiated fee. The concession agreement sets out the rights and obligations of the service provider, who generally retains ownership of the principle assets. This method is well suited to enterprises which provide services that are economically and socially important and need significant improvement; are large and usually enjoy a monopoly position; are politically and/or practically difficult to sell; and are in need of investment capital, e.g., trucks and bins.

2. **Management contract:** a contract placing a municipal service under private management for a specified period of time, for which the contractor is paid a fee. The fee may be based partly on performance. The private manager has extensive autonomy, as set out in the contract.
3. **Commercialization:** a process in which the city authority forms a wholly owned subsidiary. Shares of the new company are restricted, and consumer representatives, the local government and other stakeholders make up the board of directors. The ownership of assets, regulation of tariffs and quality control remain at all times vested in the municipal authority. This method is suitable for managing water supplies.
4. **Franchise:** a process in which the city authority awards, through competition, a finite-term, zonal monopoly to a private firm for the delivery of service. The private firm pays a license fee to cover the government's costs of monitoring and recovers earned revenue through direct charges to households and the establishments served. The city authority provides control over the tariff charged to the consumer. This method is suitable for solid waste management.
5. **Private enterprise/entrepreneurship:** a mode whereby the city authority freely allows qualified private firms to compete for service delivery. Individual households and establishments make private arrangements with individuals firms who compete for business. Under such arrangements, city councils license, monitor, and (as needed), sanction the private firms. Private firms bill their customers directly.

Criteria for Privatization

In deciding whether to privatize a specific aspect or portion of its service, a government needs to weigh the risks—political manipulation, changing environmental regulations, government tariff regulation, currency devaluation, inflation, and unclear taxation systems—against the economic benefits of private sector efficiency. The following criteria may be helpful in considering private sector involvement in solid waste management services (adapted from Cointreau-Levine, 1994):

- **Ease of defining outputs.** Ensure that defined, measurable outputs of the proposed service are incorporated in written performance specifications to clearly establish public and private sector deliverables. The government must have the resources and capabilities to monitor service levels and enforce penalties for noncompliant behaviors.
- **Efficiency.** Consider reasons for public and private sector inefficiencies, including cost accountability, labor tenure, government wage scales, restrictive labor practices, personnel benefits, inflexible work arrangements, bureaucratic procurement procedures, political limitations, and hiring and

firing procedures. Assess options for reducing or removing these barriers. Give preference to plans offering economies of scale.

- **Capability.** Ensure that adequate government capacity exists for planning, design, construction, operation, maintenance and oversight. Evaluate both the public and private sectors for technical and financial resources, including expertise, skills and access to capital. Private companies must possess required facilities and equipment, or have a business plan that covers them. Governments must have both the capability to monitor performance and the political will to enforce contractual or license agreements.
- **Competition.** Ideally, a privatization plan will allow for competition between a number of private firms or between the government and a few private firms. Consider possible barriers to market entry and exit, as well as economies of scale that might limit competition. Determine if financial incentives or technical assistance would result in better performance from private firms. Ensure the government's ability and commitment to conducting a competitive procurement process.
- **Duplication.** Ensure that the government has the political will to cut personnel and assets when services are privatized. Balance the cost savings from reduced staff with new monitoring and enforcement costs.
- **Risk.** In some developing countries, commercial lenders and private companies do not want to risk their money on long-term or large-scale investments that rely on government payments. Regulatory framework must exist to protect the private sector against risks such as environmental damage, currency adjustments, inflation and political changes. Local governments must be able to generate enough revenue to meet contractual agreements with the private sector and protect against economic instabilities. Plans should include provisions for loss due to corruption (kickbacks, bribes and favors).
- **Accountability.** Ensure that private sector participation will not disproportionally benefit wealthy classes. Market openings should be made available to small- and medium-size enterprises, helping to redistribute income. Government must guarantee a fair minimum wage and safe working conditions. Government should also make provisions for displaced workers, including job training and employment networking.
- **Costs.** The costs for public waste collection services must be well understood. Cost factors should be analyzed separately for the different components of solid waste service—collection, cleansing, disposal and transfer. Government must have detailed accounting information to determine whether private sector participation would be more cost-effective. A strategic planning and feasibility study should be conducted to know whether the

technology offered by the private sector would result in lower costs.

These criteria help to determine the extent to which a society is open or closed to competitive market forces, whether the procurement process is straightforward or opaque, how interrelated and transparent taxation and subsidies are, and the extent to which corruption skews the system. Moving public services to the private sector will be efficient only where competition, performance monitoring and accountability exist.

Privatization: Beneficial But No Panacea

Solid-waste management (SWM) in Dar es Salaam is the responsibility of the Dar es Salaam City Council (DCC). An estimated total of 1,929 tons of waste is generated daily from households, businesses, institutions and market centers. Before the decision to privatize solid-waste collection and disposal, the City Council was only able to manage 2–4 percent of the waste generated daily.

The main reasons for this inability to manage waste collection were:

- Lack of equipment (trucks and machinery.)
- Lack of funds to replace equipment, purchase spare parts, service existing equipment and fuel them. Historically, DCC has allocated less than 8 percent of its total budget for SWM. Out of the 30 trucks and machinery donated by the Japanese government in 1987, only three were operational in 1992. In addition, the operational vehicles functioned at less than 20 percent of capacity.
- Lack of an official disposal site. The only "dump site" in the city was closed following an August 1991 court ruling in favor of residents of the Tabata area who complained of air pollution caused by burning waste dumped at the site.
- Lack of involvement of other stakeholders.

The DCC chose to try privatization to improve waste collection services. Privatization was accomplished in two phases, Phase I from 1992 to 1996, and Phase II from 1996 onwards. For Phase I, a single contractor was assigned to collect waste from 10 city wards and empowered to charge customers directly. For Phase II, four additional firms were given contracts through a process of open tendering, making a total of five contractors servicing 13 wards.

The major achievements realized during the first phase of privatization included:

- Establishment of a solid-waste management partnership advised by a multi-disciplinary stakeholder working group .
- More efficient service and revenue collection. Households responded positively to the need to pay for refuse collection. Initially, collection of solid waste improved to 70 percent of waste generated. However, this rate started to decline six months after the engagement of the private contractor, for reasons outlined below.
- 318 jobs were created for workers employed by the contractor. Also, human resources and stakeholders were used more efficiently; whereas 800 DCC workers collected only 30–60 tons per day, 318 workers under the private contractor collected 100 tons per day.

The problems identified in the first phase of privatization included:

Non-fulfillment of obligations from all parties. Under the contract, the contractor was supposed to pay the DCC the monthly costs of renting trucks, a leased depot, and the refuse disposal charges at the dump. DCC was obliged to pay revenue collection charges for the services provided by the contractor at DCC-owned premises like schools, hospitals, offices, etc. Unfortunately, neither party paid the other, and the DCC withdrew its facilities in September 1995. Also, the DCC was responsible for the public awareness campaigns among residents of the privatized area, and for prosecuting customers who defaulted on refuse collection charges (RCCs). When the defaulters were not prosecuted, the contractor's ability to collect revenue was further limited.

Lack of competition. Using only a single contractor did not result in optimal pricing for the consumer or overall system efficiency.

Poor monitoring. Staffs of both the DCC and the contractor were unfamiliar with privatization of solid-waste collection and disposal, leading to poor monitoring and oversight.

Lack of well-functioning management information system (MIS) to track payment information.

Problems within the contract agreement. Some of the items within the contract were not well elaborated, such as the period when RCCs would be reviewed, how to deal with complaints by the refuse producers, how to monitor the daily operation of the contractors, and methods of arbitration.

During Phase II, the daily solid-waste collection increased in the newly contracted wards. Solid-waste heaps were reduced, especially in open spaces and market places.

However, the constraints were similar to phase I, including inadequate payment of RCCs to the contractors. Preparations were insufficient to involve and raise awareness of people on the new strategies to clean the city and the responsibilities of individuals and stakeholders. Inadequate revenue collection prevented contractors from meeting financial targets. Contractors' equipment and facilities were inadequate, and they failed to meet promises to purchase replacements.

DCC was unable to provide an enabling environment for the contractors (e.g., information on residents liable to pay RCCs, an effective public awareness campaign). The contractors required close supervision, monitoring, support for planning, technical advice and financial assistance. All households were not treated equally in all wards.

Source: *Privatization of Municipal Services In East Africa: Governance Approach to Human Settlements Management*, UN Center for Human Settlements

Limitations of Privatization

To be successful, privatization of solid-waste management must contend with a variety of problems, including insufficient public awareness and little ability to generate the necessary public participation in planning, administering, or monitoring; managerial deficiencies and weaknesses in local authorities that make it hard to carry out policy reform measures; and lack of experienced and competent personnel to administer and manage the privatization process (see privatization story on the previous page). Municipal councils opting to privatize or commercialize their services often find that they need to upgrade all staff in accounting, auditing, information management, policy development and implementation to make these options work.

Although private solid-waste entrepreneurs work all over a city, most activity is concentrated in residential neighborhoods and biased towards middle- and higher-income households who can be relied upon to pay for services. Little or no private sector solid-waste collection activity occurs in low-income areas, due to inability to pay rather than lack of access to these areas. Large firms usually serve wealthy areas, while small firms generally serve a single, middle or lower-middle income neighborhood. Informal private sector waste entrepreneurs or "scavengers" operate in all areas.

Although popular belief states that the private sector will field better-maintained refuse collection vehicles, this is not usually the case. Unless contracts provide incentives for the private firms to invest in appropriate equipment, firms lease second-hand dump trucks that frequently break down.

Community-Based Management of Solid Wastes (CBM)

Community participation in solid waste management covers a variety of types encompasses several forms of local involvement, including:—

- awareness and teaching proper sanitary behavior;
- contributing cash, goods or labor; and andor
- participating in consultation, administration, and/or management functions.

At the most basic level, participation might be providing separated waste to the waste can be handing over separated waste at a particular time to the waste collector or granting space to park waste management vehicles. With more greater public participation, the community can cooperate with public or private entities to set payment rates for service charges. Community management, the highest level of community participation, gives the community authority and control over operation, management and/or maintenance services benefiting its members. Community management may come about through partnership with governmental agencies and NGOs.

Community- based waste managementCBM projects require institutional support and recognition in order to be successful. An integrated system - —including waste separation at the source, resource recovery, and composting of organic waste - —requires representation of waste pickers, and integration of the community to work with alland stakeholders, including representatives of waste pickers. Local leaders are often active in managingement of the service or maintain close contact with the municipality or community management body. Women and teens can play crucial roles, such as initiators, managers, operators, political activists, educators, and watchdogs for the community.

Community-based management (CBM) can may also address the following social and management problems:

Low participation of households. Households may not participate in waste management programs because they may view solid waste management ais a low priority., They may be they are unwilling to participate in collection systems or in keeping public spaces clean, or they are unwilling to pay for service. Community Provisions for education, is often key to overcoming the best counter to these barriers, canmay be inadequate in but traditional approaches to waste management often do not provide enough for education. Community-based solutions can use preliminary research and input offrom the community to generate a list of desired services, appropriate incentives for households and servants, and systems for cleaning streets and other public places.

Management problems. Problems with traditional waste management schemes include ineffective, inefficient, or unrepresentative management, as well as lack of community accountability to the community. CBM can introduce performance control techniques, share management with an NGO, adjust or by-pass an existing management committee, orand provide incentives for managers, such as training and exchange visits.

Operational problems. With poor motivation operators are poorly motivated, due to low salaries, low status and bad working conditions, operator motivation can be low, and public service may become can often be unreliable. Finding adequate space for waste facilities and equipment is another potential operational issue. Sound CBM can addresses motivational problems by involving operators in decision-making, using special group incentives, and, in some cases, by granting exemptions from municipal taxes. Operators can be officially introduced to households and provided with identity cards to improve operator status. Space problems can be resolved by lobbying municipalities and local leaders, as well asnd conducting media campaigns in the neighborhood.

Financial difficulties. Public and private management plans often face financial difficulties caused by inadequate fee collection and inability to pay for service in low-income neighborhoods. CBM gives community input into plans for fee collection payments, incentives and sanctions for non-payment. Community input can also help waste management providers find lead to additional revenue- generating services.

Lack of municipal cooperation. If waste collection between the municipal government and private operators is badly coordinated and the community may lose interest in trying to improve the waste situation. Extending service, mobilizing communities to lobby the municipality for assistance, involving local authorities, and structuring formal and informal opportunities for cooperation all improve municipal performance and community support for waste management plans and programs.

Capacity Building

Insufficient capacity is a fundamental impediment to sound solid waste management programs in much of the developing world. Operating an efficient, effective, environmentally sound municipal solid waste management program requires building administrative capacity for government and private sector players and technical capacity for designing, operating, maintaining, and monitoring each part of the process.

Often those people working in solid waste management—private sector companies, NGOs, and government entities—lack the technical and financial knowledge to operate efficiently. Training that builds human resource and institutional capacity at appropriate levels is essential. Peer-to-peer training for everyone from waste-pickerwaste pickers to local government officials has proven effective in extending and sustaining these programs.

Integrating the informal sector

In Rufisque, Senegal, an innovative community initiative helped extend solid waste collection services to 3,000 households by employing horse-drawn cart operators, contracted to work two hours a day to collect refuse from households. The operators were free to work the rest of the time as general haulers. The local municipality is involved in all stages of the initiative—it is regularly represented at community meetings, assigns and approves collection routes, and maintains contractual relationships with cart operators.

-UNESCO, *MOST Clearing House Best Practices Database*. June, 2000

Environmental Mitigation and Monitoring Guidelines

In designing and operating integrated solid waste management programs:

- Minimize the quantity of waste that must be placed in landfills through elimination, recovery, reuse, recycling, remanufacturing, composting and similar methods.
- Manage non-hazardous wastes and special or hazardous wastes separately.
- Collect and transport all waste effectively and efficiently.
- Design sanitary landfills and ensure appropriate siting, operation, monitoring and closure.
- Establish sound fiscal and administrative management, privatizing operations with open competition, whenever feasible.

Waste minimization

Reduce, reuse, recycle. Reducing the quantity of waste that must be transported and disposed of should be a primary goal of all municipal solid waste management programs. Waste should be recovered at the source, during transport or at the disposal site. The earlier the separation, the cleaner the material, and, in the end, the higher its quality and its value to users. Incentives which integrate and foster the involvement of the informal sector—itinerant collectors, microenterprises, cooperatives—can be essential to improved waste minimization. Other tips on reducing waste include:

Encouraging recycling can help build capacity among local micro-enterprises and reduce the waste handled by landfills and dumps. (Photo courtesy of United Nations Development Programme)

- *Organize itinerant collectors and publicize prices.* In cities throughout Africa, itinerant collectors recover high-value recyclable materials at residences and small industries. Organizing collectors can improve both their standard of living and the stability of the collection services. Publicizing prices can help stimulate the market and mitigate possible exploitation by intermediaries.

- *Foster secondary markets.* The extent to which a material is recovered is dependent on the existence of local industries that can use the recovered material. Secondary markets to serve these industries do not always develop independently. Consider developing a program to identify and develop such markets where there is untapped demand.

- *Offer incentives.* A deposit system on glass bottles has maintained a high recovery rate throughout the continent. South African beverage manufacturers also issue deposits for tin and aluminum cans, which have generated high levels of reuse.

Facilitate separation at disposal site. When waste pickers are allowed access to disposal sites, significant amounts of material can be recovered. However, because they interfere with efficient operation of dumps and landfills, waste pickers are usually excluded from these sites, lowering recovery rates and causing severe economic hardship. Some sites provide a measure of structured access to waste pickers—at the Bisasar Road landfill in Durban, for instance, registered pickers from an adjacent squatter settlement are allowed into the site after hours, earning US$77 per month from this activity. At all other times, armed guards restrict access to the site. Similarly, the South African Boipatong landfill limits access to 100 registered waste pickers.

Composting and anaerobic digestion. Organics make up 30–80 percent (~70 percent on average) of the waste stream in Africa, although this varies with the incomes of the neighborhood, region or country. If this part of the waste stream could be used for compost or methane production, many adverse impacts of open dumps and landfills would be reduced. Landfills would require less space, last longer, and produce less leachate.

- *Evaluate the possibility of composting.*

  Large centralized composting efforts, designed to separate the organic component from mixed waste, have almost always failed in Africa for reasons which include poor (or absent) feasibility studies and subsequent failure to meet cost recovery expectations. The city of Accra in Ghana has a successful creative variation on this theme: a **co-composting plant** that converts human waste sludge and solid waste to compost which is then sold to recover the plant's operating costs.

  Small composting enterprises have fared somewhat better. Higher urban demand or subsidies may be necessary if composting is to become a part of integrated waste management. For example, a city could pay small composting operations for each ton of material that is diverted from landfills and base that payment on the disposal costs the city can avoid.

  Backyard composting is a third option, but may be difficult to coordinate the level of effort needed for a city-level impact. In Uganda, community-based groups are experimenting with backyard composting, using the compost in a variety of ways, from conventional agriculture to producing fishpond algae as fish feed.

- *Promote vermiculture treatment of vegetable food waste.* Small earthworm composting farms, operated by 5–6 people, have proven more successful than traditional composting facilities in developing countries, though they are not yet in widespread use in Africa. Vermiculture benefits from better quality control and the cultural perception that the final product, consisting of "worm castings," is derived from "clean" vegetable waste, whereas compost is derived from unclean "garbage." The final product is also more nutrient-rich than compost.

- *Investigate anaerobic digestion.* Anaerobic digestion can generate a nutrient-rich slurry to be used on soil and a methane-rich biogas to be used for fuel.

Collection and transfer

As noted earlier, most African city dwellers lack regular waste collection or access to disposal services, except in the better-off neighborhoods or communities. Careful consideration of the city, climate, and culture is essential to achieving universal collection at recommended frequencies. The following general insights from international experience may be valuable:

- *Use appropriate technology—regular trucks and alternative vehicles.* Specialized compaction trucks are very expensive, difficult to repair and often out of service. Moreover, compacting garbage provides little advantage, considering the density of the waste currently produced in most of the region. Regular trucks require less capital investment and are easier to maintain. They may also be better adapted to poor road conditions and can be used for other purposes if the municipality or company decides to transfer collection responsibility to others. For waste collection in hard-to-reach areas—very narrow streets, alleys, deteriorated roads—alternative collection vehicles should be considered, including semi-motorized carts, front-loaded tricycles, donkey carts, or handcarts.

- *Integrate the informal sector*. Co-operatives and microenterprises are the primary users of smaller collection vehicles and can effectively collect waste from hard-to-reach areas at a low cost. Community members are generally more willing to pay for such flexible and inexpensive services.

- *Build on the existing system*. Radical changes are often difficult to achieve, especially with limited political support, administrative and technical capacity, or financial resources. Develop new structures and processes as part of a strategy of incremental improvement.

- *Introduce transfer activities*. Transfer activities often increase efficiency, for both small- and large-scale systems. In small-scale transfer, microenterprises or cooperatives bring waste to a centralized area for pickup by private or municipal trucks. In large-scale transfer, waste is transferred from a compactor or small truck to larger trailer trucks. Both types of transfer activities save fuel, reduce wear and tear on trucks, and shorten the amount of time spent traveling to and from the landfill. The farther the landfill is from the city, the greater the benefits of large-scale transfer. However, transfer activity is virtually unknown in sub-Saharan Africa.

- *Shift to direct fee-for-service and local financing*. Most solid waste collection is paid out of tax revenues collected by national or local governments and redistributed to the municipality. Mismanagement of funds, lack of competition, and the resulting inefficiencies often result in non-payment or unwillingness to pay for services. Market-oriented systems in which residents' fees support collection and disposal services are less likely to suffer from these crippling flaws. Nevertheless, unwillingness to pay can still be a problem under such systems. One strategy for overcoming this problem, used in a number of developing countries outside of Africa, has been to link billing for

Siting guidelines for landfills

Do not site landfills:

- In wetlands or areas with a high water table
- In floodplains
- Near drinking water supplies
- Along geological faults or seismically active regions
- Within two kilometers of an airport

Do site landfills:

- Above clay soils or igneous rock
- With active public involvement
- In areas with sufficient capacity

solid waste collection to utility bills. Electricity consumption is closely correlated with waste generation, so fees for waste collection can be tied to electricity use and integrated into the electrical bill. After charging a small administrative fee, the utility passes the payments to the municipal solid waste department.

Landfills

Most of the waste in Africa is disposed of in environmentally unsound open or controlled dumps. Even using the best waste minimization practices at all stages, some non-recoverable waste will remain, making landfills necessary. The ultimate goal for land disposal should be:

- separate disposal of hazardous and non-hazardous materials; and
- construction of clean and properly sited landfills with diligent management, including leachate and methane controls, during operation and after closure

When these conditions are met, the landfill becomes a *sanitary landfill*. It is recommended that the transition from open or controlled dumps to sanitary landfills be made incrementally. The following steps are suggested:

Open dumps. If open dumps are currently being used, initial upgrades can be made with little capital investment and minimal ongoing costs:

1. Construct perimeter drains to catch runoff and leachate.
2. Minimize leaching through soil by and repeating periodically (every two months is often sufficient compacting and grading. This causes rainwater run off into perimeter drains instead of soaking in. Manual labor or heavy equipment may be used (renting heavy equipment is often the least expensive option).
3. Protect the health of waste pickers and landfill staff by providing soap, water and hygiene training.
4. Regularly test groundwater for contaminants, including bacteria, heavy metals, and toxic organic chemicals.
5. Conduct a formal environmental assessment of the current site before making further upgrades. If it is environmentally sound and has adequate additional capacity, it can be converted directly to a controlled dump. Otherwise, an appropriate alternative site for a controlled dump or sanitary landfill must be located.
6. Engage the public in decision-making. Public involvement in upgrades, siting decisions, and subsequent planning is essential. Otherwise, strong opposition that delays or halts the project may develop.

Controlled dumps. To transform an open dump into a controlled dump:

1. Fence in the active face of the landfill and hire staff to monitor and control dumping.
2. Track how much waste is delivered.
3. Compact waste before or after dumping.

4. Schedule monitoring of methane gas production, landfill composition, and surface water and groundwater conditions.
5. Develop closure and post-closure plans.
6. Seal and cover the dump in stages as its capacity to receive waste is exhausted.
7. Maintain scheduled monitoring until sampling indicates it is no longer necessary—possibly 30 years or more.

Sanitary landfills. Sanitary landfills are the only land disposal option that enables control and effective mitigation of

- potential surface and groundwater contamination;
- health and physical threats to waste pickers and sanitation workers; and
- methane emissions.

Sanitary landfills require much greater initial investment and have higher operating costs than controlled dumps. Full community involvement throughout the life cycle of the project is essential. Proper design, operation and closure also require a much higher level of technical capacity.

Siting. Siting is possibly the most difficult stage in landfill development.

1. Carry out an environmental impact assessment that addresses all siting criteria (see box at left).
2. Organize full community involvement. This is especially important given the greater expense and often greater size of sanitary landfills.

Design. To mitigate environmental impacts, sanitary landfill designs should include:

1. An impermeable or low-permeability lining (compacted clay and polyethylene are most common in developing countries; geopolymers and asphalt are prevalent in the developed world).
2. Leachate collection, monitoring, and treatment.
3. Gas monitoring, extraction, and treatment.
4. Fencing to control access.
5. Provisions for closure and post-closure monitoring and maintenance.

Leachate management. Leachate impacts can be controlled only with lined landfills.

1. Install collection systems to retrieve leachate from the bottom of the landfill.
2. Treat leachate physically, chemically, or biologically through:
   a. An off-site sewage treatment plant (adequate sewage treatment facilities are readily available in only some parts of Africa), or in a dedicated on-site treatment plant.
   b. Recirculation that sprays leachate from the bottom of the landfill onto its surface. This is a popular landfill management practice

in Africa. It reduces leachate volume by increasing evaporation, stores remaining leachate in the body of the landfill, and may accelerate degradation and extend the life of the site. However, recirculation is a new technique whose long-term effects are not yet known.

   c. Evaporation of leachate through a series of open ponds. This method requires pumping and some means for disposing of possibly toxic residues. Ponds should be designed with enough capacity to accommodate increased volume during the rainy season.

3. Monitor groundwater and surface water regularly, both down-gradient and up-gradient from the landfill. At a minimum, monitoring should include indicators of core contaminants, chemical oxygen demand, biological oxygen demand, and total nitrogen and chloride levels.
4. If it is uneconomical to recover and use landfill gas as fuel, it should be vented and flared. Currently, recovery and processing systems are both expensive and difficult to operate. These systems are economical only when the landfill generates large quantities of gas, where local or regional demand exists, or where the price for natural gas or other substitutes is high. At a minimum, buried perforated pipes that can safely vent gas should be installed, and a flaring system should be added to reduce global methane release to the atmosphere.
5. Fence in landfills to prevent waste pickers from accessing the site. This enables landfill personnel to work efficiently and protects waste pickers from exposure to harmful substances. However, it also deprives them of their livelihood. They should thus be integrated into formal collection or disposal operations by, for instance, helping them organize a cooperative and offering them structured access at the landfill gates. Also, they should be made a part of the earlier stages of the collection process, perhaps by helping them establish a cooperative that collects recyclables from industry.
6. When the landfill is full, implement the activities specified in closure and post-closure plans that were developed during design. These should include sealing the landfill and applying a final cover (including vegetation) to it, land use restrictions on both the old landfill and surrounding areas, and long-term gas, leachate, surface water and groundwater monitoring.

Incinerators

Do not construct incinerators. Incineration of municipal solid waste is rarely economically feasible for developing countries. Burning the wet waste found in Africa often requires adding supplemental fuel. Furthermore, the composition of the waste often varies a great deal between neighborhoods, which makes consistent and optimal operation difficult to achieve. Without proper controls, incinerators can be highly polluting, generating dioxins and depositing toxic heavy metals into water bodies. The proprietary technologies involved require very large capital investments and have high maintenance costs.

Wastes Requiring Special Attention

Certain wastes merit special handling and disposal because of their dangers or volume. The best option is to minimize or eliminate the generation of these wastes by encouraging users to apply cleaner production approaches and substitute materials or change processes (see "Environmental Guidelines for Activities with Micro- and Small Enterprises" in this volume). Those that are generated should be collected and disposed of separately from one another and away from the rest of the solid waste stream.

Hazardous waste. Wastes pose a wide range of risks. They may be chronically and acutely toxic, cause cancer, trigger birth defects, explode, corrode many materials, and cut, puncture, crush, burn and infect people and animals. Hazardous wastes endanger many different classes of people, placing waste producers, collectors, landfill workers, waste pickers, and nearby residents at risk. The leachate from a landfill may be dangerous as well; its level of toxicity is directly related to the quantity and toxicity of hazardous materials mixed in with other solid waste.

Management of hazardous wastes needs urgent attention in Africa. The variety and classes of materials and sources—from households to industrial and medical facilities—makes this particularly challenging. Action is constrained by limited financial resources to deal with these problems and ignorance or unwillingness to acknowledge the risks.

Sound management of hazardous materials includes four elements: waste reduction, segregation, safe handling, and disposal. The best solution is to not generate this waste in the first place. When this is not possible, every effort should be made to minimize generation, and generated wastes should be handled cautiously to reduce risks. Producers of hazardous waste should segregate different types of materials to make recycling easier and prevent chemical reactions or explosions. Suggested best practices for accomplishing these goals in the developing world include:

- *Providing technical assistance and training* to educate decision-makers, system operators, and the public. These efforts should strengthen stakeholders' capacity to identify cost-effective waste reduction measures, and to help design and to put in place practical hazardous waste management plans. (See the Cleaner Production approach described in the "Small and Micro Enterprises" section of these guidelines.)

- *Establish incentives, disincentives, or regulations* to promote waste reduction where it is not otherwise cost-effective.

- *Establish dedicated hazardous waste recycling and disposal facilities.* Few countries in Africa operate hazardous waste treatment and disposal facilities. Thus, much of the hazardous waste generated continues to be disposed of in dumps and landfills without any provisions for segregation, containment or treatment.

- *Develop systems to ensure that waste is not illegally dumped*. One model that provides checks on illegal dumping is the hazardous waste manifest system in the United States, where a “paper trail” (a sequence of required documents) is generated to prove that the material reached its intended final destination.

- *Explore options for contracting private sector firms that specialize in the handling and disposal of hazardous wastes.*

Medical waste. Wastes from health posts, clinics, hospitals, and other medical facilities pose serious and urgent problems in the Africa region. (A detailed discussion of impacts and appropriate mitigating measures can be found in the “Healthcare Waste: Generation, Handling, Treatment and Disposal” section of this volume.)

These wastes can contain highly infectious organisms, sharp objects, hazardous pharmaceuticals and chemicals, and even radioactive materials. Since the various forms of healthcare waste require different types of treatment, they should be segregated at the source. General waste should be segregated from hazardous material to reduce volume: sharps should be placed in puncture-proof containers, infectious waste separated for sterilization, and hazardous chemicals and pharmaceuticals segregated into separate bins.

Unfortunately, all of the available disposal options are imperfect. The most immediate threat comes from highly infectious waste. On-site treatment is generally preferred to reduce the risk of disease transmission to waste handlers, wastepickers and others. Suggested mitigation measures include:

- In rural areas, burn infectious waste in a single-chamber incinerator, if possible. This kills >99 percent of the organisms and is the best option for minimal facilities.

- In urban areas, burning is not advisable, as the fly ash, toxic gases and acidic gases pose a much greater health threat in more densely populated urban environments than in rural areas. Thus larger facilities should autoclave infectious waste. While high-temperature incineration is theoretically the best option in urban environments, in practice the equipment is rarely operated properly and disposal is highly polluting.

- In some large cities, off-site wet thermal, microwave or chemical treatment options may be available.

- The least expensive option is land disposal. If waste is to be disposed of in a dump or landfill, it should be packaged to minimize exposure, placed in a hollow dug below the working face of the landfill, and immediately covered with 2 m of mature landfill waste. Alternatively, it may be placed in a 2 m deep pit and covered in the same manner. Waste-picking must then be prevented.

Tires, oil, and batteries. These three common automotive wastes cause difficulties throughout the continent:

- Stockpiled tires can spontaneously combust, producing prolonged, polluting fires. Reuse or retreading are the best alternatives available for reducing tire waste in developing and industrializing countries.
- Used motor oil from auto shops is often burned as fuel, contributing to air pollution. Re-refining this oil is the best alternative, but this alternative is neither readily available nor commercially feasible in most of Africa.
- Lead acid batteries should not be placed in landfills—the lead is toxic, the acid corrosive and contaminated. Lead acid batteries are often recycled in small-scale foundries that are highly polluting and located in residential areas. Recycling in large facilities that have emission and environmental controls is preferable, if this option is available.

Construction and demolition debris. Prevent disposal of construction and demolition debris in dumps or landfills, as this will greatly reduce the life of the facility. Residual lead paint, mercury switches, asbestos and PCBs can also make this debris toxic. Arrange for the return of unused construction materials, recovery of all reusable or recyclable materials, and on-site separation of different waste materials to simplify reuse. The UN Environment Programme's *International Sourcebook on Environmentally Sound Technology for Municipal Solid Waste Management* recommends the following best practices for construction and demolition debris:

- *Inventory control and allowance for return of construction material.* This ensures that unused materials will not be disposed of unnecessarily.
- *Selective demolition.* This involves dismantling, often for recovery, selected parts of buildings to be demolished before the wrecking process is initiated.
- *On-site separation systems.* Use multiple smaller containers instead of a single roll-off or compactor.
- *Crushing, milling, and reusing secondary stone and concrete materials.* There can be a tie-in to approved road construction material specifications.

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- *Decision Maker's Guide to Solid Waste Management Vol. II (sic. Second Edition)* (1995). U.S,. Environmental Protection Agency, Washington, D.C. http://www.p2pays.org/ref/03/02021.htm

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Other Useful Internet Resources

- *Listserve: Solid Waste Management-Recycle*, National Academic Mailing List Service. http://www.jiscmail.ac.uk/lists/solid-waste-management-recycle.html

  A listserve for discussion of all aspects of solid waste management and recycling in developed and developing countries. Main areas of interest include recycling, composting, re-use, recovery, the informal sector and organization of waste management.

- Waste Advisors on Urban Environment and Development. http://www.waste.nl/

  WASTE is a non-profit organization for development projects in countries in Africa, Asia, Latin America and Eastern Europe. WASTE works for organizations engaged in sustainable improvement of the living conditions of urban low-income populations, and of the urban environment in general. Their website contains a variety of papers and project reports relevant to all sectors of waste management and practical approaches to small-scale waste management activities.

Chapter 16

Water Supply and Sanitation

Contents

Sector overview 16 - 1

ESDM Approach to Small-Scale Water and Sanitation Projects : General Guidance 16 - 3

Potential Environmental Impacts 16 - 4

ESDM of Activities & Programs: Best Practices 16 - 8

ESDM of Activities and Programs: Specific Mitigation and Monitoring Measures 16 - 13

References and Resources 16 - 19

Good sanitation and hygiene practices are key to preventing contamination of water resources.

At the same time, good facilities and practices provide few health benefits if the water resource remains contaminated.

Therefore, water supply and sanitation projects and hygiene promotion should be viewed as interdependent activities. Implementing them at the same time leads to the

Sector overview

Adequate, safe water: a basic need. To remain healthy, human beings need an adequate, year-round supply of high-quality water. Many debilitating or even fatal illnesses are spread by contamination of the water supply with human fecal matter containing disease-causing viruses, bacteria, and parasites. In addition, there is a high opportunity cost to the lack of safe water., especially for women and children.

- Children are more likely to become ill, and women are the primary caregivers for ill family members.
- Women and girls carry out most water collection, and many spend long hours doing so. Time spent collecting water could be spent in more productive activity, such as food production or, especially in the case of children, education.

However, infrastructure alone will not result in improved health. It is necessary to integrate provision of water supply and sanitation facilities with sanitation and hygiene promotion activities to ensure sustainability of the infrastructure and correct and consistent hygiene behaviors to reduce waterborne diseases.

The YACUPAJ project: community participation promotes sanitation

The YACUPAJ project in Bolivia (1991–94) integrated many of the features analysts have found in successful sustainable projects:

Respond to demand. To participate in the project, communities had to ask for it. The first stage of the project in every community was to strengthen and expand this demand through a coordinated education and demonstration program.

Community management. Community members took part in managing the entire project. They defined their needs, set the level of participation, chose the project type, and shared costs.

Involve women. Steps were taken to engage women as active participants in every stage of the project.

Install appropriate technology. Facilities were simple, low-cost, and easily maintained by users.

Local construction and maintenance. Family or community personnel constructed household latrines. Local masons were trained in latrine construction and as hygiene promoters.

Promote hygiene. Hygiene was promoted through education and training. Promotion was identified as a key activity for ensuring effective and sustained use of the services.

Monitor sustainability. State and private institutions remained involved after the project ended to monitor sustainability.

The results:
Communities provided over 50% of the funding, even though they were the poorest in the country.

A sustainability study in 1995 showed 82% of latrines still in use.

Trained masons continue to build latrines with direct responsibility to client families and no external support.

Attitudes toward latrine use have improved dramatically.

See Soto (1998).

The basic need is not met. Unfortunately, over one-third of the world's population, nearly 2.5 billion people, have inadequate access to sanitation, and over 1 billion people do not have access to enough safe water. Overall, polluted water affects the health of 1.2 billion people every year and contributes to the death of 15 million children under five every year. Vector-borne diseases, such as malaria, kill another 1.5 to 2.7 million people per year, with inadequate water management a key cause of such diseases (*UNEP Global Environmental Outlook Report 2000*). In Africa alone, over 300 million people lack either sanitation or adequate water, and frequently both.

Significant international focus and investment during the "Water and Sanitation Decade" (1981–1990) brought water to 80 percent of the world's population and sanitation to 50 percent. During the 1990s, however, no additional gains were made, and population growth led to an increase in the absolute numbers of people without safe water or sanitation.

The Hakitagata Bakyara Twimukye Hot Springs near Kisoro, Uganda are believed to have special medicinal properties. Disease sufferers are living in makeshift huts at the source. Water quality downstream may be harmed by the effluent from this site.

Water resources in general are poorly managed, especially in the developing world. For example, many urban areas in developing countries lose more than 50 percent of distributed water through leaking pipes. The water and sanitation technologies used in the developed world, such as extensive sewer systems and large wastewater treatment plants, are frequently too costly or impractical for developing countries, although this has not necessarily discouraged attempts to implement them. Rural populations and the rapidly growing peri-urban and urban poor are disproportionately under-served.

Water supply, sanitation and hygiene are closely related. Good sanitation and hygiene practices are essential to preventing contamination of water resources. At the same time, good hygiene practices and sanitation facilities provide few health benefits if the water resource remains contaminated. Therefore, water supply and sanitation projects and hygiene promotion should be viewed as interdependent activities. *Implementing them at the same time leads to the greatest health benefit and is considered a best practice in the sector*.

ESDM Approach to Small-Scale Water and Sanitation Projects: General Guidance

Environmental issues. Water and sanitation projects are intended to improve environmental health conditions for beneficiaries. However, poor design, construction or implementation or activities in this sector can result in **environmental failures** that eliminate or offset the intended benefits. These failures range from heightened risks to human health, to damage to ecosystems and economic activities, to depletion and degradation of water resources available to neighboring and downstream communities.

Environmentally sound design and management (ESDM) of activities in all sectors requires design and management to anticipate and avoid or otherwise mitigate these impacts.

Participatory approaches for environmental soundness and sustainability. Environmental soundness depends significantly on community participation and commitment:

- Operating practices and maintenance are essential to environmental soundness, and this usually requires continuing involvement by the community. (For example, after the NGO leaves, communities must continue to protect source waters, maintain latrines, etc.).
- In addition, beneficiaries must actually *use* the latrines, water supply points, etc. and adopt complementary behaviors (like hand-washing after defecating) for environmental health benefits to be achieved. Both require changes to behavior that are sustainable only with education and commitment.

For these reasons, ESDM in the water and sanitation sector requires a participatory approach. Over the past three decades, experience has shown that water and sanitation activities are most effective and sustainable when they adopt a participatory approach that (1) acts in response to genuine demand, (2) builds capacity for operation and maintenance and sharing of costs, (3) involves community members directly in all key decisions, (4) cultivates a sense of communal ownership of the project, and (5) uses appropriate technology that can be maintained at the village level. Also important are educational and participatory efforts to change behavioral practices.

Representative small-scale water and sanitation activities/technologies

Water sources
pond and spring improvements
hand-dug wells
small-diameter boreholes
wells with hand pumps
roof rainwater catchments
small dams and seasonal impoundments
Rivers and streams

Water distribution
Simple spring-fed gravity feed water distribution systems
Well or surface water source pump with storage tank and piped distribution to standposts or individual yard taps or connections,
Extensions of existing urban water lines into unserved or under-served peri-urban zones

Water use points
showers
clothes-washing basins
cattle troughs
hand washing taps

Individual latrines
Ventilated improved pit (VIP)
Composting latrines
Dehydrating latrines
Pour-flush latrines
Simple pit with or without cover

Community latrines
(see technologies above)

Sewerage
Small-scale septic and leach field systems
Settled and simplified sewers
Water stabilization ponds
Constructed wetlands
Water borne sewage to primary/secondary treatment
Ecological sanitation (urine diverting toilets, arborloo latrines)

This guidance is intended for application to a variety of **small-scale** rural and urban water supply and sanitation activities that PVOs and NGOs may help design or manage. Large-scale water projects are not considered here. Representative small-scale activities/technologies are listed in the sidebar.

Potential Environmental Impacts of Water and Sanitation Activities and Their Causes

As noted above, while water and sanitation projects are intended to improve environmental health (and provide numerous other benefits), they may cause adverse environmental impacts that can offset or eliminate these intended benefits.

This section discusses these potential adverse impacts. Summary tables appear at the end of the section.

Debilitating disease and death. Water supply and sanitation projects may cause increased incidence of infectious water-borne diseases such as cholera, non-infectious disease such as arsenic poisoning, and water-enabled diseases such as malaria, schistosomiasis or bilharzia.

- contamination of surface and groundwater supplies with infectious organisms from human excreta is especially serious. Contamination may be caused by poorly designed, operated or maintained sanitation facilities, such as sanitation systems that transfer sewage to receiving waters without treatment, or pit latrines located in areas with high water tables.
- Infectious diseases may also be spread by improper use of wastewater to grow food crops.
- Failure to test new sources of water, especially groundwater, for possible natural or industrial chemical contaminants, such as arsenic, mercury, fluoride and nitrate, can have devastating consequences.

These adverse impacts may occur in both urban and rural areas. Increased population densities and the lack of facilities can increase the negative impact in peri-urban areas.

This well near Tamale, Ghana has poor drainage and thus significant potential for adverse health impacts. Possible impacts of stagnant water include increase in vector-borne diseases and soil erosion/sedimentation.

Native plants and animals harmed and associated land, water, and coastal ecosystems degraded. These impacts most often arise from water diversion, construction or decommissioning activities in or near a watercourse, or from fecal contamination of water. Numerous impacts on ecosystems are possible:

- Construction of facilities in sensitive areas (wetlands, estuaries, etc.) can destroy flora or fauna or their habitats, leading to loss of biodiversity, reduction of economic productivity and loss of aesthetics and recreational value.
- Water-supply projects can also deplete fresh water. Increased consumption of water can reduce water flows and cause loss of habitat, wetlands and wildlife downstream.
- Water supply projects can erode soil from pipe leakage or poor drainage at taps. Soil erosion may cause sedimentation in receiving waters, which may reduce the capacity of ponds and reservoirs, increase flooding, or substantially alter aquatic ecosystems by changing streambed, lakebed and estuary conditions.
- Contamination of receiving waters with human excreta or animal manure can cause nutrient enrichment, depletion of dissolved oxygen and other changes that disturb natural ecosystems and reduce the vigor, abundance, and/or diversity of plants and animals that live either in the water or on land. Disease-causing microorganisms from excreta and manure may also contaminate fish or shellfish, creating health hazards.

Fresh-water resources depleted. This may occur when projects do not adequately assess the quantity of available surface and groundwater (including typical seasonal and annual variations.) Other causes include poor mechanisms for regulating withdrawals and use of water, and insufficient monitoring and maintenance of leaks.

- Depletion of surface water sources destroys the resource itself, damages aquatic life, reduces economic productivity, diminishes downstream use, and curtails recreational possibilities.
- Overdrawing wells and boreholes can alter groundwater flows, reduce groundwater levels, or cause aquifers in coastal or island areas to experience salt-water intrusion. All can lead to loss of drinking water sources and reduced economic productivity. Aquifer depletion and falling water tables can also lead to land subsidence (sinking of the land’s surface).

Both these situations increase the cost of future water supply systems. In addition, depletion of water resources may lead to poorer water quality, health impacts, and elevated costs of potable water supplies in downstream or down-gradient locations.

Increased disease transmission from standing, stagnant water. Poor design, operation and/or maintenance of water supply improvements can lead to pools of stagnant water near water taps, water pipes and storage tanks. Improper or ineffective practices for disposing of excreta and solid waste make this problem worse.

These pools form an excellent breeding place for disease vectors (mosquitoes that carry malaria, etc.). They can also increase transmission of water-related diseases, especially when the wet spots are clogged or contaminated with solid waste or excreta.

Table 1: Potential Environmental Impacts of Water Supply Projects and Their Causes

Problems	Possible Impacts	Possible Causes
1. Depletion of fresh water resources (surface and groundwater)	Destruction of the natural resource Destruction of aquatic life Loss of economic productivity Loss of recreation areas Land subsidence Increased cost of water supplies in the future or in down-gradient locations	Overestimation of water supplies Underestimation of water demand Over-pumping of water resources Lack of information on resource yields Waste and leakage of potable water Poor water pricing policies and practices, leading to excessive use, waste and leakage
2. Chemical degradation of the quality of potable water sources (surface and groundwater)	Concentration of pollution in surface water sources Salt water intrusion Poorer quality water, with associated health problems Increased water treatment costs in the future or in down-gradient locations	Depletion of surface and groundwater resources (see above) Reduced stream flows Runoff/drainage from improper solid and liquid waste or excreta disposal
3. Creation of stagnant (standing) water	Increase in vector-borne diseases Contamination of standing water with fecal matter, solid waste, etc., leading to health problems Soil erosion/sedimentation	Drainage systems lacking or poorly designed Leakage from pipes/wastage from taps Lack of user/operator concern for stagnant water
4. Degradation of terrestrial, aquatic, and coastal habitats	Alteration of ecosystem structure & function and loss of biodiversity Loss of economic productivity Loss of natural beauty Loss of recreational values Soil erosion/sedimentation	Improper siting of facilities (within wetlands or other sensitive habitats, etc.) Poor construction practice Leakage/wastage from pipes and taps Increased population density/agricultural activity because of new water systems
5. Supply of contaminated water	Arsenic poisoning Mercury poisoning Water-related infectious diseases	Failure to test water quality before developing the water resource Lack of ongoing water quality monitoring Inadequate protection of wells and water supply points Biological nitrite/nitrate and / or pesticide contamination

Source: Adapted from Alan Wyatt, William Hogrewe and Eugene Brantly (1992). *Environmental Guidelines for PVOs and NGOs: Potable Water and Sanitation Projects.* Water and Sanitation for Health Project, USAID.

Table 2: Potential Environmental Impacts of Sanitation Projects and Their Causes

Problems	Possible Impacts	Possible Causes
1. **Contamination of surface water, groundwater, soil, and food by excreta, chemicals and pathogens**	Increased disease transmission associated with excreta (diarrheal, parasitic, etc.) Malnutrition caused by above diseases Higher infant mortality Reduced economic productivity Health problems from use of chemically contaminated water Increased cost of down-gradient water treatment for domestic and industrial uses	Failure to use sanitation facilities Disposal of excreta or wastewater directly on land or into surface water without adequate treatment Improper siting of sanitation facilities near water supplies Inadequate protection of groundwater Improper operation of sanitation facilities Failure of sanitation facilities due to lack of maintenance Improper use of wastewater in food production
2. **Degradation of stream, lake, estuarine and marine water quality and degradation of land habitats**	Health problems from contact with contaminated water Fish or shellfish contamination (health hazards, lost economic productivity) Nutrient contamination (eutrophication) Alteration of ecosystem structure and function; loss of biodiversity Reduced economic productivity Soil erosion and sedimentation	Failure to use sanitation facilities Disposal of excreta or wastewater directly into sensitive areas without adequate treatment Improper operation of sanitation facilities Failure of sanitation facilities due to lack of maintenance Improper siting of facilities (within wetlands or other sensitive habitats, etc.) Poor construction practice

Source: Adapted from Alan Wyatt, William Hogrewe and Eugene Brantly (1992). ***Environmental Guidelines for PVOs and NGOs: Potable Water and Sanitation Projects.*** **Water and Sanitation for Health Project, USAID.**

ESDM of Activities & Programs: Best Practices

As noted above, avoiding the potential adverse impacts of water and sanitation activities and achieving ESDM in this sector requires a **participatory approach** to activity/program design and management.

In addition, **good technical design** is required. Each design choice has potential impacts, and appropriate measures must be used to avoid or otherwise mitigate these impacts.

This section provides some basic, general elements of best practice drawn from lessons learned in the field over more than 30 years. Some concern the participatory approach and some concern issues of technical design.

Best Practices For Water and Sanitation Projects

- Use others' experience
- Concentrate on the human component
- Use a promotional program, especially for sanitation, to build demand
- Participatory approach
- Cost sharing
- Integrate water supply, sanitation and hygiene promotion
- Use existing community organizations
- Economically self-sustaining design
- Provisions for operation and maintenance

A low cost alternative to a hand pump—a privately owned shallow well with a trap door cover near Segou, Mali. Note that water retrieved may require treatment to achieve desired quality according to end use.

The next section (environmental mitigation and monitoring) sets out the potential impacts of specific technologies and activities, and specific mitigation measures to counter them.

Both the general best practices and the technology- and activity-specific measures in the next section are necessary to achieving ESDM. As in other sectors, these issues should be addressed early in the design process.

Best practices applicable to both water supply and sanitation projects

- **Take advantage of the experience of others**. A number of excellent and detailed guidelines, manuals, sourcebooks, and checklists provide clear and concise guidance on developing water supply and sanitation projects. In most cases these are available via the internet.

  Many of these resources, most with URLs, can be found in the Resources and References section at the end of these guidelines.

- **Concentrate first on preparing and developing the human component of the project** and use a demand-focused approach. Projects will be welcomed and supported by the local community only when they perceive a need. Cost sharing, especially for operation and maintenance, should be encouraged because of the positive effects it has on ownership, community support, and long-term sustainability. However, there may be some instances, such as emergency relief situations, where cost-sharing may not be possible. Cost sharing can be in-kind, such as community clean up days for drainage ditches, or community supplying locally available materials (sand, wood, etc). This type of commitment indicates genuine household-level demand for the project, as does an interest in adopting hygienic behaviors.
- **A promotional program/social marketing must accompany infrastructure development**. Water supply and sanitation projects that fail to improve hygiene behaviors generally achieve little or no improvement in public health. Community participation (discussed below) and awareness building are essential to achieving these changes. Improving hygiene practices requires sensitivity to the community's cultural and social preferences. Realism must be applied in this process—it may take years for the community to adjust to new practices.

  Reaching school children is often an effective strategy, but efforts to bring about behavior change must focus on all other family members as well. Sanitation practices of infants, as well as those of pre–school age children, the elderly, the sick and the disabled, generally do more to contaminate water supplies and spread disease than those of healthy adults.

  Understanding local hygiene behaviors and social-cultural beliefs that limit options is an essential first step in design. For example, in some cultures sanitation facilities for men and women must be strictly segregated even at the family level, so that a single latrine per family is inadequate. In other cases there may be the belief forbidding defecation in roofed structures.

  Resources exist to help design programs to improve hygiene behavior. See *Sanitation Promotion* (Simpson-Hébert and Wood, 1998), *PHAST step-by-step guide: a participatory approach for the* *control of diarrhoeal disease* (Sawyer et al., 1998), and *Sanitation and Hygiene Promotion Programming Guidance* (WHO, 2005). The Resources and References section at the end of this guideline provides a summary description and access information for each.

- **Use a participatory approach, including choice of technology** that actively engages the community in all stages of the project, including planning and development of management systems, establishment of user fees, construction, operation and maintenance, and possible future decommissioning. This will lead to appropriate design, enhance adoption of new behaviors and help generate the levels of community commitment and support needed for proper maintenance of the project.

  An essential part of the process is to give families and communities a selection of generally appropriate technology and design options to choose from, instead of beginning the project with a predetermined technology.

  Offer technology alternatives that can be operated and maintained locally/at the village level (VLOM). Confirm that spare parts and necessary expertise are readily available. The VLOM (village operation and maintenance) is widely used to bring operation and maintenance of communal hand pumps down to the level of the users, but it must be part of a well-established system of community management, training, and technical support when repairs require outside expertise

- **Use some form of cost sharing to minimize subsidies**. When households share the cost of building latrines they feel a sense of ownership and responsibility for the project. This can reduce overall costs, increase correct usage, and improve maintenance.

- **Integrate water supply, sanitation and hygiene promotion interventions**. If these elements are treated individually, the fecal-oral route of disease transmission will not be broken and public health benefits from infrastructure investments will be limited.
- **Draw upon existing community organizations instead of starting new ones.**

- **Design the program so that it will be economically self-sustaining**. Generally, this requires cost recovery mechanisms such as user fees, taxes or levies to finance operations, monitoring, maintenance and repairs, along with a sustainable management structure for collecting these monies and overseeing their use.

- **Include a system for sustaining operation and maintenance** as part of overall program design. The failure to ensure ongoing operation and maintenance is one of the most common reasons projects fail. The system should include a mechanism for training local residents to operate, monitor, maintain and repair the improvement and to keep up institutional memory, for example, maintaining a pool of community members trained in operation and maintenance.

Best practices for water supply projects

- **Calculate yield and extraction rates** in relation to other area water uses and available supply. This is necessary to avoid depleting the resource or adversely affecting aquatic ecosystems and/or communities down stream/down gradient.

  These calculations should take into account historic and projected upstream/up-gradient and downstream/down-gradient supply and demand for water. Projects tapping groundwater should also consider depth to water table and groundwater hydrology.

- **Design improvements with an appropriate scale and capacity**. Estimate current and projected water quantity and availability based on current water sources and existing uses, baseline measurements on quantity of water available (including seasonal fluctuations), current and historic use data (household, agricultural, and institutional), population data and forecasts, current and projected demand up and down stream/up and down gradient, and actual water use for similar projects in the past.

  If possible, data on typical water leakage rates in other existing water schemes should be examined. Demand projections should take into account the likelihood that the project will attract additional users.

- **Assess water quality** to determine if water is safe to drink and to establish a baseline so that any future degradation can be detected.

  Ideally tests should be performed on the chemical, biological and physical quality of the proposed water source. At a minimum arsenic and fecal coliform tests should be conducted. *USAID requires testing for arsenic for all USAID-funded water supply projects, as there is currently no way to determine which locations may contain natural arsenic deposits.*

- **Maintain periodic testing**. *Ongoing testing is the only way to determine if a water supply is or has become contaminated* (other than by observing dramatic and sustained increases in water-borne disease).

- **Minimize downstream/down-gradient effects of intervention**, perhaps by establishing some form of communication with downstream parties.

Best Practices—Water supply

- Calculate yields and extraction rates
- Appropriate scale and capacity
- Assess water quality
- Periodic testing
- Minimize downstream impacts
- Promote improved hygiene behaviors

Selected Water Quality Standards for Human Health

- Arsenic < 0.01 mg/L
- Total Coliforms = not detectable in any 100mL sample
- Lead < 0.01 mg/L
- Copper < 2 mg/L
- Nitrate (as NO_3^-) < 50 mg/L
- Nitrite (as NO_2^-) < 0.2 mg/L for long-term exposure
- Fluoride < 1,5 mg/l

Reference: WHO, *Guidelines for Drinking-Water Quality (3rd Edition)*, 2004. http://www.who.int/water_sanitation_health/dwq/gdwq3/en/index.html

Factors to consider for siting wells

Location:

- Locate the well at the highest point on the property.
- Avoid positioning down slope from potential sources of contamination, including surface water flows and flooding conditions.
- Locate the well in a site easily accessible for maintenance.
- Define a sanitary protective area around the wellhead that is kept in its natural state.

Potential Contaminants:

- Yield and quality of water supply will depend on soil type (which determines filtering capability and transmissivity).
- Course gravel, limestone, and disintegrated rock can allow contaminants to travel quickly with little opportunity for natural purification.
- **Distance to nearest point of potential contamination** is site and aquifer specific. The following MINIMUM distances from potential sources of contamination are best practice for sites with sand-like filtering capabilities:
  - 150 ft (45.7 m) from a preparation area or storage area of spray materials, commercial fertilizers, or chemicals that may cause contamination of the soil or groundwater.
  - 100 ft. (30.5 m) from a below-grade manure storage area.
  - 75 ft (22.9 m) from cesspools, leaching pits, and dry wells.
  - 50 ft (15.2 m) from a buried sewer, septic tank, subsurface disposal field, grave animal or poultry yard or building, privy, or other contaminants that may drain into the soil.
  - The distance between a septic tank leach field and a down-gradient well should be greater than 100 ft (30.5 m) if the soil is coarser than fine sand and the groundwater flow rate is greater than 0.03 ft/day (0.01 m/day).

Source: Driscoll, Groundwater and Wells, Second Edition.

Best Practices—Sanitation

- Promotion sanitation to create demand
- Match demand, customs, preferences and ecosystem
- Assess local water quality
- Minimize downstream impacts
- Minimize hardware subsidies
- Consider natural treatment before mechanical options

Best practices for sanitation projects

- **Develop a hygiene promotion strategy** that takes into account the current hygiene behavior (handwashing, latrine use, water collection, transport, and storage) of all users, including women, infants, children, the elderly and the infirm and, as well as any social/cultural religious factors that may hinder changing behavior.
- **Design improvements to match demand, user customs and preferences, climate, and abundance of water**.
- **Test water quality downstream/down gradient** from the proposed site before construction of infrastructure to establish a baseline. Testing after completion of project will provide necessary information for mitigation purposes.

Elements to test for include fecal coliform, total suspended solids (TSS), biological oxygen demand (BOD) and nutrients. Maintain ongoing testing to monitor for contamination.

- **Minimize downstream/down-gradient effects of intervention**. See box below on Sanitation and Hydrology.
- **Consider appropriate natural treatment systems instead of mechanical systems**. These tend to be preferable for small-scale activities as they generally cost less, do not require highly skilled labor, and can frequently be manufactured locally. Also, supplies for maintenance and repair are likely to be more readily available.

  There are many proven natural treatment options. Examples include double-vault batch composting toilets, double-vault batch dry toilets, upflow anaerobic filters[1], biogas reactors[2], confined-space constructed wetlands, subsurface wetlands, floating aquatic macrophytes, stabilization ponds and ecological sanitation (urine diversion and arborloo systems).

Sanitation and Hydrology

Preventing microbial contamination of groundwater sources depends on several factors:

- Type of latrine – the rate of flow of pathogen-containing liquid from latrine pits to the soil beneath is proportional to the quantity of liquid in the pit (static head). Dry latrines present the smallest risk of groundwater contamination.
- Water table – a latrine pit must be above the water table during all seasons. 1.5m below the surface is the minimum depth necessary to ensure the pit contents remain dry. The greater the distance between the base of the pit and the water table, the more time is required for pathogens to seep from the pit into the groundwater, thus allowing more pathogens to die-off naturally.
- Soil type – Clay, silt, and fine sand soil types all have grain sizes small enough to act as natural filters for microbial contaminants (<0.2mm). Certain clay soils can also absorb viruses.
- Distance to nearest water source – the risk of contamination of a surface or groundwater source by a latrine depends on the distance to the source, the direction and velocity of the flow of water in the soil (hydraulic gradient), and the soil/rock permeability. 30m is considered the minimum separation for most soil types.

Balancing these factors to determine the best combination of siting and sanitation technology should involve input from engineers and/or hydrologists. For more information, see S. Sugden, *WELL Factsheet: The Microbiological Contamination of Water Supplies*, 2004. http://www.lboro.ac.uk/well/resources/fact-sheets/fact-sheets-htm/Contamination.htm

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[1] [2] The reference to upflow anaerobic filters and biogas reactors both require pumping, so they are not truly “natural treatment systems”.

ESDM of Activities and Programs: Specific Mitigation and Monitoring Measures

The table in this section (overleaf) matches impacts and mitigation measures to specific water and sanitation activities/technologies.

Achieving ESDM requires that these impacts are considered and the corresponding mitigation measures adopted when the impacts are potentially significant. Note that in many cases, the mitigation measures are good practices.

In general, USAID IEEs or subproject review documents should note and assess the potential impacts listed here and specify corresponding, appropriate mitigation measures.

An "enviroloo" (dry composting toilets) mandated by the Department of Public Works in the Northern Province of the Republic of South Africa (2002)

Table 3: Impacts and mitigation measures for specific water and sanitation activities and technologies

Activity/ Technology	Potential Impacts *The activity or technology may. . .*	Mitigation measures *Note: Measures apply to the project phase specified: planning and design (P&D), construction (C), or operation and maintenance (O&M).*
General		
Site selection (P&D)	Damage sensitive ecosystems or endangered species (P&D)	Survey for, and avoid, wetlands, estuaries or other ecologically sensitive sites in the project area. Identify nearby areas that contain endangered species and get professional assessment of species' sensitivity to construction at site (P&D)
Construction of buildings and structures (C)	Damage sensitive ecosystems or endangered species (C) Cause erosion and sedimentation (C)	Follow guideline on Construction in this manual (P&D) (C) Train and monitor workers on best practices in construction of buildings and structures (P&D) (C) Gather data on soil type, slope and topography to determine the potential for significant erosion (P&D) Use silt screens, straw bales or similar erosion control measures (C) Avoid damaging vegetation (C) Revegetate areas damaged during construction. Do not remove erosion control measures until revegetation is complete (C) Use proper bedding materials for pipes (P&D) (C)
Soakways and drains	Cause erosion (O&M) Alter the natural flow of rainwater runoff (O&M) Create pools of stagnant water (O&M)	Use riprap (cobbled stone), gravel or concrete as needed to prevent erosion of drainage structures (P&D) (C) Monitor and keep drains and soakways clear (O&M)
Water Supply Improvements		
Hand-dug wells, seasonal ponds, improved springs, ground-level catchment and similar structures	Contaminate water with human pathogens (O&M)	Include focus on proper use and maintenance of the improvement as part of behavior change and education program (P&D) Construct spigot or similar system that prevents people from touching impounded water with their hands or mouths (P&D) (C)
	Contaminate water with animal manure (O&M) Create pools of stagnant water (O&M) Exhaust water supply (not applicable to improved springs or hand-dug wells) (O&M)	Use fencing or equivalent that will keep live stock from grazing uphill or up gradient of the water supply improvement (P&D) (C) Do not allow animals to drink directly from the water source (O&M) Monitor drains and soakways and keep them clear of debris (see entry on soakways and drains above for more detail) (O&M) Monitor and repair leaks from cracked containment structures, broken pipes, faulty valves and similar structures (O&M) Put in place a system for regulating use, such as a local warden or appropriate

Activity/ Technology	Potential Impacts *The activity or technology may. . .*	Mitigation measures ***Note: Measures apply to the project phase specified: planning and design (P&D), construction (C), or operation and maintenance (O&M).***
		pricing (P&D) Give the community training in operating the improvement (P&D) (O&M) Monitor water levels in wells or impoundment structures to detect overdrawing (O&M)
Wells	Provide water contaminated with nutrients and bacteria from animal waste (O&M) Create pools of stagnant water (O&M) Change groundwater flow (O&M) Create saltwater intrusions (O&M) Deplete aquifer (groundwater) (O&M) Cause land subsidence (impact from many wells) (O&M)	Don't let animals graze or be watered up-gradient from wellhead (P&D) (O&M) Monitor and repair leaks from cracked containment structures, broken pipes, faulty valves and similar structures (O&M) On islands and coastal areas, keep withdrawals within safe yield limits to avoid overdrawing, possible salt water intrusion and contamination of the well (P&D) Put in place a system for regulating use, such as a local warden or appropriate pricing (P&D) Include a focus on proper use and maintenance of the improvement as part of the behavior change and education program (O&M) Monitor water levels (O&M)
Standpipes	Create pools of stagnant water (O&M) (This problem can be more severe when water table is high, clay soils are present, or population/tap density is high)	Ensure that spilled water and rainwater drain to a soakway or equivalent structure and do not accumulate and create stagnant standing water (C) Monitor and repair leaks from cracked containment structures, broken pipes, faulty valves and similar structures
Treatment systems		
Pit latrine	Increase transmission of vector-borne diseases (O) Contaminate groundwater supply with pathogens (O) Contaminate water supplies, damage water quality and/or transmit disease at other locations if waste is not properly handled and treated during or after servicing (O)	Devote adequate attention to identifying and addressing social barriers to using latrine (P&D) Use the ventilated improved pit latrine design that traps insect vectors (P&D) Evaluate depth to water table, including seasonal fluctuations and groundwater hydrology. The size and composition of the unsaturated zone determine the residence time of effluent from the latrine, which is the key factor in removal and elimination of pathogens. Pit latrines should not be installed where the water table is shallow or where the composition of the overlying deposits make groundwater or an aquifer vulnerable to contamination (P&D) Ensure that a reliable system for safely emptying latrines and transporting the collected material off-site for treatment is used. This should include use of a small pit-emptying machine such as the vacutug that relies on an engine-driven vacuum pump. The vacutug was tested for UNCHS in low-income areas of Nairobi, Kenya, and was found to give workers much greater protection from disease than conventional methods. See Wegelin-Schuringa, *Small Pit-Emptying Machine: An Appropriate Solution in Nairobi Slum,* for more details) (O&M)

Activity/ Technology	Potential Impacts *The activity or technology may. . .*	Mitigation measures ***Note: Measures apply to the project phase specified: planning and design (P&D), construction (C), or operation and maintenance (O&M).***
	Cause injury to people or animals	Ensure that collected material is adequately treated and not directly applied to fields or otherwise disposed of improperly (O&M) Properly decommission pit latrines. Do not leave pits open. Fill in unused capacity with rocks or soil.
Composting toilets	Increase transmission of vector-borne diseases (O) Contaminate groundwater supply with pathogens (O) Cause disease transmission to field workers and consumers of agricultural products (O)	Maintain humidity of composting material above 60% and supplement excreta with generous quantities of carboniferous material (dry leaves, straw, etc.). The pile should then remain aerobic, odor-free and insect-free (O&M) Construct sealed vaults to hold composting material if using fixed-batch systems. If using movable-batch systems check removable containers for leaks before installing (O&M) Test samples from active chamber and mature chamber after fallow period for *Ascaris* eggs and fecal coliforms (O&M) Allow sufficient residence time in mature chamber. This may vary from 6 months in warm climates to 18 months in cooler climates (O&M) Ensure that the systems will be properly operated and maintained so that the soil amendment taken out after the treatment period is truly sanitized (O&M)
Dry toilets	Increase transmission of vector-borne diseases (O) Cause disease transmission to field workers and consumers of agricultural products (O)	Maintain humidity of composting material below 20% and supplement excreta with alkaline material (ashes or lime). The pile should then remain both odor free and insect free (O&M). Generous applications of ashes will help ensure that pathogens are destroyed. pH is the most important factor for sterilization (O&M) Construct sealed vaults to hold dehydrating and curing material (C) Ensure that the systems will be properly operated and maintained so that the soil amendment taken out after the treatment period is truly sanitized (O&M) Test samples from active chamber and mature chamber after fallow period for *Ascaris* eggs and fecal coliforms to assess level of sterilization (O&M) Allow sufficient residence time in mature chamber. This may vary from 6 months in warm climates to 18 months in cooler climates (O&M)
Septic tanks	Contaminate groundwater supply with pathogens (O&M) Contaminate surface water supplies with nutrients, biological oxygen demand (BOD), suspended solids (SS) and pathogens. (Septic tank effluent generally contains relatively high concentrations of pathogens, BOD, and SS) (O&M) Contaminate water supplies, damage water quality and/or	Evaluate depth to the water table, including seasonal fluctuations and groundwater hydrology. If water table is too high, line the tank with clay, plastic sheeting or some other impermeable material to prevent leakage (P&D) (C) Avoid direct discharge of effluent to waterways if possible. Direct discharge to waterways with sufficient volume and flow to assimilate the waste may be acceptable. It is better to add a secondary treatment, such as passing effluent through an anaerobic filter, followed by discharge to an absorption field, or better yet, a constructed wetland (P&D) Ensure that a reliable system for safely removing sludge and transporting the

Activity/ Technology	Potential Impacts *The activity or technology may. . .*	Mitigation measures *Note: Measures apply to the project phase specified: planning and design (P&D), construction (C), or operation and maintenance (O&M).*
	transmit disease at other locations if waste is not properly handled and treated during or after servicing (O&M)	collected material off-site for treatment is available. This should include use of a mechanized (probably vacuum-based) removal system (P&D) (O&M) Ensure that collected sludge is adequately treated and not directly applied to fields or otherwise improperly disposed of (See Sludge management below) (O&M)
Upflow anaerobic filters	Damage ecosystems and degrade surface water quality. Sludge has high concentrations of nutrients, BOD, and solids (O&M) Cause disease transmission to field workers and consumers of agricultural products (Sludge may still contain pathogens) (O&M)	Treat sludge before secondary use (see Sludge management below). Do not allow disposal in or near water bodies (O&M) Provide workers servicing, transporting, and otherwise exposed to sludge with appropriate protective clothing including, at a minimum, rubber gloves. Train workers to wash hands and faces frequently with soap and warm water and make both available. (See Wastewater and sludge use in agriculture and aquaculture below) (O&M)
Settled and simplified sewers	Damage ecosystems and degrade surface water quality (O&M) Transmit diseases to field workers and consumers of agricultural products (O&M)	Ensure that collected sewage will be treated, e.g., in a wastewater stabilization pond, and not simply discharged to a river or stream or used directly in agriculture or aquaculture. This is especially important for simplified sewerage, since there is no interceptor tank (P&D) (O&M)
Biogas reactors	Damage ecosystems and degrade surface water quality (O&M) Transmit diseases to field workers and consumers of agricultural products (O&M)	Do not allow disposal of digested slurry in or near water bodies (O&M) Follow WHO or other national or international guidelines for use of sludge in wastewater in agriculture and aquaculture (see Sludge and wastewater reuse below) (P&D) (O&M)
Wastewater stabilization ponds **(anaerobic, facultative, aerobic)**	Damage ecosystems and degrade surface water quality (O&M) Transmit diseases to field workers and consumers of agricultural products (O&M)	Avoid discharging single (facultative) pond systems directly into receiving waters. If this is unavoidable, construct hydrography-controlled release lagoons that discharge effluent only when stream conditions are adequate. Install secondary treatment such as a constructed wetland, if possible (P&D) (C) (O&M) Use two-, three- or five-pond systems if possible (anaerobic, facultative, (maturation)) (P&D) Allow only restricted uses for agriculture and aquaculture of effluent from all but five-pond systems (O&M)
Reed bed filter	Contaminate groundwater or surface water (O&M)	Evaluate depth to the water table, including seasonal fluctuations and groundwater hydrology. If water table is too high, line tank with clay, plastic sheeting or some other impermeable material to prevent leakage (P&D) (C)
Subsurface wetland	(See reed bed filter above)	
Free water surface wetland **Floating aquatic**	Provide breeding ground for disease vectors (O&M) Introduce invasive non-native species (O&M)	Use plant and animal species that are native to the region. Avoid introducing water hyacinth, water milfoil, or salvinia, which have proven extremely invasive outside of their natural range (P&D) If using water hyacinth, maintain dissolved oxygen at 1.0 mg/L, frequently

Activity/ Technology	Potential Impacts *The activity or technology may. . .*	Mitigation measures ***Note: Measures apply to the project phase specified: planning and design (P&D), construction (C), or operation and maintenance (O&M).***
macropytes		harvest and thin plants and/or add mosquitofish (*Gambusia affinis*) to the wetland or use other plant species such as duckweed, water lettuce (*Pistia stratiotes*), water milfoil, or salvinia (*Salvinia spp*.) (O&M)
Slow-rate overland flow	Contaminate groundwater or surface water (O&M)	Use where growing season is year round. Requires vegetation (P&D) (O&M) Use only where soil textures are sandy loam to clay loam (P&D) (O&M) Use where groundwater is >3 ft. below surface (P&D) (O&M)
Slow-rate subsurface flow	Contaminate groundwater or surface water (O&M)	Use only where soil textures are sand to clayey loam (P&D) Use only where groundwater is >3 ft. below surface (P&D)
Rapid infiltration	Contaminate groundwater or surface water (O&M)	Use only where soil textures are sandy to loam (P&D) Use only where groundwater is >3 ft. below surface (P&D)
Sludge management	Damage ecosystems and degrade surface water quality (O&M) Cause disease in handlers and processors (O&M)	If possible, choose treatment technologies that do not generate sludge, such as wastewater stabilization ponds (P&D) Compost sludge, then use as soil amendment for agriculture (O&M) Provide workers with appropriate protective clothing, including rubber gloves, boots, long-sleeved shirts and pants. Train workers to wash hands and faces frequently with soap and warm water and make both available (O&M)
Wastewater use in agriculture and aquaculture	Cause disease in field workers and consumers of agricultural products (O&M)	WHO guidelines recommend (1) treat to reduce pathogen concentrations, (2) restrict use to crops that will be cooked, (3) use application methods that reduce contact with edible crops, and (4) minimize the exposure of workers, crop handlers, field workers and consumers to waste (P&D) (O&M) Wastewater used in aquaculture should have $<10^3$ fecal coliforms per 100 ml to minimize risk to public health. (*See Guidelines for the safe use of wastewater and excreta in agriculture and aquaculture: Measures for Public Health Protection*, 1989, WHO, Geneva (P&D) (O&M) http://www.who.int/environmental_information/Information_resources/documents/wastreus.pdf

Resources and References

Guidelines for Water Supply and Sanitation Programmes

- *Assessing demand for water supply and sanitation projects.* (2000). Sarah Parry-Jones. http://www.lboro.ac.uk/well/resources/well-studies/well-studies.htm

  An exploration of the issues surrounding a demand-responsive approach to water and sanitation service provision, with a discussion of the relative merits of the most commonly used demand assessment tools.
- *Best-practice sourcebook on water, sanitation, and environmental health* (2000). CARE (in press? Is this still in press with a 2000 date on it?).
- *DFID guidance manual on water supply and sanitation programmes* (1998). United Kingdom Department for International Development (DFID). http://www.lboro.ac.uk/well/resources/Publications/guidance-manual/guidance-manual.htm

  An excellent general resource designed to assist DFID staff and partners in developing effective and sustainable water supply and sanitation programs. Comprising three chapters and appendices, it takes the reader from an overview of the sector, through specific development perspectives, to detailed recommendations for each stage of the project cycle.
- *Environmental guidelines for PVOs and NGOs: potable water and sanitation project (1992).* Alan Wyatt, William Hogrewe and Eugene Brantly. Water and Sanitation for Health Project, USAID. http://www.foodaid.org/worddocs/environmentwg/WASH.doc

  A guideline designed to assist PVOs and NGPs in identifying and mitigating environmental impacts of water supply and sanitation projects. The guidelines outline a process for conducting an environmental evaluation of proposed projects.
- *Participation in the water and sanitation sector.* World Bank Dissemination Note based on Environment Department Paper No. 002. Written by Gabrielle Watson and N. Vijay Jagannathan as a contribution to the Participation Sourcebook. Copies of the full paper are available from the Environment Department, Social Policy and Resettlement Division, World Bank, Washington, D.C. 20433, fax (202) 522-3247. http://lnweb18.worldbank.org/ESSD/sdvext.nsf/60ByDocName/ParticipationintheWaterandSanitationSectorSocialDevelopmentNoteNo2June1995/$FILE/sdn02.pdf#search='%E2%80%A2%20Participation%20in%20the%20water%20and%20sanitation%20sector.%20World%20Bank%20Dissemination%20Note'
- *Private sector participation in the water and sanitation sector: public-private partnership and the poor* (1999). Mike Webster and Kevin Sansom. http://www.lboro.ac.uk/well/resources/well-studies/well-studies.htm

  A review of existing work examining the impact of Public-Private Partnerships (PPP) in the water and sanitation sectors on service delivery to the poor. Important gaps in current knowledge are also identified.
- *Standard methods for the examination of water and wastewater*, 20th ed. (1995). Washington, D.C.: APHA. http://www.standardmethods.org/

  This comprehensive reference covers all aspects of water and wastewater analysis techniques.

Standard Methods is a joint publication of the American Public Health Association [(APHA)](), the American Water Works Association [(AWWA)](), and the Water Environment Federation [(WEF)]().

- *Water for the world* (1982). USAID Development Information Center. A series of 160 technical notes covering all aspects of rural water supply and sanitation. Out of print but available online through Lifewater International. http://www.lifewater.org/resources/tech_library.html
- *Water, sanitation and hygiene for populations at risk.* (2005). Action Contre La Faim. www.**actioncontre**la**faim**.org A comprehensive guide to both infrastructure and hygiene promotion, applicable to small scale systems.

Web sites

- *IRC International Water and Sanitation Centre*. http://www.irc.nl/

  Since its foundation in 1968, the IRC International Water and Sanitation Centre (IRC) has facilitated the sharing, promotion and use of knowledge so that governments, professionals and organisations can better support poor men, women and children in developing countries to obtain water and sanitation services they will use and maintain. The website contains a vast array of references, training courses and documents. Of particular interest is the *interWater Guide to Organizations* available at http://www.irc.nl/page/126.

- NETWAS: Network for Water and Sanitation. Hosting t*he International Training Network for Water and Waste Management* (ITN – Africa). http://www.netwas.org/networks/itn_africa

  A network of regional and international training institutions, launched in 1984 by the World Bank's Water and Sanitation Program to support training in low-cost water supply and sanitation. ITN Centers provide training, disseminate information and promote local applied sector research on low-cost water supply and sanitation options. The Network links affiliated institutions serving Asia and Africa in Ouagadougou, Burkina Faso (serving countries in francophone West Africa); Kumasi, Ghana (Ghana); Harare, Zimbabwe (Zimbabwe); Nairobi, Kenya (Ethiopia, Kenya, Tanzania, and Uganda); Dhaka, Bangladesh; Calcutta, India (India); and Manila, Philippines (Philippines). New centers are under development.

- *Water and Sanitation Program Knowledge Network* http://www.wsp.org/

  The Water and Sanitation Program (WSP) is an international partnership of the world's leading development agencies concerned with improving sector policies, practices and capacities to serve poor people. Administered by the World Bank, WSP provides targeted support to national and local governments, local communities, and their support organizations.

- *Water Supply and Sanitation Collaborative Council.* http://wash-cc.org/

  Established in 1990 at the end of the International Drinking Water Supply and Sanitation Decade. Its purpose is to maintain the momentum of the Decade, by providing a regular way for water and sanitation sector professionals to exchange views and experiences and develop approaches to foster more rapid achievement of the goal of universal coverage.

- *WELL – Research Centre Network for Water, Sanitation and Environmental Health*. http://www.lboro.ac.uk/well/

  The WELL website is a focal point of information about water, sanitation and environmental health and related issues in developing and transitional countries. They publish a wide-variety of guidance documents, including factsheets, studies and technical briefs.

Disease Prevention and Control

- *Cholera and other epidemic diarrhoeal diseases control* (1996). Prepared by the Robens Institute, University of Surrey, UK. Geneva: WHO.
  http://www.who.int/csr/resources/publications/cholera/WHO_EMC_DIS_97_6/en/index.html
- *Drinking water and disease: what healthcare providers should know* (2000). Physicians for Social Responsibility. Washington, D.C. http://www.envirohealthaction.org/upload_files/dwprimer.pdf
- *PHAST step-by-step guide: a participatory approach for the control of diarrhoeal disease* (1998). R. Sawyer, M. Simpson-Hébert and S. Wood. Geneva: WHO.
  English: http://whqlibdoc.who.int/hq/1998/WHO_EOS_98.3.pdf
  French: Available for purchase at
  http://www.who.int/bookorders/francais/detart2.jsp?sesslan=2&codlan=1&codcol=93&codcch=131
- *Promoting change in environmental health behaviour* (1999). Ben Cave and Valerie Curtis.
  http://www.lboro.ac.uk/well/resources/well-studies/well-studies.htm

  A literature review focusing on the potential effectiveness of approaches to environmental health promotion in developing countries, and appropriate expectations and targets for change in health behavior.
- *Sanitation promotion* (1998). Mayling Simpson-Hébert and Sara Wood, eds. Water Supply and Sanitation Collaborative Council **(**WSSCC) Working Group on Promotion of Sanitation. Geneva: World Health Organization (WHO). http://whqlibdoc.who.int/hq/1998/WHO_EOS_98.5_pp1-140.pdf and http://whqlibdoc.who.int/hq/1998/WHO_EOS_98.5_pp141-277.pdf

  A valuable resource consisting of a number of short sections that can be used independently. A "Checklists" section (pp. 141–153) includes checklists for planning better sanitation projects, sanitation in emergency situations, hygiene behavior-change, and suggestions for addressing gender issues. Other sections focus on building political will and partnerships and on conducting promotional programs including subsections on principles and guidelines, empowerment, checklists, and promotion through innovation.

Provision of Drinking Water

- Groundwater and Wells, Second Edition. Fletcher G. Driscoll. Copyright 1986 by Johnson Filtration Systems Inc., St Paul, Minnesota 55112
- *Multi-stage filtration: an innovative water treatment technology* (2000). Gerardo Galvis, Jorge Latorre and Jan Teun Visscher. Technical Paper no. 34. IRC International Water and Sanitation Centre. http://www.irc.nl/page/1894
- *On-line bore-well and hand-pump installation tutorial.* Lifewater Canada.
  http://www.lifewater.ca/ndexdril.htm
- *Water quality assessments: a guide to the use of biota, sediments and water in environmental monitoring*, 2nd edition (1996). Deborah Chapman, ed. Published on behalf of UNESCO, WHO and UNEP. London: E & FN Spon.
  http://www.who.int/water_sanitation_health/resourcesquality/wqa/en/index.html
- *WHO guidelines for drinking water quality: training pack.* (2000). World Health Organization, Protection of the Human Environment. Geneva: WHO.
  http://www.who.int/water_sanitation_health/dwq/dwqtraining/en/

  These training materials cover a wide range of topics and include 23 sessions - both presentations and practical sessions. Each presentation in the materials includes a session plan, a background paper and overhead transparencies. Each practical session provides guidance as to how such sessions might be delivered and the materials required.

Sanitation References

- *Community-based technologies for domestic wastewater treatment and reuse: options for urban agriculture* (1999). G.D. Rose. International Development Research Centre (IDRC). http://www.p2pays.org/ref/03/02008.htm

  This document provides information on urban wastewater management. It specifically discussed issues involved in wastewater resrouce recovery, wastewater management, project planning and implementation. It also includes a good discussion of wastewater treatment technologies such as on-site treatment, anaerobic treatment systems, water-based treatments, and sludge management.

- *Guidelines for wastewater reuse in agriculture and aquaculture: recommended revisions based on new research evidence* (1999). Ursula Blumenthal, Anne Peasey, Guillermo Ruiz-Palacios and Duncan Mara. http://www.lboro.ac.uk/well/resources/well-studies/well-studies.htm

  The implications of some new studies for the setting of international guidelines for using wastewater in agriculture and aquaculture are considered, along with the wastewater treatment and other health protection measures needed to achieve these guidelines.
- *Health aspects of dry sanitation with waste reuse (*2000). Anne Peasey. http://www.lboro.ac.uk/well/resources/well-studies/well-studies.htm

  A review that collates current knowledge of health risks associated with dry sanitation technologies and the problems associated with their use and maintenance.
- *Household-centered Environmental Sanitation.* John Kalbermatten, Richard Middleton and Roland Schertenleib. Vision 21. http://www.wsscc.org/dataweb.cfm?edit_id=178&CFID=1183073&CFTOKEN=8867542

  An amplification of the HCES Model, developed following the Wageningen Meeting. It includes more detailed descriptions of the "zones" and the decision-making processes in different circumstances. Likely to be the model for environmental sanitation planning and implementation in the coming years.

- *A guide to the development of on-site sanitation* (1992). R. Franceys et al. Geneva: WHO. http://www.who.int/water_sanitation_health/hygiene/envsan/onsitesan/en/

- *On-site sanitation in areas with a high groundwater table* (1999). Sarah Parry-Jones. http://www.lboro.ac.uk/well/resources/fact-sheets/fact-sheets-htm/lcsahgt.htm

  This technical brief provides practical guidance on constructing affordable on-site sanitation facilities in areas that experience a seasonally high groundwater table or that are prone to flooding.
- Sanitation and Hygiene Promotion Programming Guidance (WHO, 2005). http://www.who.int/water_sanitation_health/hygiene/sanitpromotionguide/en/ Includes a process for engaging participation to effect and sustain a hygienic and healthy environment.

- *Sanitation for All: Promoting Dignity and Human Rights* (2000). UNICEF. http://www.unicef.org/wes/files/sanall.pdf
  Good overview of key issues. Offers a short set of recommendations for better programming.

- *Towards better programming: a sanitation handbook* (1997). UNICEF Programme Division and USAID. Water, Environment and Sanitation Technical Guidelines Series No. 3, Environmental Health Project, New York. http://pdf.dec.org/pdf_docs/PNACB124.pdf

Guidance for Operation and Maintenance

- *Operation and maintenance of rural water supply and sanitation systems*: *a training package for managers and planners* (2000). Prepared by François Brikké. WSSCC Operation and Maintenance Network and IRC International Water and Sanitation Centre. Geneva: http://www.irc.nl/redir/content/download/2548/26132/file/OME_OM_TrainingPackage.pdf
- See http://www.who.int/docstore/water_sanitation_health/wss/o_m.html for links to the following guides:
    - *Selected case studies on operation and maintenance of water supply and sanitation systems.* These case studies describe different operation and maintenance (O&M) experiences in a variety of countries, in both rural and urban settings. They are a useful source of information for improving O&M practice.
    - *Tools for assessing operation and maintenance status of urban and rural water supply* (2000). These comprehensive guidelines show how to assess O&M performance in both rural and urban areas.
    - *Operation and maintenance of urban water supply and sanitation systems: a guide for managers.* This publication examines factors which may prevent existing urban water supply systems from working efficiently, and provides guidelines and solutions for optimization.
    - *Leakage control: source material for a training package.* Materials trainers can adapt for use in local training courses, covering all aspects of leakage control, divided into individual modules for ease of use.
    - *Upgrading water treatment plants (2001).* Summarizes many different field experiences with efforts to improve the quality of water and to upgrade the capacity of water treatment plants. It provides a practical approach to improving the performance of water treatment plants.
    - *Management of operation and maintenance in rural drinking-water supply and sanitation: a resource training package.* This package contains resource material for training courses aimed at improving the management of O&M in rural areas.
    - *Models of management systems for the operation and maintenance of rural water supply and sanitation systems.* This document evaluates the factors which influence the development of O&M management systems for rural facilities. It describes models in eight representative countries and offers guidance to planners and designers in selecting the best approach.
    - *Linking technology choice with operation and maintenance.* This document helps users make more appropriate technology choices by providing information on the O&M implications—particularly the costs—of selecting a specific technology.

Case Studies

- *Learning what works: a 20-year retrospective view on international water and sanitation cooperation* (1998). Maggie Black. World Bank. English:. http://www.wsp.org/publications/global_lww.pdf French: http://www.wsp.org/publications/global_lww_fr.pdf; Spanish: http://www.wsp.org/publications/global_lww_sp.pdf; or contact the World Bank Water Help Desk (see Web sites section below for contact information).

  A detailed history of water supply and sanitation programs and lessons learned.

- *Lessons learned from village-level operation and maintenance (VLOM)* (1999). Jeremy Colin. http://www.lboro.ac.uk/well/resources/well-studies/well-studies.htm

  A literature review of sector experience of the Village Level Operation and Maintenance Management (VLOM) approach to rural water supply.

- PROSANEAR: People, poverty and pipes – a program of community participation and low-cost technology bringing water and sanitation to Brazil's urban poor (1998). Y. Katakura and A. Bakalian. UNDP-World Bank Water and Sanitation Program. http://www.wsp.org/publications/working_prosanear.pdf

  This report is a description of a water supply and sanitation project in the urban slums of Brazil. Includes participation strategies, design costs, and listings of different technologies. A good discussion of solutions to specific urban problems, such as the condominial sewage system that created shared access to sewers for clusters of closely located houses.

- *Provision of water and sanitation services to small towns* (2000). Jeremy Colin and Joy Morgan. http://www.lboro.ac.uk/well/resources/well-studies/well-studies.htm

  This report describes and analyzes the findings of rapid investigations in two small towns in Uganda and two in the Southern Indian state of Kerala.

- *Sanitation programmes revisited* (1999). Darren Saywell and Caroline Hunt. http://www.lboro.ac.uk/well/resources/well-studies/well-studies.htm

  A comparative analysis of two notable African sanitation programs, focusing on a historical analysis (investigating how, when and why the programs developed in the way they did) and an understanding of critical issues common to each program, including demand assessment, sanitation promotion, community participation, responsibility for service provision, finance and cost recovery, and health aspects of promotion.

- *Small pit emptying machine: an appropriate solution in Nairobi slum*. Madeleen Wegelin-Schuringa, IRC International Water and Sanitation Centre, and Manus Coffey, Manus Coffey Associates (MCA) for UNCHS (Habitat). http://hq.unhabitat.org/cdrom/water/HTML/Small%20Pit%20Emptying%20Machine.htm

  This article describes the results of the trial period of a pedestrian-controlled pit emptying machine. The 'vacutug' has been tested for UNCHS (Habitat) in a low-income settlement in Nairobi, Kenya, through a local NGP. The trial confirmed the viability of the principle of the vacutug, as the machine has been in operation for two and a half years. Repairs have been made locally obtained spare parts, paid from income from the service.

- *Tecnologia manual de vacido de pozos negros (manual pit latrine emptying technology (MAPET)), Dae es Salaam (Tanzania).* Habitat. United Nations Best Practices Database. In Spanish: http://habitat.aq.upm.es/bpn/bp271.html

  The Manual Pit Latrine Emptying Technology (MAPET) is a neighborhood-based service for the emptying of pit latrines in Dar es Salaam, Tanzania. The service is carried out by independent, informal sector micro-enterprises (MAPET teams). The teams use MAPET equipment that is specifically developed to suit the technical, planning and economic conditions in the low-income neighborhoods.

Introduction

Contents

MSEs and the Environment 1-2

Contribution of Guidelines to Development Goals 1-10

MSEs are particularly important contributors to the African economy, providing wealth and opportunity for many—including women and ethnic minorities. Do such small entities really have environmental problems worth worrying about? The answer, simply stated, is yes.

These guidelines are intended to help improve the environmental performance of micro- and small enterprise (MSE) development activities supported by USAID in Africa. It has been developed for staff who work with:

1. business development services (BDS) providers, which offer services such as management training or marketing support to MSEs, and/or with
2. intermediate credit institutions (ICIs) and direct lenders that work to provide credit to MSEs.

Purpose of the guidelines. The purpose of these guidelines is not to turn readers into environmental experts capable of identifying, assessing, mitigating and monitoring all of the diverse environmental problems MSEs may cause. Rather, these guidelines are intended to familiarize readers with

- the kinds of adverse environmental impacts that may be expected from MSEs;
- simple methods of identifying those impacts;
- the continuum of mitigation approaches that MSEs can implement;
- the business benefits of the preferred mitigation strategy: **Cleaner Production (CP)**.

These guidelines also provide readers with

- a strategy for screening high-priority MSEs for possible problems with regulatory compliance, as well as opportunities to introduce best management practices;
- tools and information to build environmental capacity (most specifically CP) into their business practices.

Users of these guidelines may need or wish to rely on people with environmental expertise (either inside or outside their own organizations) to design appropriate mitigation strategies, particularly in matters of regulatory compliance.

Implementation of the guidelines. BDS and/or credit providers may be able to encourage better environmental performance among MSEs in at least three ways:

Purpose of Guidelines

The purpose is to familiarize business development service providers, intermediate credit institutions and direct lenders with:

- Information on the environmental effects of micro- and small enterprises (MSEs)
- Mitigation actions that MSEs can perform
- The benefits of the Cleaner Production (CP) approach to both business success and environmental mitigation

1. by demonstrating the “cleaner production” links between more efficient use of resources and improved cash flow,
2. by encouraging the MSES to take advantage of opportunities to mitigate of environmental problems and by providing or helping to arrange financing to do so, and/or
3. by potentially requiring certain mitigation activities as a condition for access to financial or other services in some cases.

Of course, there are many different models for the provision of BDS and credit, and many different kinds of MSEs that are supported. Hence it is expected that USAID-funded BDS and credit providers will use these guidelines to work with USAID staff to develop customized, effective approaches that best fit their circumstances.

Structure of the guidelines. The guidelines are divided into four main chapters:

1. MSEs and the Environment
2. Mechanisms for MSEs to Control Environmental Impact
3. Institutionalizing Environmental Capacity
4. Subsector-Specific Cleaner Production Briefings

Chapter 1 introduces MSEs as a sector targeted for development assistance, explains their impact on the surrounding environment, and argues for credit/BDS providers to play an active role in improving MSEs’ environmental performance. Chapter 2 introduces techniques for controlling and mitigating specific environmental impacts. Chapter 3 describes the tools, information, and framework needed to integrate environmental concerns into practical assistance to MSEs. Chapter 4 contains fact sheets that (1) further discuss environmental problems caused by particular MSE subsectors (e.g., leather processing/tanneries), and (2) present opportunities to mitigate these problems—with a particular emphasis on methods that may improve the profitability of the enterprise.

Two final chapters offer substantial annotated resource lists for those seeking more detailed information, as well as sample screening forms and other tools that may help credit and BDS providers to integrate these guidelines into their daily work.

MSEs and the Environment

What Are MSEs and What Is Their Role in Development?

We define micro- and small enterprises (MSEs) as enterprises with 50 employees or less. This size distinction is equivalent to what many other authors term “small and medium enterprises” (SMEs). USAID defines a micro-enterprise as “an informally organized business activity which:

- is owned by and employs poor people;

- employs 10 or fewer people, including the microentrepreneur and any family workers;
- and is not engaged in crop production" (USAID 1996).

MSEs are particularly important contributors to the African economy. They provide income and create wealth among lower-income populations, and frequently offer market opportunities (which would otherwise be unavailable) to traditionally disadvantaged groups within African society—including women and ethnic minorities. In many cases, MSEs are the sole source of income for both entrepreneurs and the workers they employ. MSE activities range from informal commerce, such as selling food or crafts on the street, to the production of export-quality goods, such as garments or processed foods and beverages.[1] The organization of production ranges from single entrepreneurs working with their families out of their home to larger, independently sited facilities with as many as 50 permanent workers.

Promoting MSEs is an important part of USAID's poverty reduction strategy. USAID's MSE development activities typically include providing loan guarantees, direct loans and/or grants to ICIs—institutions that lend directly to MSEs and to BDS providers. In 1999, the agency spent nearly 70 percent of its $153.5 million worth of funding for microenterprises on microfinance, with the remainder going toward BDS.[2] As noted in USAID's "Policy on Microenterprise Development," this financial and non-financial support to MSEs is focused upon

- assisting women and the very poor,
- improving the market and policy environment in which microenterprises operate,
- supporting the institutional and financial sustainability of MSE-support organizations, and
- enhancing partnerships with local organizations.[3]

In Africa, USAID particularly targets countries with a high level of food insecurity for MSE development activities.

Why Are MSEs an Environmental issue?

Per unit of production, small enterprises and plants are often more pollution-intensive than larger ones.

Do such small entities really have environmental problems worth worrying about, particularly compared to large enterprises that usually produce more aggregate pollution than smaller enterprises? The answer, simply stated, is yes. Although many MSEs do relatively little direct environmental damage,

[1] For organizational and conceptual purposes, certain common income-generating activities (in particular, farming, livestock grazing and fisheries management) are excluded from consideration as MSEs here. However, the processing of agricultural and other food products has been considered in preparing this section. Specific guidance for farming, livestock and fisheries is provided elsewhere in the *Environmental Guidelines for Small-Scale Activities*.

[2] USAID 2000.

[3] USAID 1996.

and some may even have beneficial effects, others can cause significant environmental and related public health difficulties, which vary as broadly as the types of enterprises. Of course, there are the obvious problems caused by manufacturers or resource exploiters (such as miners). Yet even small-scale informal marketplaces typically create health and environmental worries because of a lack of sanitation and waste disposal facilities.

Small enterprises and plants are often more pollution-intensive than larger enterprises (per unit of production).[4] When they are numerous and/or concentrated in particular areas, they can create environmental problems of alarming proportions. For example, while small enterprises account for an estimated 40 percent of all industrial production in India, they release an estimated 40 to 60 percent of the country's industrial pollution.[5] Examples of MSE subsectors with particularly high potential for environmental damage include:

- leather processing (tanneries)
- wet textile operations (e.g., bleaching and dyeing of cloth)
- food processing
- brick and tile manufacturing
- small-scale mining
- metalworking
- wood processing and furniture-making

The adverse environmental impacts of MSEs impose heavy social and economic burdens on their communities—degrading the ecosystem and food sources, undermining the health of neighbors and workers, and consuming fuel and resources beyond the point of renewability. These burdens in turn place significant costs upon not only the culpable MSEs but also other businesses—costs of procuring fuel, costs of lost worker productivity due to sickness or injury, costs of procuring clean water (such as for fabric processors or farmers), etc.

Environmental Problems caused by MSEs

- Chemical and hazardous waste
- Air pollution and particulate dust
- Water pollution
- Soil erosion
- Natural resource depletion
- Solid waste
- Odor
- Noise
- Health and safety risks

Types of Adverse Environmental Impacts of MSEs

Depending upon their individual characteristics, MSEs can have quite a variety of environmental problems. Here are some of the most common and significant ones:

- **Chemical and hazardous waste**. Production processes may use chemicals such as acids and metals. These chemicals may be toxic, explosive or otherwise hazardous, and require considerable care in their use and disposal. If chemicals are used carelessly, or if their wastes are not disposed of properly, they can seriously pollute the air and contaminate soil, groundwater and surface water. All these can cause serious health problems for adults, children and livestock.

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[4] World Bank 1999.

[5] Crow 1999, citing Gulati 1997 and B.M. Prasad (no date).

- **Air pollution**. Air pollutants—such as chemicals, dust or smoke—can be created by burning fuel (such as wood, charcoal, gasoline or oil), by evaporation of chemicals such as solvents, or from by-products of a production process. Air pollutants can cause or exacerbate respiratory illnesses such as asthma, and can damage both near and distant environments when they are deposited in the soil or water supply. Pollution from rock dust can lead to silicosis, a sometimes fatal “digging disease” with long-term effects on lungs and breathing.
- **Water pollution**. Chemicals used in production processes may be present in the firm’s wastewater. If untreated wastewater is released into the environment, the chemicals can contaminate community water sources and poison irrigated crops.
- **Soil erosion**. Mining, land-clearing or digging can leave an area vulnerable to soil erosion, leading to damaging landslides or floods. Over time, soil erosion can greatly reduce the replenishing of local aquifers, leading to dangerous water shortages.
- **Natural resource depletion**. Fuelwood use creates deforestation, which degrades arable lands. Excessive or wasteful extraction of water from surface and groundwater sources can deplete water sources for future production or community use. Too much groundwater use may also lower the water table and lead to irreversible land sinking; in coastal areas, it may allow salt water to contaminate groundwater bodies. Overall, waste in production processes frequently results in higher costs for energy, water and raw materials for the entire community.
- **Solid waste/garbage**. Inefficient production techniques reduce productivity and create excessive solid waste. Even if such waste is not toxic or otherwise hazardous, it is unsightly and can lead to more serious problems if not disposed of properly. For instance, waste from food processing may attract disease-carrying rodents and insects, and it can contaminate water supplies if washed away by rain. In urban areas, solid waste may also take up valuable space. Burning solid waste can cause air pollution, as noted above.
- **Odor**. Waste from MSEs’ production processes can have a strong odor that can damage the quality of life nearby. Odors may also reduce or destroy community support for further production or expansion.
- **Noise**. Production can involve equipment that is very noisy or causes strong vibrations. This can affect workers’ hearing and health, as well as that of the local community. This may also work against the enterprise’s ability to expand production in the future.
- **Health and safety risks**. One of the most immediate and significant adverse impacts of MSEs can be on the health of workers and of family members who live on the premises, particularly when the affected persons are already weakened by conditions such as HIV/AIDS. For example, touching or breathing hazardous chemicals can cause poisoning, skin irritations, burns or lung disease—including conditions that may not become apparent for years. Excessive heat caused by operating machinery in poorly ventilated areas is also hazardous to

"Green" Enterprises

A number of different kinds of MSEs may be environmentally helpful, although even these should be managed carefully to avoid unintentional adverse impacts. “Green” enterprises offer a wide range of goods and services including the following:

- Sale of solar energy
- Sustainable agriculture/forestry
- Ecotourism
- Harvesting rain forest products
- Commercial production of “wild fruits”
- Production of fertilizer from organic waste
- Latrine service
- Waste collection and disposal
- Recycling, repair and remanufacturing
- Manufacture of pollution control equipment or resource-efficient machinery
- Manufacturing bicycle carts or other forms of non-automotive transport

workers' health. Poor maintenance and housekeeping can increase the risk of fires and accidents.

Of course, some MSEs can have positive impacts on the environment. Such MSEs, sometimes called "green" enterprises, may create benefits by cleaning up or preventing environmental problems, or by creating incentives to protect environmental resources. (See the box on the previous page for a list of examples of such enterprises.) It may be desirable to target assistance toward such enterprises, if they are financially viable and sustainable. However, support organizations should be aware that these enterprises might still cause environmental problems requiring mitigation. For instance, ecotourism operations must guard against overuse of facilities, trails and scenic areas, as well as problems with human and solid waste that are typical of tourism operations worldwide. Improper or excessive harvest of rain forest products can also degrade the ecosystem.

Causes of Environmental Damage

How does environmental damage occur? Most decisions made by MSEs have the potential to harm the environment and public health. Specific examples include:

Even "green" enterprises, like trade in non-timber forest products, can cause environmental problems if they use unsustainable production methods, such as felling yohimbe trees (pictured) for their bark. As harvests shrink, non-"green" uses of forestlands—e.g., logging or clearing for farms—grow more attractive to local communities.

- **Location decisions**. Where an MSE decides to locate its operations may have a profound impact on the environment. For example, an MSE's pollution and resource impacts, even if small, will be magnified if it operates in an area that is ecologically sensitive, that lacks proper or adequate infrastructure for waste treatment/disposal, or where other industries are already polluting or rapidly consuming natural resources. Locating in an undeveloped area may require the construction of roads and other infrastructure with secondary environmental impacts.
- **Purchasing decisions**. MSEs may be unaware that more efficient or less hazardous inputs and equipment are available and may save them money. For example, brick-making MSEs may be able to use biological waste instead of wood products as a fuel.
- **Processing/manufacturing decisions**. An MSE's choice of manufacturing methods is among the most important factors determining how heavily it affects the environment. For example, many MSEs lack knowledge about the proper amount of chemical inputs (such as fabric dyes) to use in their processes. Another common difficulty is the use of energy-inefficient machines. Such problems frequently lead MSEs to use significantly more inputs than necessary, increasing both their own costs and the risks to the environment.
- **Housekeeping decisions**. MSEs that are not clean and orderly enough are apt to waste or spill inputs needlessly, and environmental contamination is likely to occur.
- **Waste disposal decisions**. Improper disposal of waste byproducts may unintentionally poison community members and/or contaminate water and air.

Overall, adverse impacts are often caused by poor practices that go uncorrected because people don't have the right technical information.

Insufficient knowledge can lead to improper use of chemicals, inadequate treatment or disposal of solid and liquid waste, uncontrolled chemical air pollution, and production techniques that make intensive use of nonrenewable resources. Health and safety problems, in particular, are compounded by ignorance of industrial safety and environmental standards, as well as by lack of awareness of protective devices that are generally inexpensive and easy to obtain.[6]

Why Development Agencies Need to Address MSE Impacts

While all or most MSE development organizations recognize that something must be done to arrest MSEs' degradation of the environment, some may ask, "Why should *my* organization address this issue?" Basically, at least four reasons justify integrating environmental considerations into the activities of BDS and credit providers: (1) development agencies may be required by USAID regulations to mitigate adverse environmental impacts; (2) development agencies may be the actors with the best opportunity to alter MSEs' behavior; (3) for businesses, better environmental performance is increasingly linked to better financial performance; (4) mitigating environmental problems can enhance the long-run sustainability of development efforts.

Why Do Assistance Providers Need To Address Mse Environmental Issues?

- Regulatory requirements
- Opportunities to integrate environmental protection into everyday MSE operation
- Positive link between environmental and financial performance
- Promoting sustainable development

Regulatory requirement. At the donor level, USAID staff are required to review all proposed programs, including MSE development programs, to ensure that they comply with Federal environmental regulations (22 CFR 216). These regulations are designed to ensure that environmental concerns are incorporated into USAID projects, when USAID is aware of the specific activities or loans that would have an environmental impact.

However, the regulations do not explicitly require environmental review or mitigation measures when *intermediaries* will design the specific activities and/or make the specific loans.[7] For example, some credit activities may qualify for a "categorical exclusion" under Regulation 216. This is a judgment that an activity is inherently exempt from USAID environmental review. For a credit activity to qualify, a USAID mission must affirm that (1) the activity's purpose is the equivalent of capitalizing an ICI (e.g., capitalizing a guaranty *facility*, as contrasted with the making of individual guaranties); (2) USAID does not retain the right to review and approve each loan (or equivalent) by the ICI; and (3) USAID does not know what kinds of activities are being funded. The exemption is available whether USAID's funds are used for loan guaranty or for direct loans.

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[6] IADB 1997

[7] The regulations state that an Initial Environmental Examination and/or Environmental Impact Statement are generally not required for projects in which "A.I.D. does not have knowledge of or control over, and the objective of A.I.D. in furnishing assistance does not require, either prior to approval of financing or prior to implementation of specific activities, knowledge of or control over, the details of the specific activities that have an effect on the physical and natural environment for which financing is provided by A.I.D." (22 CFR 216.2(c)(ii)).

Even when a categorical exclusion is appropriate under Regulation 216, however, the following reasons show why MSE credit and service providers should build their own environmental reviews into their credit and service projects and activities.

Leverage opportunity. Traditionally, legislatures in many countries, both developed and developing, have created stringent standards and regulations for preserving the environment. Environmental protection agencies, independent and distinct from economic agencies, have been responsible for assuring that people comply with those standards. The standards are important, and complete environmental protection may not be achievable without strong environmental protection institutions. But relying solely upon these institutions—particularly in developing countries—is unwise.

As many readers are aware, a large number of developing countries are only beginning to put environmental, legal and regulatory standards and/or enforcement institutions in place—either for their entire economies, or for particular industries such as brickmaking, mining and textile dyeing.[8] In addition, not all small plants, even in countries with strong legal and regulatory institutions, may be regulated because of competing political and economic pressures or for fear of undermining employment, income and profits. Moreover, when MSEs are regulated, they are much more costly for regulatory agencies to oversee than larger plants because of their sheer number and geographic dispersion.

Under these circumstances, it is vital to integrate incentives for both short- and long-run environmental protection into day-to-day economic development efforts. Doing so can help bring about gradual, institutionalized change in the private sector. This may be the most viable way for MSEs to improve their environmental performance—in part because such institutionalization may also bring with it efficiency gains (discussed later) that can directly benefit the MSE. To provide incentives, governments can use economic tools, such as emissions charges or taxes on pollution or on the purchase of chemicals or energy. However, such tools need an effective regulatory structure to ensure compliance and payment. As mentioned above, most developing countries are only beginning to build this capacity.

Thus, integrating environmental concerns into MSE credit and BDS operations is vital, because existing, frequent interactions with MSEs create an opportunity for positive change.

Links between environmental performance and financial performance. The primary mission of economic development organizations is to ensure the success of the enterprises they support—as measured by profitability, productivity, income generation, employment and/or long-term sustainability. This success not only achieves public policy objectives, but also ensures that credit institutions remain solvent through healthy loan repayment rates and that MSEs continue to seek services from BDS providers. Incorporating environmental concerns fits well with these traditional missions.

[8] Intermediate Technology Consultants 1997c.

For instance, as will be discussed in Chapter 2, environmental measures are not necessarily costly. Worldwide, banks and other service providers increasingly recognize that "good environmental performance is often linked to good financial performance."[9] Specifically, following the "cleaner production" resource efficiency strategy can actually result in measurable benefits for both the enterprise and the environment.

It follows, then, that BDS providers may in many cases be able to help MSEs improve their profitability while they also improve their environmental performance. Likewise, incorporating environmental considerations into the process of reviewing aid applications gives credit institutions a better sense of the investment risk and may increase the enterprises' potential for success.[10] Moreover, it's nothing new for MSE credit providers to consider so-called "non-business" factors. For example, many of these institutions have long recognized that giving credit to women is socially beneficial. More recently, they have come to realize that it makes business sense as well, since women have a better repayment rate than men and thus provide a better return on investment.

Opportunities to promote sustainable development. In large part, USAID believes it is important to aim for environmentally sound MSEs by:

- increasing MSEs' understanding of their own environmental profiles, and
- encouraging them to improve their performance.

USAID recognizes that this is critical both to making MSE programs sustainable and to helping communities to develop overall. As already described, unaddressed MSE environmental impacts may do substantial and long-lasting harm to community health and to the value, availability, and productivity of important environmental and economic resources (such as clean water). Such effects undermine any attempts to alleviate poverty.

How Implementing These Guidelines Aids Development Goals

Implementing these guidelines supports the primary mission of BDS and credit organizations, and of USAID's MSE development activities: facilitating MSEs' short- and long-term economic and financial success in order to alleviate poverty. Table 1 (next page) shows how these guidelines can assist BDS providers, direct lenders, ICIs, and USAID staff. It outlines how the consideration of environmental issues aligns with the development mission and the steps each organization can take to contribute to that mission.

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[9] Jeucken and Bourma 1999, citing World Business Council on Sustainable Development 1997.

[10] For example, several private European banks integrated environmental risk into their credit risk assessments (Jeucken and Bourma 1999).

Table 1: Contribution of Guidelines to Development Goals

Development Actor	Alignment with Mission Goals	Steps to Contribute to Mission
Business Development Services (BDS) Providers	- Provide MSEs with the skills to effectively mitigate certain adverse environmental impacts, particularly using methods that reduce costs or improve quality - Improve the sustainability of MSE assistance programs - Improve net community benefits of MSE assistance programs	- Integrate strategies for efficient resource use into BDS activities - Assist MSEs in meeting specific environmental mitigation requirements instituted by lenders (or other entities, such as regulatory agencies) - Ensure that MSE assistance activities meet USAID regulations - Incorporate general environmental management skills into training provided to MSEs - Help connect MSEs with environmental service providers
MSE Direct Lenders	- Improve long-term MSE performance and, consequently, improve the likelihood of repayment. - Improve sustainability of MSE assistance programs - Improve net community benefits of MSE assistance programs	- Ensure that MSE assistance activities meet USAID regulations - Require or encourage selected environmental mitigation measures before certain MSEs receive loans - Incorporate general environmental management skills into training provided to MSEs - Offer financing to MSEs for environmental projects, including those that have a direct positive impact on business performance - Help connect MSEs with environmental service providers - Provide environmental management skills training to MSEs (directly or by contract)
Intermediate Credit Institutions (ICIs)	- Improve the performance of direct lenders by enhancing the economic and environmental sustainability of MSE lending programs. - Improve net community benefits of MSE assistance programs	- Ensure that direct lenders' MSE assistance activities meet USAID regulations - Provide training and guidance to direct lenders (directly or by contract) - Ensure that MSE direct lenders actively promote better environmental practices among MSEs
USAID	- Improve the performance of all MSE development activities, and reduce MSEs' harmful effects (such as pollution) on other development priorities such as public health and agriculture.	- Provide oversight on all MSE development activities, to reduce environmental impacts and abide by Regulation 216 - Identify and fund new training needs of USAID and private voluntary organization (PVO) staff - Facilitate coordination between different development actors, including BDS providers, direct lenders, intermediate credit institutions, and environmental and resource efficiency experts

Chapter 2
Mechanisms for MSEs to Control Environmental Impact

Contents

Mitigation Approaches (Pollution Control , Cleaner Production) 2-1

Problems with Pollution Control 2-2

Illustration of CP Approaches and Benefits 2-3

CP Strategies Overview 2-5

Overcoming Challenges to the Adoption of CP 2-8

Environmental Management Systems 2-9

Businesses have two main options for dealing with the environmental problems they generate: pollution control and cleaner production (CP). Pollution control deals with problems after they are created. CP examines and improves production processes to reduce problems before they happen—and can also benefit a firm's bottom line.

The previous chapter illustrated both the importance of MSEs in development, and the range and severity of adverse environmental impacts that these enterprises can generate. This chapter focuses on two approaches to mitigating these impacts: pollution control and cleaner production. The chapter closes by briefly describing environmental management systems, which enterprises of any size can use to regularly assess and mitigate their adverse environmental impacts.

Mitigation Approaches

An MSE (and the organizations assisting it) must find a strategy for controlling and/or mitigating each environmental problem it causes. The two main options available to any enterprise, including MSEs, are **pollution control** and **cleaner production** (CP). Pollution control is a strategy that addresses problems after they are created, while CP is an approach that examines and improves production processes to reduce pollution and other adverse impacts before they happen. Importantly, CP can also have financial benefits for the enterprises that implement it. These advantages typically point to CP as the preferred mitigation approach, although it may not solve all environmental problems.

Pollution Control

Pollution control is a class of methods for controlling and/or capturing pollutants leaving a manufacturing facility before they can enter the environment. Because pollution control approaches are added on to the production process without directly affecting it, they are commonly referred to as "end-of-pipe" solutions. The most common approaches deal with the air, water and the waste leaving an enterprise:

Pollution Control

Pollution control approaches are "end-of-pipe" solutions added on to the production process. Pollution control can be necessary to mitigate environmental problems in some instances. However, over-reliance on pollution control is problematic from both an environmental and a financial perspective, for the following reasons:

- It represents an added cost to the business.
- Oversight is needed to ensure that MSEs install and use control equipment.
- Technical training is needed.
- It does not address issues of unsustainable use of resources.
- It cannot mitigate certain critical pollution problems, such as carbon dioxide emissions associated with global climate change.
- It does not get rid of pollution permanently; extracted contaminants must be disposed of and monitored.

- **Air pollution control technologies** can include filters and other devices that remove contaminants from smoke or exhaust.
- **Water control technologies** typically use a variety of methods to remove impurities from the **effluent** (water leaving the premises).
- **Incinerators** can be used to decrease the volume of solid waste (trash) created by a facility, but they themselves will usually require pollution control technologies to minimize the amount of contaminants they release into the air.
- **Disposal techniques** create a safer place to put hazardous waste (including contaminants captured using other pollution control techniques). The waste may be placed in landfills or wells specially designed to prevent escape of contaminants into the environment.

For example, to meet government regulations on water pollution, a facility may install an effluent treatment plant and arrange its production processes to discharge all liquid wastes into it. Depending upon the type of effluent, contaminants, requirements and ability to pay, the effluent treatment plant could use a variety of different methods to remove impurities. These include filtering, settling, stirring and evaporation. Impurities that are removed must then be appropriately disposed of, for example in a lined landfill, so that they do not enter the environment via a different pathway—such as washing away in the rain. The treatment plant needs to be operated and monitored carefully by a worker who must be trained to ensure that effluent leaving the plant meets all pollution control requirements. The output from the plant may also be monitored by regulatory agencies to ensure compliance.

Problems with Pollution Control

Pollution control equipment was developed in the early days of environmental protection, when regulatory agencies first required companies to comply with pollution regulations. Such end-of-pipe devices can be effective at removing pollutants from waste streams, and may sometimes be the only way to mitigate an environmental problem—short of stopping the productive activity altogether. However, pollution control presents numerous disadvantages from both business and environmental perspectives, particularly for MSEs in developing countries. These include but are not limited to following:

- Pollution control typically only represents an added cost to businesses. Moreover, because pollution control strategies frequently offer economies of scale, they are relatively more burdensome for MSEs to adopt than they are for larger enterprises.[1] In many assistance situations,

[1] MSEs in some countries such as India have banded together to share the costs and technical expertise needed to operate effluent treatment plants, hoping to reap the benefits of economies of scale. However, such efforts have had mixed success and experienced numerous difficulties—such as problems ensuring fair play and finding cost-effective ways to transport effluent to a central location cost-effectively (Crow 1999). Hence, it is difficult to recommend such strategies without extremely careful consideration.

the cost of a pollution control mitigation technology could substantially outweigh the initial amount of assistance sought by the MSE.

- Because of the added cost, most MSEs typically will not install or operate pollution control devices without oversight.
- Many pollution control devices require technical training and sophisticated operation to work properly, which places an additional burden on even well-meaning MSEs.
- Pollution control will not address concerns about unsustainable use of resources, such as wood burning that leads to deforestation.
- Pollution control cannot mitigate the critical pollution problem created by the release of carbon dioxide from burning fuel, which is a leading cause of global warming.
- Pollution control does not get rid of pollution permanently. Contaminants that are removed must be disposed of and monitored in proper facilities, which often do not exist in developing countries.

In the face of these problems, over the past 10–20 years businesses and environmentalists have developed an increasingly sophisticated alternative mitigation approach: cleaner production.

Cleaner Production

Cleaner production (CP) is the preferred approach to mitigate adverse environmental impacts from MSEs. It represents a new way of thinking about success in business and environmental management. CP is:

- a **problem-solving strategy** that uses a set of analytic tools to improve the **efficiency** of production processes, improve profitability and reduce the risks to humans and the environment.
- a **business-focused approach** that can be seamlessly integrated into a business planning process, and that may boost creativity and innovation.
- **relevant to all** sizes of enterprise, from home-based to multinational.

CP is also commonly referred to as pollution prevention (as opposed to pollution control), waste minimization, green production or eco-efficiency.

Mitigation Approaches

Cleaner production (CP) is the preferred approach for MSEs. CP is:

- A problem-solving approach that improves the efficiency of resource use
- Business focused, and can be integrated into MSE business practices and operations
- Relevant to all size of enterprises

Illustrations of CP Approaches and Benefits

Because it is easiest to gain an initial understanding of CP through examples of its application, we now present several stories of the successful implementation of CP by MSEs. These examples have been chosen to illustrate the range of possibilities for CP among enterprises of different size, capacity, and manufacturing subsectors. As you read, pay attention to all the different kinds of CP approaches used by enterprises to improve their business environmental performance. These approaches will be detailed and classified in the subsection that follows this one.

CP and Profitability

Many CP improvements require little or no initial investment and offer rapid payback. Examples include:

- Simple management techniques, such as the “First In, First Out” approach to storing perishables.
- Good housekeeping, such as keeping the workspace free from obstructions.
- Low-cost improvements, like replacing leaky values or recalibrating thermometers and pressure gauges.

Example 1: Cleaner Production in Soap Production[2]

Shivji and Sons Ltd., of Dar es Salaam, Tanzania, manufactures laundry soap. The company has a production capacity of five tons of bar soap per hour; it employs 45 permanent staff members and 20 seasonal workers.

A CP assessment revealed the following problems:

- The facility is powered by steam generated through diesel fuel combustion. The company was wasting steam through leaky valves and inefficient use.
- Improper unloading of shipments to the factory resulted in loss of 3,000 kilos of fat per year. The spilled fat was absorbed by the soil.

By replacing leaking valves and traps, halving the fat storage tank heating time, adjusting water use to minimize steam consumption during cooling, and recovering the spilled fat, the plant was able to realize an **annual return on investment of US $185,700**. An initial investment of US $830 was needed for the installation of the steam valves; no input or energy costs were required for recovering the spilled fat. The payback time for this project was two days. Consumption of industrial diesel oil was **reduced by 54 percent, saving 415,800 liters per year** and reducing plant air emissions.

Example 2: Technology Change and Energy Efficiency in Cashew Nut Processing[3]

Three cashew nut processors in Ghana had problems controlling the quality of their product. To process cashews, the raw nut is first steamed, then shelled, then dried in industrial dryers. The shells of the cashew nuts are used as fuel for steaming, but the dryers were being fueled by firewood harvested locally. Using firewood for fuel sometimes caused a problem for the businesses since the smell of the wood smoke would stay in the kernels, making the product unusable. Using firewood also made it difficult to regulate the temperature of the dryer. If the temperature were too hot, the kernels would burn, again resulting in waste product. Thus, the businesses wanted to find a new source of fuel to run their dryers.

The government in Ghana agreed to subsidize the use of propane gas as a fuel source as part of a program to reduce deforestation. For two of the businesses, the subsidized gas was **less expensive** to use than the fuelwood. For the third business, however, the fuelwood had been essentially free, since the staff harvested trees on site. Nevertheless, all three businesses opted to switch to propane to run their dryers. The most important criteria for this decision were the ability to control temperature and smoke. **Reducing waste cashews** resulted in higher profits, even for the business whose fuel costs increased with propane use.

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[2] UNIDO NCPC Case Studies, ICPIC

[3] Case study data collected by TechnoServe/Ghana and compiled by Tellus Institute (Tellus 2002). See sidebars in Part III, Chapter 3, for additional case studies.

Example 3: Coffee Microenterprise in the Philippines[4]

To improve its coffee-grinding process, a microenterprise switched from using plastic pails to using stainless steel bins to collect the ground coffee. The ground coffee particles had been sticking to the plastic pails, requiring washing to remove. The particles, however, did not adhere to the stainless steel, resulting in less lost product and lower water usage. The steel bins were also more durable than the plastic pails, which had required annual replacement.

The company **invested US $800** and realized an annual **return on investment of US $168** from recovering lost coffee grounds and avoiding the cost of replacing the plastic pails.

Example 4: Cleaner Production in Woodworking[5]

After being introduced to CP, a small carpentry shop in Brazil producing furniture components for the local market took another look at its wood scrap waste. After some investigation the owner learned that the waste could be reprocessed into new boards 2–4 meters in length using a process that cuts the scraps into triangles and then glues them together again (finger joint processing). After first outsourcing the work, the owner purchased a secondhand finger joint machine that his employees operate during slow periods.

This example of waste-to-product CP required an initial **investment of US $180**, provided an **annual return on investment of US $6,000**, and paid for itself in **10 days.**

CP Strategies Overview

As the examples above illustrate, CP opportunities can be discovered using several approaches. These approaches can be arranged into nine categories, with many opportunities crossing the boundary between different categories.

1. ***Good housekeeping:*** *preventing leaks and spills, instituting preventive maintenance schedules, regularly checking equipment, and making sure employees follow official work procedures.* In Example 1, replacing leaky valves and traps represented good housekeeping.
2. ***Input substitution:*** *substituting one or more cheaper, safer, or more efficient inputs for an existing input*. Example 2's switch to propane fuel represents one type of input substitution, but replacement of input materials (such as chemicals) is also common.
3. ***Better process control:*** *changing working procedures, machine instructions, and process recordkeeping to increase throughput,* [6] *reduce waste, and/or improve product quality*. In Example 1, decreasing

[4] GTZ (2000a).

[5] GTZ (2000b).

[6] *Throughput* is output or production over a period of time.

CP can raise profits by reducing upfront costs of materials and energy, as well as costs for waste disposal. Using CP, an enterprise can also improve product quality, increase throughput, and avoid regulatory and compliance costs. Many CP improvements require little or no initial investment and offer rapid payback.

the storage tank heating time and optimizing the use of water for cooling both demonstrate better process control.

4. ***Equipment modification:*** *changing the existing process equipment to increase throughput, reduce waste, and/or improve product quality*. In Example 3, switching to stainless steel bins for collecting coffee particles was an equipment modification that reduced waste and improved profitability.
5. ***Technology change:*** *replacing the existing technology or simply changing the order of process steps to increase throughput, reduce waste, and/or improve product quality*. Both the cashew processors in Example 2 and the carpenter in Example 4 used new technologies to take advantage of a CP opportunity.
6. ***Product modification****: changing the characteristics of a product to increase throughput, reduce waste, and/or improve product quality*. For instance, joining the parts of a product together with bolts instead of glue may make a product more durable and easier to repair.
7. ***Energy efficiency:*** *making changes in any aspect of business operations to reduce energy consumption or cost*. The soap producers in Example 1 increased energy efficiency by optimizing heating and cooling needs, while the nut processors in Example 2 increased energy efficiency by switching fuels.
8. ***On-site recovery and reuse:*** *capturing and reusing onsite materials that were previously wasted*. For instance, Example 1's soap producers captured previously wasted fats.
9. ***Waste-to-product:*** *identifying an end market and marketing a material formerly considered waste. This may involve changes in processing of original product or new processing steps to transform waste*. In Example 4, the small carpentry operation created a new, profitable product from its previously unused wood waste.

Why Is CP the Preferred Mitigation Strategy for MSEs?

Better environmental management translates into better overall management. Pollution can be thought of as a non-product output—material that the enterprise has paid for but for which it will receive no revenue in return. Controlling pollution at the "end of the pipe" requires an additional expenditure beyond the cost of the non-product output. This cost burden is difficult for MSEs to bear, as resources are limited and investment priorities are numerous. Cleaner production is more suitable than pollution control technologies for MSEs, because the benefits are more in tune with the realities of their competitive environment. Specific benefits include:

Flexibility. CP can be applied to any size business, from microenterprise to transnational corporation. Because it is a business-focused, profit-driven approach to pollution management, CP can be seamlessly integrated into a firm's planning process.

Environmental benefits. CP can reduce both pollution output and demand for natural resources (water, energy, raw materials, etc.) used as production inputs. By minimizing fuel use, CP can help reduce the emissions of greenhouse gases like carbon dioxide, which contribute to global warming. By reducing the need for chemicals and other inputs, CP helps reduce environmental damage by suppliers. CP also reduces the need to rely upon technically sophisticated disposal methods to protect the environment.

Health and safety benefits. Typically, MSEs can mitigate their primary threats to health and safety at low cost—and improve productivity at the same time. Threats to workers' health and safety can also be sources of poor quality products. For example, in the food-processing sector, products can be contaminated and/or workers harmed by mishandled hazardous chemicals, pesticides, broken glass, scrap metals and trash. CP can help find alternatives to chemicals and pesticides, as well as identify sources of glass, metal and trash, which can be controlled through good housekeeping or proper management.

CP approaches can also help improve working conditions, which reduces the risk of accidents. For example, to reduce energy costs, a CP solution might be to improve natural lighting by painting the production area white and regularly cleaning windows. This type of improvement not only saves money by reducing the need for artificial lighting, but also reduces employee eyestrain, preventing mistakes and injuries and raising morale.

Financial benefits. CP can increase profitability by reducing upfront costs of input materials and energy, as well as costs for non-product outputs and waste disposal. Using CP, an enterprise can also improve product quality, increase throughput, and avoid regulatory and compliance costs. Additionally, many CP improvements require little or no initial investment and offer rapid payback.

Simple management techniques such as instituting a "First In, First Out" approach to stored perishable goods can reduce losses from spoilage. Good housekeeping procedures such as keeping the workspace free from obstructions can reduce the likelihood of accidents and spills. Low-cost improvements, like replacing leaky values or recalibrating thermometers and pressure gauges, can pay back their investment quickly and involve minimal interruption of production schedules.

Risk Reduction. CP can help reduce reliance on specific inputs, minimizing the risk of supply chain disruptions. For example, using renewable energy sources might be appealing because of the opportunity to bypass unreliable electricity supplies. Honing water conservation techniques may help businesses survive during droughts.

Marketing Opportunities. CP can help an enterprise establish new product lines or access new markets. The Brazilian carpenter described earlier was able to establish a completely new, profitable product line by applying the CP waste-to-product strategy. CP skills can help food-processing enterprises achieve HACCP[7] certification, allowing them access to the export markets of Europe and the United States. CP also improves company image in communities and among environmentally conscious customers, and may offer enterprises access to niche markets.

CP: The Preferred Mitigation Strategy for MSEs

MSEs can benefit both financially and managerially from the introduction of CP into their operations. Specific benefits include:

- Flexibility in applying CP to different sized businesses
- Environmental benefits from reduction of natural resource use and lower carbon dioxide emissions
- Health and safety benefits for workers that improve productivity
- Financial benefits, from lower costs for materials and more efficient use of resources
- Risk reduction
- New marketing opportunities
- Enhancing the firm's management skills

[7] HACCP stands for Hazards Analysis Critical Control Points. It is a strategy for managing and guaranteeing the safety of food-processing systems.

Management Enhancements. CP can improve an MSE's management by:

- *Building decision skills*. The CP process identifies poor or inadequate accounting practices, allowing better, more consistent oversight of risk, short-term cash flow and product quality.
- *Improving management competence*. Like Total Quality Management, CP builds quality and efficiency into products, rather than repairing defects.
- *Enhancing profitability and competitiveness in the long run*. Improved management and quality, combined with cost savings, lay a solid foundation for economic sustainability of the enterprise (and for repayment of any loans).

Like Total Quality Management, CP builds quality and efficiency into products, rather than repairing defects.

Recognizing these advantages, as mentioned in the previous chapter, a major European bank, UBS, has begun to screen all loan applicants for energy efficiency and good resource management. UBS focuses on operational cost indicators that "reflect efficiency in financial terms."[8]

Overcoming Challenges to the Adoption of CP by MSEs

Of course, implementing even the most enticing CP opportunity and reaping its benefits may be challenging for any enterprise, but particularly for MSEs. For instance, in India, Project DESIRE worked with 12 small-scale enterprises in the textile, pulp and paper, and pesticides industries and identified approximately 450 different CP options.[9] At the same time, however, the project identified a number of barriers inhibiting CP adoption, which can be grouped into four categories: systemic barriers, technical barriers, economic barriers, and attitudinal barriers. Understanding these barriers was critical to helping the enterprises implement over 46 percent of the CP opportunities within a 15-month timeframe—with a payback in all cases of less than six months.

The barriers to CP adoption can sometimes seem daunting, but BDS and credit providers already offer services that counter these barriers. The challenges that these providers might encounter in promoting CP are very similar to those encountered in promoting any new way of doing business, and may be less formidable than the challenges posed by "end of pipeline" pollution mitigation strategies. The table on the next page presents the kinds of barriers encountered in Project DESIRE and CP projects everywhere, and also gives suggestions for dealing with them—although it is expected that readers are experienced in overcoming such barriers in their own work.

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[8] Hugenschmidt et al. 1999.

[9] Information on Project DESIRE outcomes adapted from Chandak 1994 and Pallen 1996.

Table 1. Cleaner Production Barriers: Examples and remedies

Barrier Type	Barrier Examples	Suggested Approaches to Overcoming Barriers
Systemic	Poor recordkeeping and reporting Ineffective management systems Ad hoc production planning High staff turnover Seasonal variations, making high efficiency difficult	Business planning assistance and advice Building management capacity Technical assistance to improve recordkeeping and reporting capacity
Technical	Limited general technical ability Limited access to technical information/success stories Limited maintenance capabilities	Technical assistance Networking with successful CP implementers Focus on least technical CP approaches
Economic	Lack of financing for CP Preference for least capital-intensive option even if it is not the best option Poor investment planning, leading to partial implementation	Facilitate financing for CP Give training in investment planning
Attitudinal	Lack of good housekeeping culture Resistance to change Risk aversion/fear of failure Lack of employee input in decision-making	Leadership training Technical assistance Building management capacity Employee training

Environmental Management Systems

Up to now, this chapter has focused upon approaches that help MSEs mitigate environmental problems at a single point in time. However, proper management of environmental responsibilities can require frequent attention. How can MSEs continue to mitigate both existing and new environmental problems over time?

An MSE can do so by setting up and operating an environmental management system (EMS). An EMS is a formal approach that an enterprise of any size can use to help it to *regularly* detect and assess environmental problems (and opportunities), develop and implement solutions, and monitor the results.

The most widely known environmental management system is ISO 14001, a complicated system typically used only by medium and large enterprises (see box next page). Readers should recognize that ISO 14001 is unlikely to be relevant or useful to the MSEs they work with. More generally, the paperwork and the formal allocation of environmental responsibilities that go with a standardized EMS are probably unnecessary for an MSE. More can be accomplished if the MSE will commit to monitoring its mitigation

Making EMSs Work for Small Businesses

For MSEs, an environmental management system need not be fancy. An MSE can simply schedule a regular (e.g., annual) review of its processes to look for fresh CP opportunities. Even after many inefficiencies have been corrected, a careful look will detect new ways to avoid waste and pollution—and, often, avoid needless costs as well.

methods and regularly reassessing the situation, on a schedule that suits the situation. This type of EMS might be as simple as reviewing CP approaches once a year, during a seasonal lull in business, to identify new opportunities.

Research has shown that CP opportunities, like fruit, grow back. That is, even after an MSE has resolved numerous inefficiencies, new CP opportunities will present themselves. A primary goal of an EMS is continual improvement, and each individual enterprise must decide on the right mechanisms to meet that goal.

ISO 14001: The Environmental Management System Standard

ISO 14001 is the most common EMS in the world today, having been adopted by thousands of businesses worldwide. This certifiable standard has detailed requirements for the following components of an EMS: policy, planning, implementation and operation, checking and corrective action, and management review.

Because setting up, operating and becoming officially certified as ISO 14001–compliant can represent a substantial investment, the vast majority of certified companies are large and medium enterprises. Furthermore, firms in the electronics and automotive sectors are the predominant ISO 14001 companies, because certification to ISO has been required by major purchasers, such as GM and Ford. The benefits of certifying to ISO 14001 are dubious for an MSE, unless doing so will give it access to a lucrative market opportunity that the MSE is well placed to take advantage of—such as becoming a supplier for GM.

Readers should also recognize that ISO 14001 certification does not necessarily prove a company has good environmental performance. It only indicates that the company has properly implemented the ISO 14001 environmental management system—which does not specify any particular performance levels. There is currently a lack of evidence showing that ISO 14001 companies have better environmental performance than similar companies that have not implemented ISO 14001.

Chapter 3

Institutionalizing Environmental Capacity

Contents

Screening—Which MSEs to focus on?	3-1
Environmental Impact Assessments for MSEs	3-7
Cleaner Production Assessments for MSEs	3-14
Sample CP Assessment Checklist	3-17
Building an Organization’s Environmental Capacity	3-21

The previous chapter introduced mitigation strategies that MSEs can use to control their environmental impacts. Here we will address the challenges facing credit and BDS providers in effectively reviewing MSE activities for compliance with USAID regulations, as well as improving the overall environmental and economic performance of MSEs.

This chapter will help providers understand how to (1) develop a screening process to identify potentially damaging enterprises, (2) identify adverse environmental impacts of those enterprises, and (3) find opportunities for them to mitigate these impacts using the Cleaner Production (CP) approach (see chapter 2).

This section also discusses different aspects of implementing these guidelines that may be critical to success. These include **suggestions and tools** for

- integrating environmental considerations into normal operating procedures,
- procuring environmental commitments from MSEs,
- customizing the guidelines,
- working with partners who may be able to help implement and customize the guidelines, and
- providing training both for BDS/credit staff and for their client MSEs.

This section gives credit and BDS providers a framework for incorporating environmental concerns into their operations, without having to become environmental experts themselves.

Screening—Which MSEs to Focus On?

In applying environmental oversight to MSE activities, one of the first steps for BDS and credit providers is to categorize the MSEs they work with according to the types and seriousness of environmental impacts they generate. A BDS or credit provider needs to ensure that assistance for an MSE complies with local, national, USAID, or its own organizational environmental policies. Yet, it is unreasonable to expect BDS and credit providers to conduct a detailed assessment of the impacts of every MSE they work with. The goal of the screening phase is to determine quickly and easily if an assistance request from an MSE (for a loan, business planning, accounting training, etc.) will need environmental review before it can be approved.

The sample screening framework proposed in these guidelines uses information about an MSE's subsector to characterize its expected environmental impacts. This approximation will not be true for all circumstances, but it allows staff members with limited environmental expertise to process a large number of requests for assistance quickly and easily. This framework emphasizes flexibility and collaboration to suit a wide variety of MSE development scenarios. It can be easily modified to address the specific needs of each BDS and credit provider. (See "Developing a Customized Screening Process," page 5.) Although they may seem burdensome at first, initial screenings are intended to help BDS and credit organizations become more efficient in applying environmental guidelines to their operations. This overall pre-assessment effort can also help minimize the costs of incorporating environmental concerns into the smallest projects.

Screening Roles and Responsibilities

Screening requires the cooperation of different stakeholders to avoid environmental damage and help MSEs contribute to development objectives.

- MSEs, the focus of the screening process
- Assistance provider, the entity that is directly assisting the MSE (i.e., the BDS provider or direct lender)
- USAID mission, providing oversight of the assistance providers programs
- Intermediate credit institutions, which play a mediating role between the mission and the direct assistance provider

Roles and Responsibilities

Screening requires input from many different participants—including the MSE, the BDS or credit organization, and the USAID mission—in order to provide development assistance to as many MSEs as possible while mitigating the most serious potential environmental problems.

MSEs. The MSE is the focus of the screening process. The MSE asks an assistance provider (BDS or credit organization) for some type of assistance, which must be screened for potential environmental impacts before being approved. The MSE is responsible for providing any needed information about its financial and environmental performance to the BDS or credit organization, to fulfill screening requirements. For most MSEs, this information will be very limited, and may not differ from the ordinary business information collected by BDS and credit providers. The MSE is also responsible for working with the BDS or credit organization to develop mitigation and monitoring plans (MMPs) and to perform any required monitoring.

Assistance providers. The assistance provider (BDS and/or credit provider) is the entity that will be directly providing the requested assistance (loan, training, technical assistance, etc.) to the MSE. To ensure that any assistance meets USAID requirements for environmental performance, the provider must fulfill three main responsibilities:

- create appropriate screening criteria and procedures, working with the USAID mission and referencing the governing Initial Environmental Examination (IEE) conducted by USAID;
- help selected MSEs create and implement required MMPs;
- oversee any monitoring activities required in the MMP.

These responsibilities typically require participation from the assistance provider's environmental officer (EO) and the person handling the MSE's assistance request (loan officer, business consultant, field staff, etc.), hereafter referred to as the caseworker.

Missions. The USAID mission oversees the assistance provider's development activities. In providing environmental oversight, the mission has two main responsibilities:

- work with the assistance provider to develop and approve its screening process.
- help the assistance provider address any assistance requests that are not covered by the existing screening process.

For example, the mission would help the provider screen MSEs newly identified as generating environmental impacts of concern. Typically, the mission environmental officer (MEO) participates in these activities.

Intermediate credit institutions (ICIs). ICIs serve as intermediaries between the mission and direct credit providers. In this role, ICIs are responsible for ensuring that direct lenders develop appropriate screening procedures, as described above, and for giving the mission information showing that the screening is being carried out.

Screening Process

Screening is expected to be completed by caseworkers without environmental expertise, using simple tools, and may take no more than a few minutes to complete. Figure 1 (next page) provides an overview of the proposed sample screening process. Screening begins when an MSE makes a request for assistance that the assistance provider has determined is financially viable. MSE subsectors are then divided into three categories: (1) MSEs which generate environmental impacts of concern, (2) MSEs which do not generate impacts of concern but have known opportunities for CP, and (3) MSEs which do not require any further environmental action. It is expected that assistance providers will divide the most commonly assisted MSE subsectors into categories in advance, in collaboration with the USAID MEO.

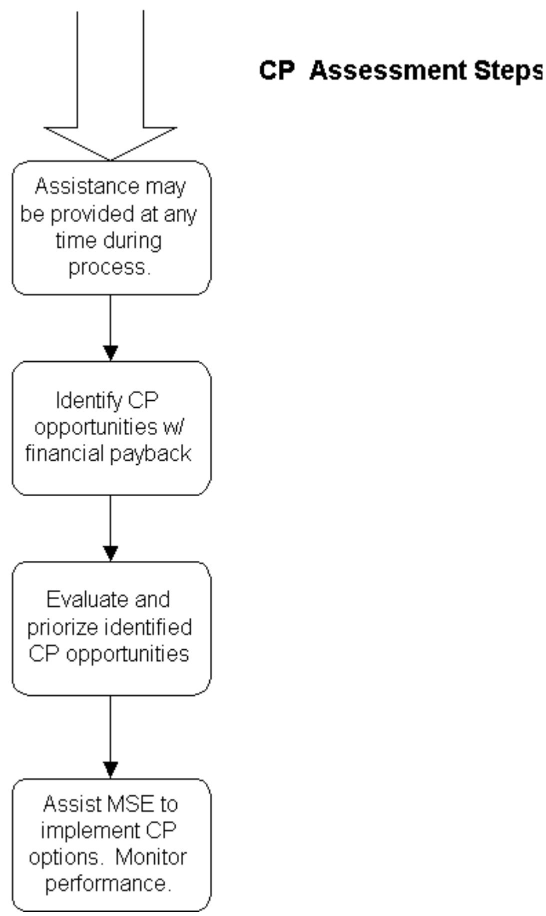
Screening is expected to be completed by caseworkers without environmental expertise, using simple tools, and may take no more than a few minutes to complete.

If the MSE subsector does generate impacts of concern, then an **Environmental Impact Assessment (EIA)** must be performed for this enterprise before any assistance can be approved.[1] This is discussed below in the section on EIA for MSEs.

[1] Even though an enterprise belongs to a sector that generates environmental impacts of concern, its impacts may not necessarily require a full EIA. A provider may

If it is not known whether an MSE generates impacts of concern, it is necessary for the caseworker to notify the assistance provider's EO so that he/she may research this new subsector. The EO may need to consult with USAID mission staff as part of this research. The assistance provider should work with the MEO to determine if the EO needs to research every new subsector the provider encounters; they may decide that a minimum number of assistance requests from a new subsector is required before it must be classified. The provider also should determine if the caseworker must wait for a decision from the EO, or proceed with the screening as if the MSE does not have impacts of concern. It is very important to develop a process that does not ignore "unknown" subsectors. Otherwise, unusual assistance requests from MSEs with potentially significant adverse impacts may fail to be flagged for an EIA**.**

Figure 1



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choose to initiate a second level of screening to see if the impacts generated by the MSE merit a full EIA. This second screening would focus on the activities of the individual MSE to categorize the MSE's specific impacts and determine if they meet EIA thresholds. In practice, however, such a screening is unlikely to exempt MSEs, and may not offer significant time or cost savings over a full EIA.

If it is determined that the MSE does not generate impacts of concern, then it should be screened for known opportunities for cleaner production (CP). Most enterprises will offer opportunities with and without financial payback. If the MSE sector is known to offer CP opportunities with financial payback, then it is recommended that the assistance provider link a CP assessment with the assistance request. A CP assessment is not mandatory, but it will strongly support any other assistance activities because of its potential to improve financial performance.

If an MSE has unknown CP opportunities, it is recommended that the caseworker notify the provider's EO so that the EO may track that subsector and decide whether to conduct further research. The EO may need to consult with mission staff as part of this effort. Whether or not the screening process calls for a CP assessment, the requested assistance can be approved and processed once the CP screening step is completed.

Developing a Custom Screening Process

It is important to keep in mind that sound environmental design and implementation should be tailored to the local conditions of each project. A particular activity that is environmentally harmful in one instance may be helpful in another. Thus, assistance providers will wish to develop a customized screening process to suit their clientele and operating conditions.

Sound environmental design and implementation should be tailored to local conditions. An activity that is environmentally harmful in one instance may be helpful in another.

What if these guidelines don't make sense for my organization?

The guidelines recognize that credit and BDS providers operate under diverse service models. Each individual organization has a particular focus and set of capabilities that make wholesale implementation of any general guidelines unwise. Furthermore, these organizations work with large numbers of clients, and these clients vary enormously in terms of their business profiles and their potential for successfully adopting new approaches to doing business (including environmentally sound approaches). Credit and BDS providers are thus encouraged, and expected, to work with USAID to adapt USAID's criteria, procedures and forms to meet their own situations. For example, they should:

- look at common mitigation or CP opportunities for the kind of clients they most frequently work with and try to judge how feasible they are in terms of technical demands and cost;
- identify environmental technologies and processes with a high rate of return; and
- set screening thresholds to identify MSEs that will need to implement environmental measures in exchange for assistance.

How do I set threshold criteria for environmental performance?
As mentioned in the "Roles and Responsibilities" section, developing a screening process requires collaboration between the assistance provider and the mission (and in some cases the intermediate credit institution). The mission and the assistance provider should use these guidelines and the IEE as a basis for setting up a tailored screening process that suits both parties. These guidelines do not attempt to identify specific

In screening its applicants, a provider needs to consider how far giving a loan or business services to a commercial activity will contribute to a substantial environmental problem if the effects of the activity are not mitigated.

thresholds for deciding which sectors and what kinds of enterprises should be targeted for regulatory compliance and/or CP implementation. Each organization and program should set specific thresholds for its activities. Factors to consider in deciding on screening thresholds may include:

- The environmental risk presented by enterprises of a particular sector, in general;
- The extent to which a loan or BDS support to a business activity will contribute to a substantial environmental problem if the effects of the activity are not mitigated;
- The extent of opportunities for profitable CP;
- The size of the enterprise;
- The significance of the assistance being given to the enterprise (e.g., the size of the loan or the level of BDS support).

These guidelines offer several tools to aid assistance providers and missions in developing their own threshold criteria. To help them determine if an MSE generates damaging environmental impacts, Annex B includes a list that classifies a wide variety of MSEs according to the potential severity of their environmental impacts. Assistance providers may wish start with this list to select and categorize the MSEs with whom they work. Alternatively, they may wish to focus on only the highest-priority subsectors, such as those for which CP fact sheets have been prepared (see chapter 4). Assistance providers may also wish to check with local environmental regulatory agencies, which sometimes prepare their own lists of sectors of concern. [2]

Do I need to consider compliance (or lack thereof) with in-country environmental regulations?
BDS and credit providers should identify all relevant environmental regulations and municipal ordinances (including relevant zoning requirements, if any) that apply to the MSEs with which they work. These organizations should help their clients meet or exceed in-country standards.

To what extent should entrepreneurs, workers and communities be involved?
In customizing their environment review procedures (and in conducting EIAs), organizations may wish to set up an interactive appraisal process. This would involve working closely with enterprise owners/staff and affected communities, who are best suited to understanding and responding to MSE environmental issues. Doing so can result in the

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[2] For assistance providers that choose to screen individual enterprises, Annex C provides a sample MSE loan screening form which could also be adapted to suit BDS needs. This form is a comprehensive example of an enterprise-level screening form—likely to be used only for enterprises of a subsector known to present environmental impacts of concern. An assistance provider choosing to screen individual enterprises would need to develop its own, focused version of this form, along with appropriate decision-making criteria and procedures.

development of better understanding of the problems and constraints, as well as workable, creative solutions that gather support from all parties.

One such approach is known as Participatory Subsector Analysis (PSA). Under PSA, MSE community and organization members examine every stage of production or distribution for inefficiencies. This process can help stakeholders understand "a whole array of factors related to the production process, working environment, technology, resource use, and end use of waste."[3] Excellent reference works are available to provide guidance on PSA and other methods of involving the community in developing solutions to MSEs' environmental problems.[4]

It should be noted that while stakeholder involvement can lead to higher project success rates, it can also come with high transaction costs. That is, it can require much more investment of time and resources per project than other approaches because of the give-and-take involved. Support and credit organizations for MSEs have to balance these transaction costs with the need for location-specific information and stakeholder buy-in. For example, it is unrealistic and imprudent to expect assistance providers to perform an assessment and obtain stakeholder participation for the smallest individual MSE loans.

For the smallest loans, it is recommended that providers rely upon standardized tools as starting points. Stakeholder participation is perhaps most useful in helping providers set up standard screening protocols and to process MSE assistance requests that will require an EIA.

Participatory Subsector Analysis: Pros and Cons

To customize their screening processes, assistance providers may decide to conduct a Participatory Subsector Analysis (PSA). Under PSA, MSE community members and provider staff look closely at every stage of production or distribution for inefficiencies. This can lead to

- better understanding of the firms' problems and constraints
- workable, creative solutions that gather support from all parties

On the other hand, because of the give-and-take involved, it can require

- much more time and resources per project than other approaches

For the smallest loans, providers should probably start with standardized assessment tools.

Environmental Impact Assessment for MSEs

The purpose of any EIA is to identify and mitigate environmental impacts, preferably during the design phase of the project. This is also the goal of EIA for MSEs, but the small scale of most MSE assistance projects places serious limitations on its scope. Because of the low cost of individual MSE assistance activities, EIAs must be inexpensive to complete and, when possible, offer mitigation strategies that are also inexpensive or offer financial benefits to the MSE. A suggested EIA procedure for MSEs is shown in Figure 2, next page.

Once the initial screening process has shown that the MSE requesting assistance belongs to a subsector with problematic environmental impacts, the assistance provider and MSE must work together to develop a mitigation and monitoring plan (MMP) to address the MSE's specific impacts. This MSE cannot receive assistance until the MMP is in place.

EIA begins by identifying the specific environmental impacts generated by the MSE. Once the impacts are identified, they must be assessed to determine if mitigation is required. For each impact that requires mitigation, a mitigation option must be selected. As discussed in Chapter 2, these can be CP options, pollution control options, or some

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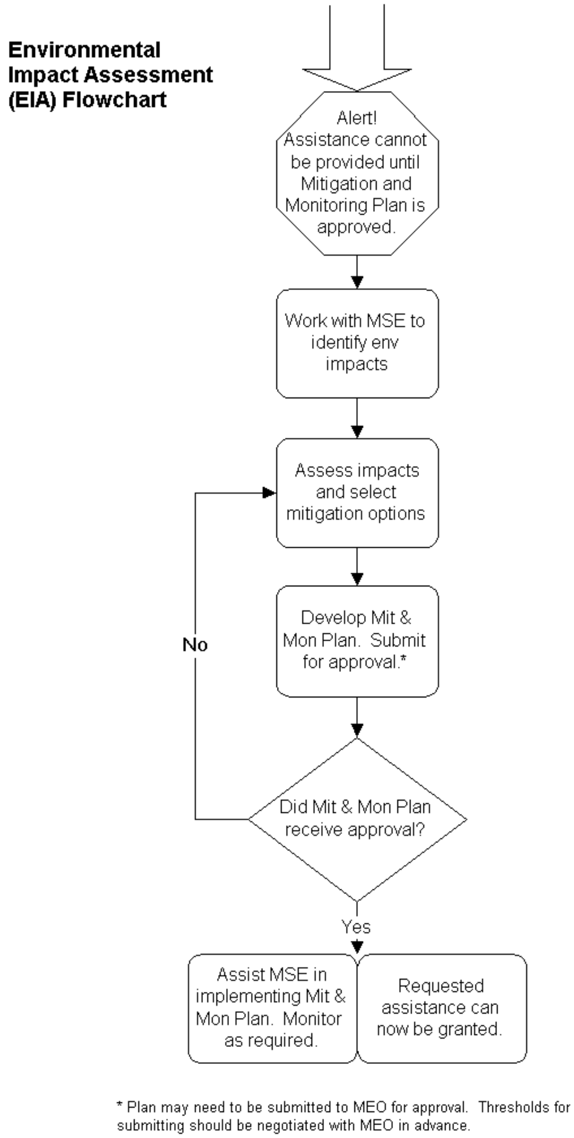
[3] Srinivas and Pallen 1998.

[4] e.g., Srinivas and Pallen, Pallen.

Figure 2



Because most MSE assistance projects are so small, EIAs must be inexpensive to complete and, when possible, offer mitigation strategies that are also inexpensive or offer financial benefits to the MSE.

combination of the two. The mitigation strategy must ensure that the impacts are reduced to required levels, regardless of financial payback.

The selected options should be then formally written down as an MMP. This plan must be approved by the assistance provider's EO or, if necessary, the mission, before implementing the mitigation strategies. Assistance is contingent on approval. Although the assistance provider may internally process the assistance request, it cannot give any credit, training, or other assistance until the MMP has been approved.

Once the MMP is approved and the assistance begins, the provider must aid the MSE in implementing the plan. The MMP may specify that monitoring is to be performed by either the MSE or the assistance provider. In either case, it is recommended that the provider perform some monitoring or oversight of the MSE's compliance with the MMP.

Guidance for Writing Mitigation and Monitoring Plans

Guidance for choosing mitigation strategies is covered in Chapters 2 and 4 of this section of the *Guidelines*. Chapter 2 introduced pollution control and CP mitigation strategies for MSEs. Chapter 4 describes various mitigation strategies for specific MSE subsectors known to have both significant environmental impacts and CP opportunities. In addition to the guidance provided in these chapters, there are two other topics to be considered when preparing MMPs.

First, assistance providers often work with MSEs in the same or related subsectors. Thus the types of impacts they generate and the preferred mitigation strategies may be consistent from project to project. If so, assistance providers may choose to create templates for MMPs. These templates would reduce the cost and decrease the time required to create them. Using consistent MMPs may help providers to "fast-track" similar projects through the approval process, and a small number of templates may serve to cover the majority of MSE projects requiring mitigation. These templates should be approved by the USAID mission, and input from the micro-entrepreneurs, their employees, and their communities should be used when drafting specific MMPs from the templates.

Second, even if the types of projects or MSEs it works with are too varied for the provider to use templates for MMPs, many may be common to all MMPs. Good practices that can be followed, in varying degrees, by a wide variety of micro-enterprises[5] include:

Work Space Organization and Storage Strategies

- ✓ Rearrange work space to reduce risks, improve efficiency, and make it easier to keep the space orderly and clean.
- ✓ Use pans and screens to prevent deposits of oil, liquid wastes or water from accumulating on the surrounding floors.
- ✓ Keep work areas clean, remove all rubbish from the work space, and situate receptacles for waste and debris in convenient places.
- ✓ Never use gasoline to clean things.
- ✓ Ensure that there is proper ventilation for indoor operations.
- ✓ Install proper lighting.
- ✓ Set aside special areas for storing raw materials, finished products, tools and accessories..
- ✓ Keep hazardous products away from wells, springs and other water sites

Advantages of Templates for MSEs' Mitigation and Monitoring Plans

If assistance providers work with many MSEs in the same few sectors, they may find it helpful to create templates for mitigation and monitoring plans (MMPs). Using templates, providers may:

- shrink the cost and the time needed to create MMPs.
- be able to "fast-track" similar projects through the approval process

A small number of templates may cover most MSE projects requiring mitigation.

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[5] Sources: Srinivas and Pallen 1998, citing multiple sources.

- ✓ Store flammable products away from all sources of heat or ignition. Remember that heat sources include electrical appliances, engines and motors.
- ✓ Store toxic substances out of the reach of children and animals. If possible, place them in a separate locked cabinet or other secure structure.
- ✓ Keep hazardous materials in plastic containers (preferably the original containers) with tight-fitting lids. If the product is in a rusting metal or breakable container, the container should be placed within a larger plastic container with a tight-fitting lid. Clearly label the outside container with the contents and date. This label should be in a language, or use signs, understandable to people in or near the workplace.
- ✓ In home-based enterprises and farming communities, keep toxic materials away from food supplies.
- ✓ Designate specific places for handling and storing effluents and waste materials.
- ✓ Avoid using newspapers and other flammable material for packing.
- ✓ Never throw away or bury wastes in or around abandoned wells.

Worker Protection Strategies

- ✓ Assess any health and safety risks to workers from dust, fumes, odors or pollutants.
- ✓ To prepare for possible poisoning, keep clean water nearby and tell co-workers what sort of chemicals or pesticides you are using and where the labels are.
- ✓ If someone inhales pesticides or toxic chemicals, get workers to fresh air immediately.
- ✓ Shorten work periods and provide enough rest breaks to eliminate accidents caused by fatigue and to reduce health risks and annoyances caused by excessive machinery noise and vibration.
- ✓ Reduce the potential for injury by taking into account the physical differences between workers, including height, strength, and ability to handle mental stress.
- ✓ Ensure that workers use proper protective equipment, especially when toxic substances are involved.
- ✓ Ban smoking and drinking on the job.

Tips on Monitoring Programs

- EIA monitoring should be integrated into existing monitoring programs.
- Choose relevant indicators for monitoring.
- Link monitoring to employees' activities and reviews.
- Work with partners to maximize resources and expertise.
- Monitoring can be intermittent and based on a sample.
- Cleaner production can reduce monitoring costs.

✓ Insist that workers wash thoroughly after handling dangerous or poisonous substances and wash before eating, drinking or smoking as well as after using the toilet.

Monitoring Techniques and Guidance

Monitoring is the last step in the EIA process. Historically, poor performance monitoring has plagued attempts to fundamentally integrate environmental assessment into development agencies' daily activities. Yet little real change or learning on the part of either MSEs or providers occurs without effective performance monitoring systems and follow-up.

Furthermore, performance monitoring is typically *required* of private voluntary organizations (PVOs) as part of the Initial Environmental Evaluation (IEE) that ensures that a project will comply with USAID Regulation 216. Such monitoring is useful to USAID and assistance providers for several reasons:

- It shows whether, and to what extent, PVO staff are actually implementing guidelines;
- It ensures individual responsibility and accountability for implementing specific parts of the guidelines;
- It provides mechanisms for reminding PVO staff to implement guidelines (such as checklists that must be filled out for every loan);
- It provides feedback on whether environmental and economic objectives are being achieved, whether such objectives/priorities should be revised, whether mitigation techniques (including CP) work, the actual cost of such mitigation techniques, the effectiveness of partner organizations, and how guidelines might be improved;
- It ensures that mitigation measures are actually carried out by MSEs, particularly those that might otherwise cause significant environmental harm;
- It provides justification to managers and staff for the resources spent on such activities; and
- It reveals when training is needed to improve performance.

Monitoring Tools

Performance monitoring typically involves using checklists and forms that staff fill out to indicate the activities they have conducted, mitigation measures they have taken, monitoring they have carried out, follow-up actions that are needed, and the results of these activities. Table 1 (next page) provides a monitoring overview template that BDS and credit organizations could revise, based on the program monitoring that they already conduct and on the screening and EIA processes that they develop.

Example of Performance Measures/Indicators

- Was the client aware of environmental impacts prior to contact with credit or support agency?
- Does the customer understand the cost implications of pollution?
- Has the customer evaluated pollution prevention opportunities?
- Did the MSE sign the form committing to environmental mitigation techniques?
- How many mitigation techniques were agreed upon?
- How many mitigation techniques were completed within one month of agreement? Three months? Six months?
- Did staff follow up with MSE within one month/three months/six months?
- What was the environmental/health impact of the mitigation measures? (Acquiring pre-mitigation baseline data can be particularly useful in this regard.)
- What was the cost impact of implementing these measures?
- What is the percentage of staff from direct credit providers who have received environmental training?
- What is the percentage of loans that follow environmental criteria?
- What is the average repayment rate for loans that follow environmental criteria vs. that of other loans?

Table 1. Sample Impact, Mitigation and Performance Monitoring Matrix

Adverse impact	Mitigation technique	Expected cost / impact	Responsibility for informing/ training the MSE and date completed	Responsibility for ensuring that mitigation technique is completed and date completed	Outcome of mitigation technique (e.g., money saved/adverse impacts avoided) and other comments

Other monitoring tools and techniques include:

- Checklists or tables filled out by caseworkers (e.g., loan reviewer, trainer) as they complete activities;
- Pre- and post-application forms, with information provided by MSE owners/managers;
- Interviews with plant personnel, neighbors and/or municipal authorities;
- Inspections of a company's activities;
- Air and water sampling; and
- Splitting development assistance into segments—the MSE must perform mitigation properly for one segment before it can receive the next segment.

Guidance for Monitoring Programs

In setting up overall monitoring programs, consider the following suggestions and observations:

Cleaner production can reduce monitoring burdens. Using CP as the primary mitigation strategy can help reduce the need for monitoring MSEs and thus the costs. Because CP approaches are integrated into a business' production process, a business is much more likely to continue to use them even when oversight is lacking.

Integrate with existing monitoring mechanisms. Assistance providers should strive to keep monitoring mechanisms short and practical. New environmental performance measures should be integrated, to the greatest extent possible, with existing performance monitoring. For example, a section on environmental issues can be added to reports that staff must fill out when processing loans. This will help ensure that the issues are not overlooked, that it appears as less of an additional burden to staff, and that an information collection system is already in place.

Choose relevant indicators. The box on the previous page gives examples of both external and internal performance measures and indicators. Providers should identify indicators most useful to them.

Link monitoring to employee activities. Performance monitoring systems can be most effective when responsibilities and timelines for specific actions and mitigation measures are clearly specified. Assistance providers, for example, might revise job descriptions or work plans for caseworkers to specifically state that the provider will review caseworkers' performance to see whether they have ensured that environmental screening procedures were followed and that essential environmental mitigation steps were implemented.

Work with partners. When appropriate, work with partners to implement monitoring programs. Doing so may reduce monitoring costs. (See guidance below on partnering.)

Monitoring doesn't have to be continuous. Necessary oversight of MSEs could be accomplished efficiently through periodic, statistically significant sampling of all MSEs served.

Incorporate monitoring into reports to USAID. MSE development organizations may wish to use oversight mechanisms such as checklists to help in preparing annual reports to USAID, which are currently required by USAID's policy on microenterprise development. The monitoring activities may also be integrated with other kinds of monitoring conducted as part of USAID's Assessing the Impacts of Microenterprise Services (AIMS) project. This project has created and disseminated a set of low-cost tools for impact assessment, some qualitative, some quantitative.[6] MSE development organizations may also consider integrating environmental performance monitoring systems into the system of evaluation tools created and provided by the SEEP Network.[7]

Table 2. Benefits of Cleaner Production

Monetary Benefits	**Other Benefits**
Increases profitability through reduced input materials and energy costs	Reduces long-term liabilities
Improves product quality	Improves worker health and safety; reduces accident risks
Increases throughput	Reduces environmental pollution and resource degradation
Avoids regulatory and compliance costs	Improves company image to community and customers
	Increases competitive advantage

[6] More information on current performance evaluation tools for microenterprise development is available at www.mip.org, the Web site of USAID's Microenterprise Innovation Project.

[7] According to its Web site, "The Small Enterprise Education and Promotion (SEEP) Network is an association of more than 56 North American private and voluntary

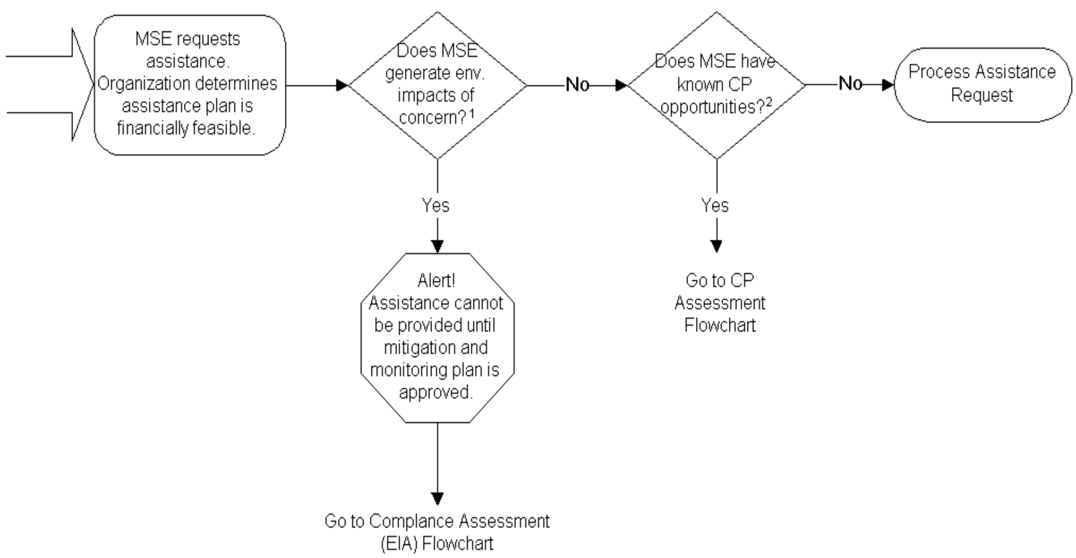
Cleaner Production (CP) Assessments for MSEs

As a reminder from chapter 2, Cleaner Production (CP) is a problem-solving strategy that uses a collection of analytic tools to improve the efficiency of production processes and improve profitability. It is a business-focused, profit-driven approach that can be transparently integrated into a business planning process. It is relevant to all sizes of enterprises, from home-based to multinational. Some of the benefits of CP are summarized in Table 2 (previous page).

CP assessments for MSEs follow an approach similar to EIAs, as shown in the following flowchart (Figure 3). However, where an EIA's focus is on finding and mitigating environmental impacts, CP assessments for MSEs will typically focus on improving MSEs' profitability by reducing waste and using input materials and energy more efficiently.

Figure 3

Suggested Environmental Screening Process for MSE Assistance Requests



1 Staff of assistance providers should be able to make this determination quickly by referencing a list of MSE sectors chosen as having environmental impacts of concern. This list will be developed in colloboration/negotiation with MEO. If it is unknown whether an MSE subsector generates environmental impacts of concern, it is necessary to notify the Organization's EO so that he/she may reseach this subsector and/or consult with the Mission. Each organization must set an internal policy as to whether this question must be answered before the assistance request can be approved.

2 It is expected that staff of assistance providers make this determination quickly by referencing a list of MSE sectors chosen as having significant CP opportunities. Assistance Providers will generate this list internally based on institutional knowledge and tools provided in these guidelines. If it is unknown whether an MSE has known CP opportunities or the opportunities do not offer significant financial payback, the organization must set an internal policy as to how to proceed. At a minimum, the EO should be notified so that he/she may research this subsector. It is recommended that a CP assessment be performed whenever technically and financially feasible.

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organizations which support micro- and small enterprise programs in the developing world." More information can be found at www.seepnetwork.org.

Another important difference is the timing of assistance approval. Assistance cannot be provided until the completion of the EIA, if required under regulations. CP assessments, on the other hand, are not ordinarily a regulatory requirement. Therefore, the assistance provider can determine whether to (a) require a CP assessment before granting assistance, or (b) incorporate CP into the assistance itself. [8]

CP assessments for MSEs will typically focus on improving their profitability by reducing waste and using input materials and energy more efficiently.

It is often wise for the MSE to perform a CP assessment before providing the assistance. For example, if a loan is requested for new production equipment (boilers, vats, dryers, etc.), it may make more sense to wait until after the CP assessment has identified cost savings with the existing equipment or the most efficient new production equipment before granting the loan. On the other hand, if the request is for management training, it may make sense to integrate CP concepts into the training. The assistance provider is free to approve and implement the requested assistance as best suits each situation. Table 3 below summarizes the similarities and differences between EIAs and CP assessments

.

Table 3. Comparison of EIAs and CP Assessments

	EIAs	CP Assessments
Process Steps	Identify environ-mental impacts, assess impacts, select mitigation options and create Mitigation and Monitoring Plan (MMP), implement MMP, monitor as required	Identify problems and opportunities, prioritize, implement, monitor/evaluate, and seek additional opportunities
Timing of assistance approval	Because EIA is a regulatory requirement, assistance cannot be provided until the EIA process is complete	CP assessment is not ordinarily a regulatory require-ment, therefore the assistance provider can decide whether to (a) require a CP assessment before granting assistance, or (b) incorporate CP into the assistance itself
Focus	Mitigation of environmental impacts	Improved profitability, which also reduces environmental impacts
Personnel	Personnel generally require more environmental expertise	Personnel generally require more busi-ness, accounting or process engineering expertise

[8] However, USAID recommends including CP assessments in the EIA process, to help determine the most cost-effective approach to mitigating adverse impacts. When CP assessments are part of the EIA process, the request for assistance cannot be granted until after the mitigation and monitoring plan is approved.

A CP assessment may need different personnel from those who conduct the EIA. The EIA typically requires more environmental expertise. CP assessments, on the other hand, require more skills in business and process engineering. (See section below on partnering with other organizations). Consequently, assistance providers may wish to create in-house CP assessment capacity. BDS providers, for example, may choose to train their field staff in CP assessment skills to complement their existing capabilities in accounting and technology selection. (See section below on training.)

It is important to note that many caseworkers may begin to implement CP even just with the basic understanding of CP presented here. In the beginning, however, partnering with CP specialists and/or providing CP training to staff may help accelerate its use.

Designing a CP Assessment Protocol

An assessment is a methodical examination and review of the MSE's business activities, ranging from production to accounting. The purpose of assessing is to carefully examine a facility's production processes and identify CP opportunities.

Although it can be helpful to have a CP expert perform the assessment, a layperson can also perform simple assessments with useful results. Many BDS and credit provider field staff who regularly visit their clients' places of business may have already performed tasks similar to a simple CP assessment.

A CP assessment will typically examine

- the condition of the facilities and equipment;
- the steps in the manufacturing process;
- production inputs, including energy, water, raw materials, and chemicals;
- waste and pollution created;
- waste disposal practices; and
- health and safety risks.

As discussed in Chapter 2, there are a variety of CP approaches to improved efficiency. It is important for a CP assessment to at least consider opportunities in each of these categories when evaluating an MSE. The checklist on the next page details these categories, and can be photocopied to help conduct field assessments.

Sample CP Assessment Checklist			
	Approach	**What to Consider**	**Field Notes**
☐	**1. Good Housekeeping**	Preventing leaks and spills, setting up preventive maintenance schedules, regularly checking equipment, making sure employees follow official work procedures.	
☐	**2. Input Substitution**	Substituting less expensive, less dangerous, or more efficient input material(s) for existing input material(s).	
☐	**3. Better Process Control**	Changing working procedures, instructions for operating machinery, and record-keeping about the production process to increase throughput, reduce waste, and/or improve product quality.	
☐	**4. Equipment Modification**	Altering the existing process equipment to increase throughput, reduce waste, and/or improve product quality.	
☐	**5. Technology Change**	Replacing the existing technology or changing the order of production steps to increase throughput, reduce waste, and/or improve product quality.	
☐	**6. Product Modification**	Changing the characteristics of a product to increase throughput, reduce waste, and/or improve product quality.	
☐	**7. Energy Efficiency**	Making changes in any aspect of business operations to reduce energy consumption or cost.	
☐	**8. Onsite Recovery and Reuse**	Capturing and reusing materials that were previously wasted.	
☐	**9. Waste-to-Product**	Identifying an end market and marketing a material formerly considered waste. May involve changes in processing of the original product or new processing steps to transform the waste.	

CP projects themselves generally fall into one of two classifications:

(1) **Projects requiring little investment.** Many CP opportunities that can be identified for MSEs fall into this category— these are “low-hanging fruit” that can have a significant impact on the efficiency of a MSE. In this case, the assistance provider is simply helping to identify CP opportunities while building capacity to identify and implement CP improvements.

(2) **Projects requiring capital investment.** CP opportunities that require an investment of capital must have a profitability assessment to see if they will be cost-effective. For this type of project, the assistance provider can help with the profitability assessment and may also help secure extra funds for the MSE for implementation.

Assistance providers will need to design their own assessment protocols (rules and procedures) to suit the needs of their staff and reflect the working conditions of the MSEs they assist. Assessment protocols can range from very simple ones (e.g, a checklist of items to identify while walking around a facility) to complex procedures and tools to examine and measure performance in a variety of ways (e.g., quantifying waste and comparing the amounts with those of similar facilities).

Case Study: Olive Oil Bottler (Lebanon)

A CP assessment performed at this facility revealed that a significant amount of olive oil was being wasted because of a reservoir that often over-flowed. The accounting records did not reflect the costs to the business from this loss, and therefore went the loss had gone uncorrected by management. For an investment of US $40 and two days of labor, the bottler realized a savings of about US $40,000 per year.

Assistance providers may also wish to partner with CP experts to assist in identifying CP opportunities. CP expertise is particularly useful for larger and more complex enterprises and when CP is first being explored for a particular type of enterprise.

A CP assessment may use a variety of different methodologies or approaches to make it easier for assistance providers—and MSEs themselves—to detect cost-saving opportunities. These guidelines offer a summary of two methodologies: (1) full cost accounting, and (2) process mapping. Both of these techniques are considered well suited to an MSE situation, and are easy to understand and integrate well with common managerial best practices.

Full Cost Accounting

Good managerial accounting practices are important for any firm to be able to identify opportunities to reduce costs. Too often, MSEs do not have an adequate accounting system even for the most basic functioning of the business. As assistance providers work with MSEs, part of a CP assessment will be to help them develop and/or improve their accounting system. Even micro-scale enterprises should have some sort of accounting system, however rudimentary. The adage “What gets measured gets managed” certainly applies to the search for opportunities to reduce wasted input materials and energy. Many MSEs know the total cost of their inputs, but not the total cost of waste and inefficiencies, nor are they aware of opportunities to reduce them. The box at left provides an example of how much it can benefit a business to identify these costs.

Full cost accounting takes standard managerial accounting a step further by revealing hidden and difficult-to-quantify costs that relate to material and energy use. This can reveal new areas where CP improvements can reduce waste. Full cost accounting is a technique that (1) identifies costs which are either misallocated as overhead costs or not otherwise accounted for at all in the present system and (2) allocates them to the appropriate business process, making inefficiencies more apparent. For example, accounting records may track raw materials used and final product shipped, but not the amount of scrap waste generated; overlooking waste generation will lead the MSE to ignore potentially cost-saving measures. Other types of costs that may not be accounted for include lost sales from returned products, equipment that must be replaced because of poor maintenance, and future depreciation of new waste-treatment equipment.

To properly identify and allocate previously unidentified sources of waste and inefficiency, full cost accounting uses

- data from the accounting system (general ledger);
- data records from various departments;
- data on activity-based costs such as labor and regulatory compliance, non-product outputs, and process losses; and
- information from colleagues and employees.

In some cases, an MSE may wish to supplement these records with data from its industry, vendors, consultants, business partners, or government. These data may only be estimates of the actual cost. Even so, they can dispute incorrect assumptions about the true costs of doing business for the MSE, and indicate where opportunities for efficiency lie.

Full cost accounting takes standard managerial accounting a step further by revealing hidden and difficult-to-quantify costs that relate to material and energy use. This can reveal new areas where CP improvements can reduce waste.

For projects that require a capital investment, full cost accounting principles can help provide a more accurate picture of the profitability of the investment by including cost savings from CP that are ignored during traditional profitability assessments. The following four elements of full cost accounting help bring more accurate data to the analysis:

- Its inventory of costs, savings and revenues includes hidden, indirect and less tangible items typically omitted from project analysis.
- It directly allocates costs and savings to specific processes, products and activities instead of pooling them in overhead accounts.
- It extends time horizons for calculating profitability to capture longer-term benefits.
- It uses profitability indicators capable of incorporating the time value of money and long-term costs and savings.

For more details on using full cost accounting to identify CP opportunities, see "Total Cost Assessment Guidelines (DRAFT)," Environment Canada, June 1997, section 7.[9]
http://www.emawebsite.org/library_detail.asp?record=2

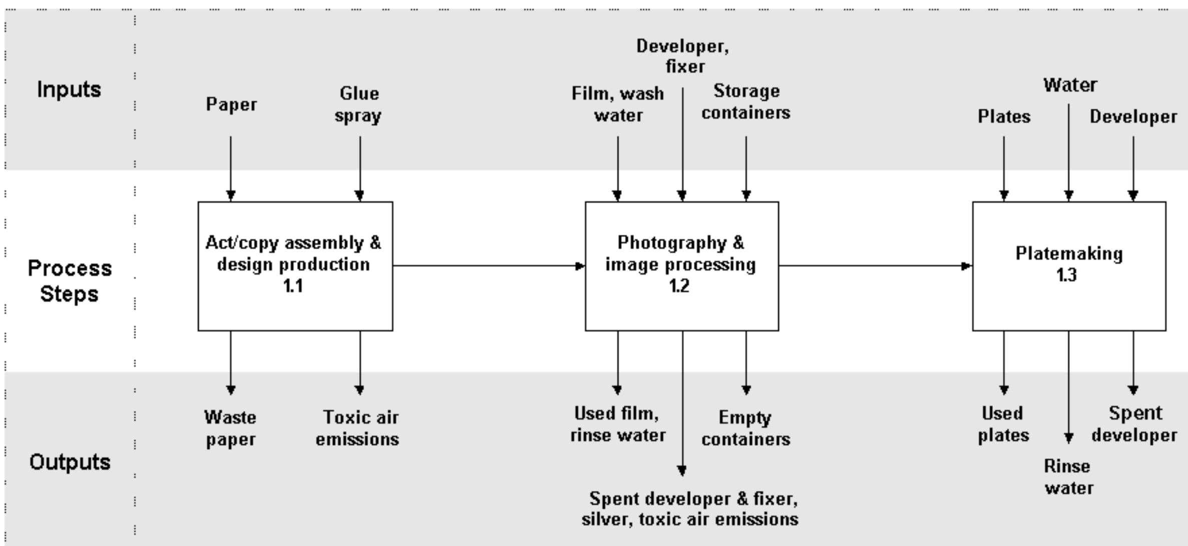
[9] Full cost accounting is often referred to as total cost accounting, total cost assessment or environmental management accounting.

Process mapping

Process mapping is a structured approach to understanding and assessing a facility's activities. It is used to make relationships in a production process visible and to help people to find efficiency improvements that span different process steps.

Often, personnel do not have a good understanding of aspects of the business different from their own. Thus a process map should be constructed collaboratively by various employees from a business in order to capture (1) the important interrelationships between various operations and (2) the cost and waste implications of each. A sample process map for a lithographic printer appears below (Figure 4).

Figure 4: Sample Process Mapping for Lithographic Printer



Here are some key guidelines for making a process map:

- The various stages in production appear chronologically from left to right.
- Initial process maps should aim at simplicity; more detailed maps can be generated later.
- Input materials and energy for each step are depicted as arrows entering from the top.
- Waste and emissions are depicted as arrows exiting from the bottom.

Process maps can depict the entire process, a series of sub-processes, or an ancillary or intermittent process. For example, the process map above shows the inputs (coming from above) and outputs (exiting below) for the steps in the prepress process for lithographic printing. Using this type of approach, it is easy to identify common inputs and consolidate similar inputs like chemicals. It is also easier to identify inefficiently used inputs (e.g., material that is lost as waste, scrap or pollution). A process map can be used as a visual aid when identifying potential efficiency improvements though the use of the "CP Approaches" checklist above. The box at right presents an example of how process mapping helped identify and resolve a costly inefficiency.

Process maps can also help to allocate costs accurately for full cost accounting. Material flow quantities can be added to a process map to help determine what fraction of input materials ends up as waste. Cost information can then be added, based on these quantities. In this way, the process map helps to give owners and managers a framework for approaching their business from a "systems" perspective.

Additional information on process mapping can be found in Pojasek 1997.

Case Study: Printing and Laminating Company (Zimbabwe)

This business prints and laminates film for the food packaging industry (e.g., potato chip bags). During a CP assessment, the staff generated a process map and noted on it the value of the lost materials associated with operations (e.g., resulting from printing errors). The CP team noticed that the cost of lost materials was significant, and that one cause of loss was the delay between the development of a printing problem and the problem's being detected.

The company decided to make a CP investment in a quality control camera at a cost of about US $100,000. The annual cost savings from reduced material waste was about US $40,000 per year.

Building an Organization's Environmental Capacity

In responding to these guidelines, BDS and credit institutions may find that they (or the MSEs that they work with) do not have all the skills or tools on hand to be able to effectively integrate environmental concerns into their daily operations right away. To address this capacity gap, BDS and credit providers may wish to consider training opportunities, partnering possibilities, and available tools and templates on which they can model their own screening and compliance materials.

Training for BDS and Credit Institutions

Proper implementation of environmental guidelines may require training for staff of organizations assisting in the development of MSEs, as well as for MSE owners, managers, and employees. Training may be available from private consultants, NGOs, national Cleaner Production centers, government agencies or international aid agencies. One example is the training available from the GTZ, the German development agency. Its Pilot Programme for the Promotion of Environmental Management in the Private Sector of Developing Countries (P3U) provides training in general and subsector-specific "good housekeeping" measures that MSEs can use to mitigate their environmental impacts, focusing upon those measures that require only a modest amount of time or money to implement. The box on the next page describes another example—a cleaner production training specifically designed to increase the value BDS staff provide to their clients. Similar training courses could be targeted specifically for credit providers.

Ideally, environmental training for BDS providers and credit organizations should include information about the following topics:

- General facts about MSEs and the occupational health and environmental issues associated with them.

- CP approaches and tools, particularly focusing on the business benefits to clients.
- Clean technologies and methods for preventing and mitigating adverse environmental impacts.
- Use of environmental screening, guided questions, and classification procedures in the environmental review of MSEs. Ideally, the specific procedures and tools used in environmental screening, EIA and CP assessment would be developed by the assistance provider before the training.

USAID partners may also wish to develop informational materials, outlining impacts and mitigation options, for use in particular subsectors of concern to their operations in specific geographic areas. The CP fact sheets in Chapter 4 illustrate the type of subsector-specific materials that staff may find useful.

These guidelines recognize that BDS and credit providers are best placed to determine how to convey environmental and/or cleaner production information to client MSEs. However, providers may wish to consider using direct MSE training materials developed by other organizations.

Training BDS Staff in Cleaner Production

In Mozambique in July 2002, BDS provider TechnoServe offered a new, three-day training course to professionals from its own and other service and credit organizations.

The USAID-funded course, "Improving Micro and Small Enterprise Success Rates through Cleaner Production," oriented these professionals to the cost-saving and other business opportunities associated with cleaner production. It helped them identify ways in which they are already promoting some aspects of cleaner production, helped them begin to develop skills in identifying cleaner production opportunities, and encouraged them to effectively and efficiently integrate cleaner production thinking and environmental regulatory compliance into their everyday operations.

This well-received course is likely to be offered again in the future. In addition, a CD-ROM of the training materials is available from Tellus Institute, the lead trainer (CP@tellus.org). The training materials may also soon be available online at the ENCAP Web site (www.encapafrica.org) .

Partnering with other organizations

These guidelines should help to make environmental review procedures and CP an integral part of all MSE support and credit activities. However, as noted above, BDS and credit providers may not always have the in-house expertise and/or resources to carry out every one of the guidelines' elements, particularly if they wish to extensively customize the guidelines.

Moreover, the guidelines are intended to allow MSE development organizations to continue to focus on their primary missions. (In fact, if properly implemented, these practices should help these organizations achieve their development goals by improving short- and long-run economic outcomes.) The organizations may wish to consider developing partnerships to maximize expertise and results, particularly until their own internal competency in environmental issues is well developed.

Partners might conduct EIAs or CP assessments of targeted enterprises, help prepare materials for trainings, oversee implementation of mitigation measures by MSEs, or conduct environmental evaluations of credit applications. For example, credit organizations may wish to partner with specialized technical consultants to provide their staff with environmental/CP training and/or train targeted clients in proper environmental procedures or CP methods. BDS and credit providers may already be partnering with such consultants to obtain other management training skills, making this a relatively easy add-on.

Potential partners include environmental NGOs; community groups; private consultants; technical organizations, such as National Cleaner Production Centers; local, regional or national environmental regulatory agencies; trade associations; universities; scientific/research programs; or other even other BDS/credit providers that have developed more advanced environmental integration strategies. Their appropriateness depends on the organizations' particular qualifications, resources, and/or mandates. Working with these organizations can help providers integrate these activities into their internal structure and make them more sustainable in the local context. The box at right gives an example of how working with a trade association may be beneficial.

Tools for BDS and credit providers

As mentioned above, these guidelines present several tools to help providers with screening, mitigation, and monitoring.

First, the sample program-level screening form in **Annex A** will help identify proposed programs which USAID Regulation 216 might not allow or for which it might require mitigation. However, Regulation 216 does not directly address many of the activities undertaken by MSEs that may damage the environment—nor does it raise awareness of many cleaner production opportunities that could cost-effectively mitigate those impacts and improve the financial viability of enterprises.

Annexes B and C are designed to help users of these guidelines identify potentially damaging enterprises that are not expressly covered under Regulation 216, and to focus in on critical adverse impacts and a more complete range of mitigation opportunities.

- To help readers orient themselves, **Annex B** lists dozens of types of enterprises that commonly receive development assistance and divides them into three groups: (1) those that are expected to have beneficial impacts on the environment, (2) those expected to have minimal adverse environmental effects, and (3) those that are expected to have potentially significant adverse effects. Some BDS and credit providers will likely wish to develop much more targeted lists for subsectoral screening purposes, depending upon the types of enterprises with which they work frequently and about which more information is available. For instance, BDS and credit providers could focus most screening activities upon types of MSEs covered in the Cleaner Production Fact Sheets (see below).

- For those BDS and credit providers that wish to conduct a more detailed screening, **Annex C** provides a sample enterprise-specific questionnaire. Only knowing the category that the enterprise belongs to may not be enough for providers to fully understand the scope and scale of its potential environmental impacts. Several important enterprise-specific factors may also need to be considered, including the nature of the proposed activities and their magnitude, location, duration of impact, environmental context, and political, social and economic importance. Helping MSEs fill out a screening questionnaire helps providers to conduct this second level of screening, which they may wish to reserve for unusual cases, given the additional resources required to conduct such an assessment.

Trade Associations Promoting Environmental Action

In the past, trade associations have played a substantial role in helping mitigate environmental damage—such as by organizing participation in common waste treatment schemes or self-regulatory approaches. For example, the Kenya Flower Council (an association of flower growers) has been instrumental in developing and promoting a self-regulatory environmental standard.

Such self-regulatory approaches might be particularly viable options when MSEs are linked to international markets that seek assurances about the sustainability profile of their producers. For example, certain industries—such as electronics and automotive manufacturing—are increasingly requiring their suppliers to be registered to ISO 14001, an industry-developed international standard for environmental management systems (EMS). In the last two years, both Ford and IBM have begun requiring their suppliers to be registered. Likewise, international standards exist for sustainable fisheries and agriculture. Experts are now beginning to focus on developing EMSs for small enterprises.

Support and credit organizations should be careful, however, before investing resources in promoting such paths, because many observers have questioned the effectiveness of these approaches. Practitioners should ensure that MSEs' initial costs for setting up management systems do not overwhelm the benefits and that environmental goals could not be accomplished otherwise.

In addition, they should try to ensure that trade associations are acting in good faith and that mechanisms can be developed to help guard against free riders (i.e., companies that participate only for the benefits and do not actually change their environmental impact).

In addition, the **Cleaner Production Fact Sheets** may be used to generate screening lists and help caseworkers better understand the environmental impacts and mitigation opportunities associated with certain different kinds of MSEs. These fact sheets, presented in Chapter 4, highlight relatively simple and straightforward techniques for mitigating many of the most serious adverse impacts from specific MSE subsectors, focusing primarily on cost-effective CP strategies. Fact sheets are available for the following subsectors: brick and tile production; leather processing; small-scale mining; food processing; metalworking; wood processing and furniture making; and wet textile operations. The subsectors are chosen based upon several considerations, including their importance to the African MSE economy, their individual or cumulative adverse impact on the environment and workers' health, and the perceived extent to which USAID funding is currently assisting MSEs in the subsector and could potentially help mitigate adverse impacts. In addition, each fact sheet offers a substantial, annotated list of resources for those organizations seeking more information.

Annexes D and E provide supplemental tools to assist BDS and credit providers in improving MSEs' environmental performance. **Annex D** is a sample Environmental Commitment Statement for MSEs. Assistance providers may wish to obtain such mitigation commitments from applicants whose activities are likely to have impacts of concern. **Annex E** provides sample terms of reference that may be modified when hiring environmental consultants.

Chapter 4

Subsector-Specific Cleaner Production Briefings

Contents

Introduction	4-1
4.1 Brick and Tile Production	4-3
4.2 Food Processing	4-11
4.3 Leather Processing	4-23
4.4 Metal Finishing	4-33
4.5 Small-Scale Mining	4-51
4.6 Wet Textile Operations	4-65
4.7 Wood Processing	4-75

This section offers tools that may be useful in evaluating micro- and small enterprises' (MSEs') environmental impacts and mitigation opportunities—emphasizing financially viable cleaner production (CP) opportunities.

These briefings have been prepared for (1) **business development services (BDS) providers**, which offer services such as management training or marketing support to MSEs, and (2) **intermediate credit institutions (ICIs)** and **direct lenders** that provide financial credit to MSEs. They are intended to be used in concert with other sections in Part III of the *Environmental Guidelines for Small-Scale Activities in Africa: Environmentally Sound Design for Planning and Implementing Development Activities,* which is USAID Africa Bureau's principal source of sector-specific environmental guidance. Part III discusses specific problems, strategies, tools and benefits of dealing proactively with MSEs' potential negative impacts on the environment and health. Other chapters in the *Guidelines* may also be of help and are referred to as appropriate.

This section presents briefings for seven subsectors that generate significant adverse environmental impacts and/or present numerous **cleaner production** opportunities[1] for cost savings. The subsectors covered are:

a. Brick and tile manufacturing
b. Food processing
c. Leather processing
d. Metal finishing
e. Mining
f. Wet textile operations
g. Wood processing and furniture making

These are by no means the only MSE sectors in need of environmental assessment and mitigation. Nor do these briefings present all possible impacts or CP opportunities. These fact sheets should be used, rather, as a starting point for an environmental audit, and are designed for use by individuals without extensive environmental training. BDS and credit organizations may want to extend these briefings to capture institutional and field experience as suits their needs. They may also wish to create similar fact sheets for other commonly supported subsectors.

Cleaner production (CP) options with clear financial benefits will be easier to find in some firms than others. Even when they use CP methods, some businesses may need to use pollution controls or other solutions offering no financial return if regulations or community relations require it.

The fact sheets focus on CP as the preferred mitigation strategy. In addition to environmental, health and safety benefits, many cleaner production techniques provide opportunities to substantially reduce operating costs and improve product quality. MSEs can profit from cleaner production through more efficient use of inputs and machinery, higher quality, and reduced waste disposal costs. Improved safety measures can also help MSEs avoid costly accidents and worker absences.

Experience has demonstrated that, with assistance, MSEs can often identify cleaner production opportunities that produce a positive financial return, sometimes with little or no investment. Many enterprises that change to CP methods may realize substantial financial and environmental benefits, indicating that CP should be the first option considered in addressing MSEs' environmental problems.

Although this approach can offer tremendous advantages, readers should also recognize that cleaner production options showing clear financial benefit will be easier to find in some enterprises than in others. Often they may not completely mitigate environmental problems. In some cases, even when pursuing cleaner production techniques, some businesses may need to use pollution control or other solutions that offer no measurable financial return—if such solutions are required by USAID's Regulation 216, local regulations, or other reasons such as community goodwill. To some extent, these fact sheets offer pollution control suggestions that supplement or complement cleaner production suggestions.

[1] See Chapter 2 of this section (Part II of the *Environmental Guidelines)* for a background discussion of cleaner production (CP) and CP opportunities for MSEs.

Chapter 4.1
Brick and Tile Production: Cleaner Production Fact Sheet and Resource Guide

Purpose

This fact sheet offers basic information on the important adverse environmental impacts of brick and tile production, as well as associated health and safety impacts. It also discusses opportunities for mitigating those impacts, with an emphasis upon "cleaner production" strategies that may also provide financial benefits to micro- and small enterprises (MSEs). In addition, each fact sheet offers a substantial, annotated list of resources for those organizations seeking more information.[2]

This fact sheet has been prepared for (1) **business development services (BDS) providers**, which offer services such as management training or marketing support to MSEs, and (2) **intermediate credit institutions (ICIs)** and **direct lenders** that provide financial credit to MSEs. It is intended to be used in concert with other sections in Part III of the *Environmental Guidelines for Small-Scale Activities in Africa: Environmentally Sound Design for Planning and Implementing Development Activities,* which is USAID Africa Bureau's principal source of sector-specific environmental guidance.

Why Focus on Cleaner Production for Mitigation?

Cleaner production (CP) is a preventive business strategy designed to conserve resources, mitigate risks to humans and the environment, and promote greater overall efficiency through improved production techniques and technologies. Cleaner production methods may include:

- substituting different materials
- modifying processes
- upgrading equipment
- redesigning products

In addition to environmental, health and safety benefits, many cleaner production techniques provide opportunities to substantially reduce operating costs and improve product quality. MSEs can profit from CP through more efficient use of inputs and machinery, higher-quality goods that command higher prices, and reduced waste disposal costs. Improved

[2] At the time of writing, USAID cleaner production fact sheets are available for the following subsectors that are likely to have substantial adverse impacts on the environment and/or workers' health: brick and tile production; leather processing; small-scale mining; food processing; metal finishing; wood processing and furniture making, and wet textile operations.

safety measures can also help MSEs avoid costly accidents and worker absences.

Experience has demonstrated that, with assistance, MSEs can frequently identify cleaner production opportunities that produce a positive financial return, sometimes with little or no investment. Many enterprises that change to CP methods may reap substantial financial and environmental benefits, indicating that CP should be the first option considered in addressing MSEs' environmental problems.

Yet, although this approach can offer tremendous advantages, readers should also recognize that cleaner production options showing clear financial benefit will only be available to varying degrees among different enterprises and often may not completely mitigate environmental problems. In some cases, even when pursuing CP techniques, some businesses may need to use solutions that offer no measurable financial return—if such solutions are required by USAID's Regulation 216 or local regulations or desired for other reasons, such as community goodwill.

Small-scale brick and tile factories, like this facility in South Africa, can benefit the environment and their finances by more efficient use of resources and inputs.

Important Environmental Issues Addressed by This Fact Sheet

- Inefficient use of fuel
- Resource extraction and depletion
- Inefficient use of non-fuel inputs
- Dust
- Chemical pollution

Adverse Environmental Impacts and Mitigation Opportunities

Several key environmental issues associated with brick and tile production are listed in the box at left and discussed below. For each impact, the fact sheet provides a list of questions to aid in the assessment of individual MSEs. These questions are followed by a number of mitigation strategies that can be considered, with an emphasis on cleaner production strategies where possible. The strategies presented typically represent a range of available options, from profitable activities that require no investment to other activities that may increase MSEs' costs.

❑ *Inefficient use of fuel*

Traditional brick and tile production requires a great deal of fuel during firing. Inefficient production technologies and techniques and excessive fuel consumption are typical. High fuel use increases air pollution, worsening respiratory illnesses. It also increases deforestation and associated environmental impacts, leaving less wood for future use. Reducing consumption reduces costs, conserves resources and lowers pollution levels.

Key questions to consider:

- What type of fuel is used in production? Where does it come from?
- What other types of fuel are available?
- Are there leaks or openings in the kiln structure?
- How close are settlements to the (proposed) kiln site?
- How much exposure to smoke and ash do workers have?
- How much bending and lifting do workers do?

Selected Mitigation Strategies:

- Use alternative fuel types. Organic wastes such as rice husks or sugar bagasse can supplement scarce fuel sources, such as wood, without sacrificing efficiency.
- Raise kiln temperature using improved firing techniques. Adding combustible material around the bricks or between clamps can increase temperatures and lower traditional fuel needs.
- Maintain kiln structure and repair cracks or leaks. Even small leaks can substantially increase fuel costs over time. Monitor structure and machinery to identify potential leaks.
- If traditional brick-making technology is used (brick clamps), ensure adequate insulation of the clamp and orient it at a 90° angle to prevailing wind direction to reduce underfiring or overfiring of bricks. See http://www.gtz.de/basin/gate/brickclamps.htm for a more extensive review of best practices.
- Increase efficiency and reduce emissions by using kiln structures that require less fuel. Ventilated-shaft brick kilns (VSBKs) or bull trench kilns (BTKs) are effective in reducing smoke and lowering the amount of fuel required for firing.

- Install filters in chimneys. One small-scale brick producer used broken brick pieces to absorb carbon dioxide (CO^2) and reduced emissions substantially.[3]

- Prepare a safety and health plan to minimize adverse respiratory effects and physical stress on kiln workers.

❑ *Resource extraction and depletion*

Brick and tile production can alter the landscape in ways that are harmful to the environment and may hamper future business plans. Production can deplete local sources of fuelwood, eventually raising the cost of labor for acquiring fuel. It can also create clay pits or "borrow" areas, which, if improperly managed, can become safety hazards. They may also accumulate rainwater and become habitat for mosquitoes. These effects, with associated soil erosion, may make land unusable for farming. For all these reasons, landowners or communities may resist further expansion.

Key questions to consider:

- How is the landscape expected to change (from tree-cutting, borrow pits, etc.) over the course of production?

Selected mitigation strategies:

- Consider planting fast-growing tree species that can be coppiced easily, such as *Leucaena* or *Albizia*, to maintain a source of fuel. Tree planting also helps to prevent soil erosion, reduce siltation of water bodies and maintain soil fertility. If trees are planted, make sure it is clear who owns them to encourage better long-term management.

Return land to a usable state. Set topsoil aside before removing clay and replace it after production ends. If topsoil has been lost or dispersed, fill the borrow pit with soil to avoid creating pools of water that attract mosquitoes.

❑ *Inefficient use of non-fuel inputs*

Inefficient production techniques reduce productivity and create excessive waste. Improper brick and tile formation and low-quality inputs result in a high number of bricks or tiles that crack or break during firing and must be discarded. This decreases output and increases waste disposal costs. Brick or tile wastes require significant amounts of space, leaving less land available for other uses. Better use of technology and training will increase productivity and efficiency while reducing costs and waste.

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[3] For more information, see "Remediation of Airborne Polyaromatic Hydrocarbons (PAHs)" in the reference section of this document.

Key questions to consider:

- What kind of machinery is used in the production process?
- What kinds of raw materials are used in production and how are they identified?
- What quality control processes are used to evaluate raw materials?
- What waste will be left after production is finished?

Selected mitigation strategies:

- If little or no machinery is used, consider low-cost technology improvements. Decrease losses during firing by improving brick preparation: use an extruder to process clay, or form bricks with manual presses.
- Improve input quality. Bricks that crack during firing may have too much organic material in them or too much topsoil mixed in with clay. Train workers and monitor quality regularly.
- Consolidate or remove brick and tile waste once production ends. This waste may be scattered over a large area and make it hard to farm the land in the future. Investigate possible uses of broken or burnt brick for construction and other processes.

❑ *Dust*

Dust, a byproduct of brick and tile production, may cause serious health problems. Dust is most prevalent and most dangerous when clay is extracted and when finished bricks are transported following the firing process. Inhaling rock dust can lead to silicosis, a disease that affects lungs and breathing. Silicosis lowers the productivity of workers and can have long-term and even fatal effects on the health of workers, owners and people who live close by (including the families of workers and owners).

Key questions to consider:

- When is dust most prevalent in the production process?
- What safety measures are available to workers?

Selected mitigation strategies:

- Provide workers with face masks and instruct them to use masks in high-dust operations.
- Dampen bricks and tiles to keep dust down. In particular, if bricks or tiles are made and then broken for use in construction, make sure to dampen them first. However, try not to use excessive water.

❑ *Chemical pollution*

Adding pigment to bricks or glazing roofing tiles produces chemical wastes that could harm workers, pollute the air and contaminate water supplies. Glazing and enameling require materials that contain acids or metals, and improper handling or excessive contact can lead to metal poisoning, skin irritations or lung disease. Unhealthy workers can lower productivity, miss work too often and contribute to costly mistakes. Poor housekeeping practices can waste materials, raising input costs.

Key questions to consider:

- What types of glaze or enamels are used in production?
- What safety and housekeeping measures do workers practice?
- Are chemical wastes disposed of away from water sources?

Selected mitigation strategies:

- If possible, use water-based acrylic glazes to minimize environmental problems.
- Improve storage practices. Close containers containing glazing or enameling material to prevent loss of the material through evaporation, spoilage or spills, and to minimize workers' exposure to fumes.
- Require workers to wear masks when they are using glazing or enameling chemicals.
- Require workers to wash their hands after working with glazes. Many glazes have traces of metal that can cause metal poisoning when ingested. Provide gloves made of rubber, vinyl or other impermeable materials for workers who are handling glazes and glazed material.
- Ventilate kilns after firing. Dangerous gases and fumes escape during the firing process and can sicken workers removing bricks or tile.
- Prevent water contamination. Apply glazes away from water sources and dispose of chemical wastes properly. Do not clean spilled glazes with water. Sprinkle them with absorbent material such as straw, clay or dirt, and sweep up the spill into a separate container. To prevent metals from leaching out of the glazes into water supply, they should be disposed of safely (for example, in clay- or concrete-lined pits). Check with an environmental expert to confirm the chosen disposal method is safe for the chemicals used.

References and Resources

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  http://www.rff.org/Documents/RFF-DP-98-15.pdf. This case study discusses the development of technology for improving polluting emissions among small-scale brickmakers in Mexico.

- *The Clay Brick Industry: Improvement of Resource Efficiency and Environmental Performance* (2000). Cleanerproduction.com, Hamner and Associates LLC.

  http://www.cleanerproduction.com/Directory/sectors/subsectors/clay.html. Direct links to online guides for cleaner production in clay brick making.

- *Clay Preparation Methods*. Wall Technical Briefs. German Federal Ministry for Economic Cooperation and Development (GTZ).

  http://sleekfreak.ath.cx:81/3wdev/GATE_DL/BUILDING/BASTB13E.PDF;
  http://sleekfreak.ath.cx:81/3wdev/GATE_DL/BUILDING/BASTB11E.PDF;
  http://sleekfreak.ath.cx:81/3wdev/GATE_DL/BUILDING/BASTB12E.PDF.

  A series of technical briefs dealing with the drying of clay for brick- and tile making, the preparation of clay, and the molding and firing of clay bricks and tiles. The brief describes basic drying processes, different drying methods, surface treatment, drying tests, choice of drying methods, economics and flexibility. A table explains drying faults, their causes and remedies.

- *Energy Efficiency Improvement in the Brick, Tile and Lime Industries on Java* (1987). World Bank Energy Sector Management Assistance Program. UNDP, World Bank.

  http://www-wds.worldbank.org/servlet/WDS_IBank_Servlet?pcont=details&eid=000009265_3960928074130 This report discusses improvements in the brick, tile and lime industry in Indonesia. Particular attention is paid to better ways to prepare clay and keep tiles from breaking in the kiln.

- "Energy Saving in Brick Industry: Brick-by-Brick Approach to Sustainable Development." (1999) *Terivision* No. 18. Tata Energy Research Institute.

  http://www.teri.res.in/teriin/news/terivsn/issue18/main.htm. A general discussion of improving energy efficiency in the brick industry. This is not a very technical document but includes useful starting strategies for dealing with energy issues.

- *Status and Development Issues of the Brick Industry in Asia* (1993). Field Document No. 35, UN Food and Agriculture Organization (FAO).

  http://www.fao.org/docrep/006/AD592E/AD592E00.HTM. A comprehensive description of brick production and alternative technologies that improve production. Specific reference to kiln types and different methods of input extraction.

- *Uganda: Energy Efficiency Improvement in the Brick and Tile Industry* (1989). World Bank Energy Sector Management Assistance Program. UNDP, World Bank.

  http://www-wds.worldbank.org/servlet/WDS_IBank_Servlet?pcont=details&eid=000009265_3960928084948. This report analyzes technical and economically feasible means for improving energy efficiency in brick and tile production in Uganda. Specific discussion of fuelwood conservation.

Other Resources

- *Bull's Trench Brick Kiln*. Wall Technical Brief. German Federal Ministry for Economic Cooperation and Development (GTZ).

  http://sleekfreak.ath.cx:81/3wdev/GATE_DL/BUILDING/BK.HTM. Description of the Bull's Trench Brick Kiln technology. Discusses advantages and disadvantages of the technology, with specific reference to lowering fuel use and improving productivity. Includes diagrams and figures.

- *Energy Conservation in the Ceramic Industry* (1994). United Nations Industrial Development Organization (UNIDO).

  http://www.unido.org/userfiles/PuffK/ceramic.pdf. This report covers the broader ceramics industry, including pottery, but contains a useful detailed discussion of how to improve energy efficiency in kilns.

- "The Environmental Colours of Microfinance Theory" and "Practice Enabling the Link between Microcredit and Environment" in *Promoting Environmentally Based Micro-Enterprises* (2000). Global Development Research Centre.

  http://www.gdrc.org/icm/environ/environ.html. This is a larger document on environmental assessment of microenterprises, but includes a case study of brickmakers in Zimbabwe.

- Maithel, Sameer, Heini Mueller and Rajinder Singh (2000). *Experiences in the Transfer and Diffusion of Efficient Technologies in the Indian Brick Industry*. CTI/Industry Joint Seminar on Technology Diffusion in Asia, 14–15 January 2000. United Nations Framework Convention on Climate Change Secretariat.

- Scott, Andrew. *The Environmental Impact of Small-Scale Industries in the Third World*. Global Environmental Change Programme Briefings No. 19.

  http://www.susx.ac.uk/Units/gec/pubs/briefing/brief-19.pdf. This technical brief includes a short discussion of the environmental impacts associated with small-scale brickmaking. *Vertical Shaft Brick Kiln Fact Sheet*. Development Alternatives Inc.

  http://www.devalt.org/da/tsb/vsbk.pdf. This fact sheet discuses vertical-shaft brick kiln (VSBK) technology and provides contact information for further inquiries and technical material.

Chapter 4.2
Food Processing: Cleaner Production Fact Sheet and Resource Guide

Purpose

This fact sheet offers basic information on the important adverse environmental impacts of food processing, as well as associated health and safety impacts. It also discusses opportunities for mitigating those impacts, with an emphasis upon "cleaner production" strategies that may also provide financial benefits to micro- and small enterprises (MSEs). In addition, each fact sheet offers a substantial, annotated list of resources for organizations seeking more information.[4]

This fact sheet has been prepared for (1) **business development services (BDS) providers**, which offer services such as management training or marketing support to MSEs, and (2) **intermediate credit institutions (ICIs) and direct lenders** that provide financial credit to MSEs. It is intended to be used in concert with other sections in Part III of the *Environmental Guidelines for Small-Scale Activities in Africa: Environmentally Sound Design for Planning and Implementing Development Activities,* which is USAID Africa Bureau's principal source of sector-specific environmental guidance.

Why Focus on Cleaner Production for Mitigation?

Cleaner production (CP) is a preventive business strategy designed to conserve resources, mitigate risks to humans and the environment, and promote greater overall efficiency through improved production techniques and technologies. CP methods may include:

- substituting different materials
- modifying processes
- upgrading equipment
- redesigning products

In addition to environmental, health and safety benefits, many cleaner production techniques can substantially reduce operating costs and improve product quality. MSEs may profit from CP through more efficient use of inputs and machinery, higher-quality goods that can command higher prices,

[4] At the time of writing, USAID cleaner production fact sheets are available for the following subsectors that are likely to have substantial adverse impacts on the environment and/or workers' health: brick and tile production; leather processing; small-scale mining; food processing; metal finishing; wood processing and furniture production, and wet textile operations.

and reduced waste disposal costs. Improved safety measures can also help MSEs avoid costly accidents and worker absences.

Experience has demonstrated that, with assistance, MSEs can frequently identify cleaner production opportunities that produce a positive financial return, sometimes with little or no investment. Many enterprises that change to CP methods may realize substantial financial and environmental benefits, indicating that CP should be the first option considered in addressing MSEs' environmental problems.

Yet, although this approach can offer tremendous advantages, readers should also recognize that cleaner production options showing clear financial benefit will only be available to varying degrees among different enterprises and often may not completely mitigate environmental problems. In some cases, even when pursuing CP techniques, some businesses may need to use solutions that offer no measurable financial return—if such solutions are required by USAID's Regulation 216 or local regulations or desired for other reasons, such as community goodwill.

Food processing is an area where many cleaner production opportunities can be found, from water usage to recycling.

Important Environmental Issues Addressed by This Fact Sheet

- Water pollution
- Working conditions
- Spoilage
- Solid waste
- Poorly maintained machinery

Adverse Environmental Impacts and Mitigation Opportunities

A wide variety of African MSEs engage in food-processing activities ranging from abbatoirs to cashew nut processing. Several key environmental issues associated with food processing are listed in the box at left and discussed below. For each environmental impact, the fact sheet provides a list of questions to aid in the assessment of individual MSEs. These questions are followed by a number of mitigation strategies that can be considered, with an emphasis on cleaner production strategies where possible. The strategies presented typically represent a range of available options, from profitable activities that require no investment to other activities that may increase MSEs' costs.

❑ *Water pollution*

Harmful wastes disposed of in pits or waterways can leach into groundwater and affect water quality for workers and the community. Contamination of water sources may not occur immediately, but can increase or accumulate over time, eventually damaging to product quality and affecting workers' health.

Key questions to consider:

- Is there any chance rain could transport elements of the firm's waste from its original site to community centers or water sources?

- How near is the waste site to the water table and/or groundwater sources, such as wells?

- How close is the waste site to streams, rivers, lakes or other surface water bodies?

- Is the enterprise mixing chemical and organic waste?

Selected mitigation strategies:

- Site small dumps or waste treatment sites far away from surface or groundwater water sources.

- Separate harmful chemical waste from organic waste, and use more care in handling chemical waste. Dispose of chemical waste in a way that prevents chemicals from leaching into ground or surface waters (such as clay- or concrete-lined pits). Check with an environmental expert to confirm the chosen disposal method is safe for the chemicals being disposed of.

- If the enterprise stores waste temporarily before transporting it to a treatment facility or landfill, make sure it is not leaking into the ground.

❑ *Working conditions*

Certain working conditions—excessive heat caused by operating machinery, lack of ventilation, skin-irritating acids from fruits—can damage workers' health. An unhealthy workforce may be unproductive, miss work too often and make costly mistakes.

Key questions to consider:

- Do workers and managers know safety measures well?

- Are there any by-products from production that cause skin, eye or breathing irritation, even occasionally?

- Is protective clothing (e.g., gloves, boots, face masks) available for workers?
- Is there enough light and air so workers do not have to strain to perform their work?

Selected mitigation strategies:

- Maintain safety equipment and reinforce safety training. Safety measures may already be in place, but workers should be reminded often; designate one person as the safety trainer and have that person train others. Check existing safety equipment regularly, and replace elements like dust filters frequently.
- Create a prevention strategy. Sometimes small changes such as buying a face mask or rubber gloves can dramatically reduce incidences of harm to workers. Find ways of preventing accidents.
- Find ways of reducing harmful byproducts. For example, clean the floors in between production cycles to get rid of excess dust, or install drip trays to catch acidic fruit juice.

❑ *Spoilage*

Certain structural features of the food-processing site may lead to spoilage or contamination of the products. Such site or building features include inadequate drainage or a lack of screens to keep out insects/rodents. Increased spoilage causes more waste and less profitability, while contamination may result in health problems for consumers.

Key questions to consider:

- Does the site experience substantial losses in raw materials during storage before production? If so, what causes these losses?
- How open are structures to the outside elements and pests? Can they be closed off more effectively while maintaining sufficient ventilation?
- What sanitation procedures are currently in place?

Selected mitigation strategies:

- Ensure that the building structure is secure not only from people but also from animals. Screens should be placed over drains and windows to keep out disease-carrying rodents and flies.
- Storage areas should be well-ventilated and large enough so that excessive heat and moisture do not spoil fruits and vegetables.

❑ *Solid Waste*

Food processing creates substantial amounts of organic and inorganic wastes. This can lead to increased costs for supplies, labor and sometimes fees for waste disposal. In addition, high volumes of burdensome waste, whether placed in a landfill or treated and disposed of, may place a serious strain on limited land resources. Minimizing waste can save on the cost of supplies and labor needed for waste disposal. Converting waste to productive uses can provide an extra source of income.

Key questions to consider:

- Are there any other uses for organic waste generated by the production process? For instance, can organic waste be turned into fodder or compost?
- What contributes most to waste?
- How can production processes be changed to reduce waste?

Selected mitigation strategies:

- Re-use organic waste. Some organic waste such as vegetable peelings can be used as animal fodder; other waste, such as the fiber from palm kernel husks, can be used as fuel.
- Modify waste disposal to facilitate faster decomposition/breakdown of organic material. Add layers of dirt and dry organic material to waste pits, or spread waste over large areas of land. This type of composting and “land spreading” can speed up decomposition and quickly lowers waste volume. Ensure, however, that this material does not attract disease-carrying vectors including birds, rodents and insects.
- Minimize wastes by improving production processes. Identify and change elements of production that may be inefficient or produce excess waste. For example, improved techniques for cutting food produce can reduce waste and yield more product.

❑ *Poorly maintained machinery*

Machinery that leaks chemicals or fuel is wasting energy, can contaminate water supplies and may threaten workers’ health. Repairing leaks lowers fuel costs and can prevent costly accidents such as fire. For dairy processors, who use more machinery and refrigeration systems than other food processors, reducing leakage can save money spent on refrigerants and other chemicals.

Key questions to consider:

- How often is machinery checked?
- Are there any routines or technology in place to detect leakages?
- Do workers ever complain of nausea or dizziness on the job?

Selected mitigation strategies:

- Schedule regular machine maintenance checks and repairs. Ensure that workers have up-to-date training in operation and maintenance. Do not wait until machinery is broken before checking it; leaks can occur long before serious equipment breakdown and may be costing the business money. If possible and cost-effective, replace faulty machinery with more efficient machinery.

- If machinery is difficult to access, then monitor wastes or emissions to detect leaks. For example, check for puddles underneath machinery or chemical/fuel smells.

- Use wood shavings, drop cloths and/or oil-water separators to catch spills and leaks.

- If the business is disposing of organic and chemical wastes separately, ensure that chemical or fuel waste does not contaminate the organic waste.

- If it is not cost-effective to replace or to repair machinery, make sure that harmful effects are minimized. Increase ventilation around any machinery that has high gas or chemical emissions.

❑ *Water use*

Food processing workers sometimes use too much water, usually when they are cleaning equipment or food materials. This may not only cause others in the community to have less water, but also lessen the enterprise's own future access to water. It may also mean that water costs are unnecessarily high, even with use of a well. New wells may have to be drilled more frequently as groundwater levels drop.

Key questions to consider:

- Does the business primarily use water to clean machinery and floors?

- Is the source of water limited?

- Is water left running when it is not in use?

- How much money does the business pay for water, and how much could that cost be reduced through more careful usage?

Selected mitigation strategies:

- Decrease water usage through "dry cleanup." Dry cleanup involves an initial cleaning without water (sweeping, wiping down) before washing. This method reduces the amount of water required to dislodge solid wastes from floors or machinery.

- Regulate water flow. Using high-pressure water hoses can ease cleaning and cut water use; usually this only involves adding a new nozzle to the end of a hose.

- Reuse water. Some food processors use steam to purify or clean packaging materials; a closed-loop system can cycle hot water back into the system. This process saves money on both water and energy costs.

❑ *Liquid waste*

Meat processing creates a good deal of liquid waste—wastewater with blood or animal fats in it—that may coagulate and clog pipes, or contaminate sources of water. Liquid wastes can also gather in stagnant pools, creating breeding grounds for insects. These conditions may cause costly losses in labor and meat from the spread of disease among workers and animals.

Key questions to consider:

- How large is the volume of liquid wastes that is produced?

- Do liquid wastes gather in pools, serving as a breeding grounds for mosquitoes and other insects?

- What waste treatment systems are in place?

Selected mitigation strategies:

- Practice water reduction strategies mentioned above, including "dry cleanup," to minimize the amount of wastewater created and the amount of waste materials in the wastewater.

- Separate fats, grease and solids from wastewater. Oil separators or oil traps can be purchased or made at relatively low cost and can dramatically reduce the amount oil in wastewater. Drain stagnant pools of liquid or water away from holding pens and working areas.

- Consider constructing waste treatment ponds. Both solid and liquid waste can be treated in these ponds, which can aid decomposition and reduce disposal costs. Since they may attract mosquitoes and other insects, site such ponds away from animals and places of human activity.

❑ *Noises and odors*

Food processing may result in noises or odors that affect the quality of life surrounding the production site. Community members may be unwilling to tolerate continued production or may block plans to expand production in the future. Loud noises may also damage the ears of workers and managers.

Key questions to consider:

- Are there some aspects of the production process that are much louder than others?

- Is your waste disposal or treatment site located near human settlements?
- What smells are produced in the production process?

Selected mitigation strategies:

- Locate waste disposal sites away from housing or town centers.
- Modify waste disposal or production practices to minimize odors. For example, if treating waste in lagoons or compost pits, make sure they are large enough to accommodate the volume of waste that is produced—if they are too small, the effectiveness of the treatment decreases and smell increases.
- Provide earplugs for workers.
- Repair and maintain machinery so that excessive grinding or squeaking is minimized. This may increase the machinery's efficiency and make it last longer

Resources and References:

- *Cleaner Production Assessment in Dairy Processing*. United Nations Environment Program, Division of Technology, Industry and Economics (UNEP-TIE).

  http://www.agrifood-forum.net/publications/guide/index.htm. A guide to the application of cleaner production in the dairy industry, with a focus on the processing of milk and milk products at dairy processing plants.

- *Cleaner Production Assessment in Meat Processing*. United Nations Environment Program, Division of Technology, Industry and Economics (UNEP-TIE).

  http://www.agrifood-forum.net/publications/guide/index.htm. This document is a guide to the application of cleaner production to the meat processing industry, with a focus on the slaughtering of cattle and pigs at abattoirs. Includes case studies, sample evaluation, and assessment forms.

- Crickenberger, Roger G. and Roy E. Carawan (1996). *Using Food Processing By-Products for Animal Feed*. North Carolina Cooperative Extension Service.

  http://www.bae.ncsu.edu/bae/programs/extension/publicat/wqwm/cd37.html. This paper gives information to help food processors prevent pollution and save money by recovering by-products for use as animal feed. It considers some by-products suitable for animal feeding and factors to consider when selecting by-products for feed, e.g., moisture content, waste stream, volume of material, and effects on feed consumption.

- *Energy Conservation in the Food Industry* (1995). United Nations Industrial Development Organization (UNIDO).

  http://www.unido.org/userfiles/PuffK/food.pdf. This document includes a general discussion on energy conservation for food processors in the areas of steam leakage, wastewater treatment, refrigeration systems, cookers, and baking furnaces. Recommendations include insulating methods, refinishing cookers to increase radiation, and various heat recovery techniques.

- Fellows, Peter. *Guidelines for Small-Scale Fruit and Vegetable Processors* (1997). Agricultural Services Bulletin 127. UN Food and Agriculture Organization (FAO).

  http://www.fao.org/docrep/w6864e/w6864e0g.htm. (see appendix). This document generally concerns the production process, but it does also include a good overview of health and safety issues for fruit and vegetable processors. Specifically discusses methods for avoiding dangers of hot liquids/jams, fruit acids and steam. Some mention of high volumes of solid organic waste and contamination of the product from workers.

- Fellows, P., B. Axtell, and M. Dillon (1995). *Quality Assurance for Small-Scale Rural Food Industries*. Agricultural Services Bulletin No. 117. UN Food and Agriculture Organization (FAO).

  http://www.fao.org/docrep/V5380E/V5380E00.htm. A good discussion of cleaner production building design. Specific mention of how to keep rodents and insects out of building structures in addition to sanitation and hygiene in production.

- *Food Processing Fact Sheets*. Minnesota Technical Assistance Program, University of Minnesota.

  http://wrrc.p2pays.org/indsectinfo.asp?INDSECT=50. Although this site gives examples of cleaner production strategies undertaken by some Minnesota food processors, it is relevant to developing country producers. Links to the following fact sheets:

  - *Composting and Landspreading Food Processing By-Products*. http://www.mntap.umn.edu/food/78-CompLand.htm. A good discussion of how to compost commercial food processing wastes quickly through landspreading methods.
  - *Dairy Waste Reduction Tips*. http://www.mntap.umn.edu/POTW/Dairywaste.htm. A discussion of what some Minnesota dairy companies are doing to reduce wastewater and product losses. Includes 10 water conservation strategies.
  - *Feeding Food By-Products to Livestock.* http://www.p2pays.org/ref/02/01247_files/fs77-r.htm. This fact sheet explains the conditions under which non-meat uncooked food by-products can be used as animal feed.

- "Fruit and Vegetable Processing" in *Pollution Prevention Abatement Handbook* (1998). World Bank.

  http://lnweb18.worldbank.org/ESSD/envext.nsf/51ByDocName/PollutionPreventionandAbatementHandbook. General guidelines on reducing pollution, noise and effluent, with specific recommendations on the recirculation of water in production, dry cleanup, and reuse of organic wastes. Also includes technical information on requirements affecting effluent and acceptable levels of waste for specific items.

- *A Guide to Cleaner Production in the Food Industry*. The United Nations Environmental Program (UNEP) Working Group Centre for Cleaner Production in the Food Industry.

  http://www.cleanerproduction.com/Directory/sectors/subsectors/FoodProc.html. These guidelines are comprehensive and include an introduction to cleaner production as well as methods of planning, implementing, and evaluating cleaner production projects. Specific fact sheets are available, including:

  - *Fruit and Vegetable Processing.* http://www.geosp.uq.edu.au/emc/CP/Res/facts/FACT3.HTM. Discusses sources of waste and ways of reducing waste and water use. Comprehensive checklist on potential targets for cleaner production.
  - *Dairy Manufacturing*. http://www.geosp.uq.edu.au/emc/CP/Res/facts/FACT2.HTM. Discusses waste points in production process and possible waste minimization solutions from Cleaning in Place methods. Comprehensive checklist at end.
  - *Meat Processing*. http://www.geosp.uq.edu.au/emc/CP/Res/facts/FACT7.HTM. Good discussion of factors involved generating waste—types of animals and cleaning methods—and suggests better cleaning methods for pollution reduction. Comprehensive checklist at end.
  - *Food Processing Checklists*. http://www.geosp.uq.edu.au/emc/CP/Res/facts/FACT1.HTM. Very good checklist that addresses general food processing strategies for cleaner production.

- *Information Resources on Industrial Pollution Prevention* (2000). United States Agency for International Development (USAID).

  Contains guides, case studies, and articles focused on pollution prevention in food processing and other sectors.

- *International Cleaner Production Information Clearinghouse* (1999). CD Version 1.0. United Nations Environment Program, Division of Technology, Industry and Economics (UNEP-TIE)

  Contains case studies, country profiles, and cleaner production strategies for food processing.

- *Separator for Organic Grease and Oil* (1990). United Nations Industrial Development Organization (UNIDO).

  http://www.unido.org/userfiles/PembletP/Vol5_Z06.pdf. A how-to document on constructing an oil separator that removes vegetable oil, animal grease and fats from wastewater. Includes diagrams.

- "Vegetable Oils and Fats." Chapter 55 in Vol. II of *Environmental Handbook: Documentation on Monitoring and Evaluating Environmental Impacts*. German Federal Ministry for Economic Cooperation and Development (GTZ).

  http://ces.iisc.ernet.in/energy/HC270799/HDL/ENV/enven/vol238.htm. This chapter provides an overview of the techniques used to process oil from seeds, nuts and fruit, as well as the environmental hazards associated with the production process. Specific discussion of the extraction of oil from wastewater using oil traps; reuse of wastewater and organic waste; and problems in chemical refining.

Chapter 4.3
Leather Processing: Cleaner Production Fact Sheet and Resource Guide

Purpose

This fact sheet offers basic information on important adverse environmental impacts of leather processing, as well as associated health and safety impacts. It also discusses opportunities for mitigating those impacts, with an emphasis upon “cleaner production” strategies that may also provide financial benefits to micro- and small enterprises (MSEs). In addition, each fact sheet offers a substantial, annotated list of resources for those organizations seeking more information.[5]

This fact sheet has been prepared for (1) **business development services (BDS) providers,** which offer services such as management training or marketing support to MSEs, and (2) **intermediate credit institutions (ICIs) and direct lenders** that provide financial credit to MSEs. It is intended to be used in concert with other sections in Part III of the *Environmental Guidelines for Small-Scale Activities in Africa: Environmentally Sound Design for Planning and Implementing Development Activities,* which is USAID Africa Bureau's principal source of sector-specific environmental guidance.

Why Focus on Cleaner Production for Mitigation?

Cleaner production (CP) is a preventive business strategy designed to conserve resources, mitigate risks to humans and the environment, and promote greater overall efficiency through improved production techniques and technologies. Cleaner production methods may include:

- substituting different materials
- modifying processes
- upgrading equipment
- redesigning products

In addition to environmental, health and safety benefits, many cleaner production techniques provide opportunities to substantially reduce operating costs and improve product quality. MSEs can profit from cleaner production through more efficient use of inputs and machinery, higher-quality goods that can command higher prices, and reduced waste disposal

[5] At the time of writing, USAID cleaner production fact sheets are available for the following subsectors that are likely to have substantial adverse impacts on the environment and/or workers’ health: brick and tile production; leather processing; small-scale mining; food processing; metal finishing; wood processing and furniture production, and wet textile operations.

costs. Improved safety measures can also help MSEs avoid costly accidents and worker absences.

Experience has demonstrated that, with assistance, MSEs can frequently identify cleaner production opportunities that produce a positive financial return, sometimes with little or no investment. Many enterprises that change to CP methods may realize substantial financial and environmental benefits, indicating that CP should be the first option considered in addressing MSEs' environmental problems.

Yet, although this approach can offer tremendous advantages, readers should also recognize that cleaner production options showing clear financial benefit will only be available to varying degrees among different enterprises and often may not completely mitigate environmental problems. In some cases, even when pursuing CP techniques, some businesses may need to use solutions that offer no measurable financial return—if such solutions are required by USAID's Regulation 216 or local regulations or desired for other reasons, such as community goodwill.

Important Environmental Issues Addressed by This Fact Sheet

- Chemicals
- Water use
- Worker health hazards
- Odor

Leather processing uses large amount of toxic and environmentally dangerous chemicals. CP techniques can prevent these chemicals from becoming a threat to public health and save money for the micro-entrepreneur.

Adverse Environmental Impacts and Mitigation Opportunities

Several key environmental issues associated with leather processing are listed in the box at left and discussed below. For each environmental impact, the fact sheet provides a list of questions to aid in the assessment of individual MSEs. These questions are followed by a number of mitigation strategies that can be considered, with an emphasis on cleaner production strategies where possible. The strategies presented typically represent a range of available options, from profitable activities that require no investment to other activities that may increase MSEs' costs.

❑ *Chemicals*

Leather processing requires extensive use of chemicals to treat and soften hides. These chemicals are present in the firm's wastewater and can contaminate community water sources. When chemicals are improperly or inefficiently used in production, costs rise and pollution increases. More efficient chemical use can both lower production costs and reduce pollution.

Key questions to consider:

- What kind of chemicals are used?
- Which of these chemicals are the most harmful?
- Which production stages use the most chemicals? In what quantities?
- Where are chemicals stored?

Selected mitigation strategies:

- Improve production methods to increase efficiency. Using higher temperatures in chrome baths helps chrome adhere to hides and reduces the amount of chemicals left in the wastewater. Instruct workers about the correct chemical ratios to use in tanning and finishing baths. Use measuring equipment to minimize overuse.
- Improve chemical storage to reduce waste and spills. Store chemicals in sturdy, waterproof containers. Instruct employees to seal containers after use to avoid spills.
- Consider using alternative chemicals that are less hazardous. For instance, vegetable-based tanning solutions can be substituted for chrome. Take into consideration, though, that switching to low-polluting chemicals may involve a tradeoff in quality. For example, vegetable dyes may produce unpredictable colors.
- Recycle chrome and tanning bath solutions. Chrome and lime effluent can be reused in future production stages without loss of effectiveness; use filters to screen out solid wastes and then set aside the solution to use it again. Assess the cost-effectiveness of such strategies before proceeding, however. For example, some chrome-recycling strategies may not be cost-effective for smaller operations.

❑ *Water use*

Leather processing requires water in almost every stage of production, but certain production methods or machinery can lead to overuse. If well or pump water is used, excessive water use can deplete water sources for future production or community use. Energy costs for pumping, as well as environmental impacts from energy consumption, will also be higher than necessary. Excessive groundwater use may lower the water table and require frequent redrilling of wells. Also, untreated wastewater (effluent) from processing operations may contain organic wastes which can both pollute local water sources and degrade water quality for downstream communities.

Using water more efficiently guarantees less costly production and ensures against water shortages that could interrupt production. If the enterprise pays by volume for the water it uses, reducing water usage can be expected to provide substantial savings.

Key questions to consider:

- Is water left running between production stages?
- Is fresh water used in every new bath? Could some water be reused?
- Are hides pre-cleaned before they are washed?

Selected mitigation strategies:

- Reuse water from “cleaner” stages of production in “dirtier” stages of the next production cycle. For example, use rinse water from the final stage of production for the initial soaking or washing of the next batch of hides.
- Conserve water by improving production methods. Turn off water between batches or while transferring hides between baths. Install nozzles on hoses to increase the effectiveness of spraying while decreasing water use. Prevent baths from overflowing by monitoring water levels closely or installing an automatic shut-off mechanism.
- Use dry cleanup methods. Wipe down spills with dry material; use brooms or cloth to remove as much solid or semi-solid waste as possible from floors or machinery before rinsing them down with water.
- Divert organic effluent away from water bodies (see below under “Odor” for production mitigation strategies for tannery effluent).

❑ *Worker health hazards*

Certain working conditions in leather processing—such as exposure to chemicals in the air or in solution baths—can be hazardous to workers. Symptoms can include skin irritations, dizziness and breathing problems. Unhealthy workers may be less productive, miss work too often and make potentially costly mistakes.

Key questions to consider:

- What safety measures are currently in place?
- How often are workers exposed to chemicals?
- Is the tannery structure well ventilated?

Selected mitigation strategies:

- Provide safety equipment such as face masks, rubber gloves and boots for workers. Small improvements can increase worker safety dramatically and improve long-run productivity.

- Ventilate the production sites well. Organic solvents, in particular, are harmful when inhaled. Over time, even minor exposure can cause long-term damage to health.

- Train workers in the proper handling of chemicals. Minimize chemical spills and accidental exposure by educating workers about preventive safety measures. For example, sealing chemical containers when not in use can prevent both spillage and evaporation and thus reduce input costs.

❑ *Odor*

Tannery effluent often contains highly odorous waste. Strong smells can damage the quality of life around the tannery site and may reduce or destroy community support for further production or expansion. Controlling odor through improved waste treatment techniques, or even recycling, can improve community relations and may reduce costs.

Key questions to consider:

- Which wastes smell the worst?

- Can wastes or trimmings be separated before chemical treatment?

- Where are solid wastes disposed of?

Selected mitigation strategies:

- Separate and sell non-contaminated wastes to farmers. Untanned collagen wastes and fats produce odors, but they can be reused as agricultural fertilizer if not contaminated by chemical wastes.

- Implement a waste disposal or treatment system. Avoid simply dumping solid wastes; instead, use a proper landfill or dig an appropriately sized pit. (See the chapter on solid waste in the *Guidelines*.) Bury waste to minimize odors. Wherever solid waste is disposed of, make sure it is away from water sources and cannot be washed away.

- Control sludge to decrease odors. Do not let sludge stagnate in or around the tannery site. Place it in a landfill or treatment area. Standing pools of liquid smell bad and are potential breeding grounds for insects, particularly mosquitoes. Eliminate these problems by draining the pools.

❑ *Excess waste*

Inefficient or poor production methods contribute to excessive waste and costly product loss. Tanneries with low-quality production processes may have to discard or rework an unnecessarily high proportion of their products. Improving production through maintenance and training can save costly reworking, reduce product loss, and thereby save money while reducing environmental impacts.

Key questions to consider:

- How much and what kind of products are lost in the production process?
- Which production processes are most prone to mistakes and wasted product?
- Which production processes are easiest to modify in order to reduce waste?

Selected mitigation strategies:

- Ensure that regular maintenance schedules for machinery are followed. For example, to reduce spoilage or losses, workers should regularly clean filters and screens of machinery used in dehairing and hide-shaving.
- Use appropriate equipment and train workers in proper machine operation and maintenance.
- Identify opportunities to improve efficiency. For example, do not overfill or underfill tanning baths with hides. Overfilling reduces efficiency, while underfilling wastes valuable inputs.

Resources and References

- Biller, Dan and Juan David Quintero (1995). *Policy Options to Address Informal Sector Contamination in Urban Latin America: The Case of Leather Tanneries in Bogotá, Colombia*. LATEN Dissemination Note # 14.Washington, DC: World Bank.

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  http://leather.webindia.com/innovation.html. This paper includes a useful overview of hide processing and presents new or alternative production methods that increase efficiency and/or reduce chemical use.

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- *Hair-Save Unhairing Methods in Leather Processing* (2000). Regional Programme for Pollution Control in the Tanning Industry in South-East Asia, United Nations Industrial Development Organization (UNIDO).

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- Money, Catherine A. (1999). *Clean Technology Challenges*. International Union of Leather Technologists and Chemists Societies (IULTCS) Congress held in Chennai, India, January 1999.

  http://www.tft.csiro.au/leather/cleantech.html#tzw. A very useful overview of cleaner production strategies in leather production. Contains checklists for cleaner production technologies. Compares advantages and disadvantages of certain methods. Also includes diagrams of filtering technology.

- *Re-Use of Chromium in Leather Tanning*. United Nations Environment Program (UNEP) Cleaner Production Case Studies. http://www.p2pays.org/ref/10/09545.htm.

  EP3—Pollution Prevention Audit for a Sheep Hide Tannery. United Nations Environment Program (UNEP) Cleaner Production Case Studies. http://www.p2pays.org/ref/10/09234.htm.

  EP3—Cleaner Production Audit for a Cattle Hide Tannery. United Nations Environment Program (UNEP) Cleaner Production Case Studies. http://www.p2pays.org/ref/10/09238.htm.

  Three short case studies of cleaner production in a medium-scale sheep and cattle hide tanneries. These provide a useful overview of cleaner production opportunities. Included are

cost estimates of cleaner production methods. The studies also focus on re-use of chemical effluents.

- Sahasranaman, A. (1999) *Occupational Safety and Health in the Tanning Industry: Emerging Challenges*. International Union of Leather Technologists and Chemists Societies (IULTCS) Congress held in Chennai, India, January 1999.

  http://leather.webindia.com/safety.html. This short reports lists worker safety issues associated with tanneries and provides policy strategies for addressing these issues.

- *Sources, Detection and Avoidance of Hexavalent Chromium in Leather and Leather Products* (2000). Regional Programme for Pollution Control in the Tanning Industry in South-East Asia, United Nations Industrial Development Organization (UNIDO).

  http://www.unido.org/userfiles/PuffK/hexavalent.pdf. This document evaluates a variety of tanning production methods to see which produce dangerous levels of chromium IV, a by-product of chromium III usage. Technical in some sections, but the general discussion on which methods produce the most danger is quite accessible.

- "Tanning and Leather Finishing" (1998). In *Pollution Prevention and Abatement Handbook.* Washington, D.C.: World Bank.
  http://ifcln1.ifc.org/ifcext/enviro.nsf/AttachmentsByTitle/gui_tanning_WB/$FILE/tanning_PPAH.pdf
  This chapter from the World Bank's pollution prevention handbook provides minimum pollution standards for tanneries and leather finishers.

Other Resources:

- Davis, M.H. and J.G. Scroggie (1980). *Theory and Practice of Direct Chrome Liquor Recycling*. Australia: CSIRO Leather Research Centre.

  http://www.tft.csiro.au/leather/dclr.html. Examples and strategies for reusing chrome solution during hide processing.

- Money, Catherine A. *Curing of Hides and Skins: Alternative Methods.* Australia: CSIRO Leather Research Centre. http://www.tft.csiro.au/leather/curinghides.html.

  Money, Catherine A. *Unhairing and Dewooling—Requirements for Quality and the Environment*: Procter Memorial Lecture. Australia: CSIRO Leather Research Centre. http://www.tft.csiro.au/leather/procter.html.

  These two papers present alternative methods of hide preparation and unhairing. There is a short discussion of current methods and alternative methods that can improve quality.

- Pojer, Peter M. and Chi P. Huynh. *A Salt-Free Pickling Regime for Hides and Skins.* Australia: CSIRO Leather Research Centre.

  http://www.tft.csiro.au/leather/saltfreepickling.html. Provides information on eliminating the salt pickle method of preparing hides for tanning.

- *Tanneries and the Environment: A Technical Guide to Reducing the Environmental Impact of Tannery Operations* (1991). Technical Report Series No. 4. United Nations Environment Program (UNEP).

  http://www.ecoethics.net/bib/tl-021-a.htm. Extensive discussion of environmental issues associated with tanneries, with possible solutions. Ordered from this Web site for US $25.

- *Trainers Workbook on Cleaner Production in Leather Tanning* (1996). United Nations Environment Program (UNEP).

  http://www.uneptie.org/pc/cp/library/catalogue/cp_training.htm. Available from UNEP for around US $120.

Chapter 4.4
Metal Finishing: Cleaner Production Fact Sheet and Resource Guide

Purpose

This fact sheet offers basic information on the important adverse environmental impacts of metal finishing, as well as associated health and safety impacts. **Metal finishing** includes both **electroplating** and **coating operations,** as well as their supporting processes (polishing, cleaning, degreasing, pickling, etching, etc.). The purpose of metal finishing is to prevent corrosion and wear, change electrical properties, enhance bonding for adhesives and coatings, and provide a decorative finish for metal products.

This fact sheet also discusses opportunities for mitigating these impacts, with an emphasis upon "cleaner production" strategies that may also provide financial benefits to micro- and small enterprises (MSEs). In addition, it provides a substantial, annotated list of resources for organizations seeking more information.[6]

This fact sheet has been prepared for (1) **business development services (BDS) providers**, which offer services such as management training or marketing support to MSEs, and (2) **intermediate credit institutions (ICIs)** and **direct lenders** that provide financial credit to MSEs. It is intended to be used in concert with other sections in Part III of the *Environmental Guidelines for Small-Scale Activities in Africa: Environmentally Sound Design for Planning and Implementing Development Activities,* which is USAID Africa Bureau's principal source of sector-specific environmental guidance.

Why Focus on Cleaner Production for Mitigation?

Cleaner production (CP) is a preventive business strategy designed to conserve resources, mitigate risks to humans and the environment, and

[6] USAID cleaner production fact sheets are available for the following subsectors that are likely to have substantial adverse impacts on the environment and/or worker health: brick and tile production; leather processing; small-scale mining; food processing; wood processing and furniture making; metal finishing; and wet textile operations.

promote greater overall efficiency through improved production techniques and technologies. Cleaner production methods may include:

- substituting different materials
- modifying processes
- upgrading equipment
- redesigning products

In addition to environmental, health and safety benefits, many CP techniques provide opportunities to substantially reduce operating costs and improve product quality. MSEs can profit from CP through more efficient use of inputs and machinery, higher-quality goods that command higher prices, and reduced waste disposal costs. Improved safety measures can also help MSEs avoid costly accidents and worker absences.

Experience has demonstrated that, with assistance, MSEs can often identify cleaner production opportunities that produce a positive financial return, sometimes with little or no investment. Many enterprises that change to CP methods may reap substantial financial and environmental benefits, indicating that CP should be the first option considered in addressing MSEs' environmental problems.

However, CP options with clear financial benefits are not equally available to all businesses. Further, such options may not completely mitigate environmental problems. In some cases, improving environmental performance may require businesses to use methods or approaches that offer no measurable financial return. Businesses typically undertake such measures if required by law or as part of a commitment to the community.

Important Environmental Issues Addressed by This Fact Sheet

- Use of hazardous chemicals
- Solid and hazardous wastes
- Air pollution
- Water use
- Wastewater

Adverse Environmental Impacts and Mitigation Opportunities

Several key environmental issues associated with metal finishing are listed in the box at left and discussed below. For each issue, the fact sheet provides a list of questions to aid in the assessment of individual MSEs.

These questions are followed by a number of mitigation strategies that can be considered. Where possible, cleaner production strategies are emphasized. The strategies presented typically represent a range of available options, from profitable activities that require no investment to other activities that may increase MSEs' costs.

❑ *Use of Hazardous Chemicals*

Metal finishing operations routinely use various hazardous chemicals, including solvents for cleaning the metal parts, acids and bases for etching them, and solutions of metal salts for plating the finish onto the desired form (substrate).

Most coating processes require the metal surface to be thoroughly cleaned beforehand, because surface contaminants greatly diminish the quality of the finished product. Both cleaning and plating processes generally occur in a “bath”—that is, a tank in which parts are dipped into a solution of chemicals. Preparing the surface of the metal for treatment involves the removal of greases, soils and oxides. Cleaning agents used for this purpose include detergents, solvents, acidic solutions and caustics.

Finished metal parts are often further coated with some combination of paint, lacquer or ceramic coating. These coatings can themselves contain toxic solvents and heavy metals.

Chemicals used may include the following:

- acids (sulfuric, hydrochloric, nitric, phosphoric)
- toxic metals (cadmium, nickel, zinc, chromium, lead, copper) and compounds which contain these metals
- solvents (1,1,1-trichloroethane, methylene chloride, tetrachloroethylene, methyl ethyl ketone [MEK], toluene, xylene)
- cyanide compounds.

These chemicals may be toxic to humans and animals, cause cancer in both humans and animals, easily catch fire, and/or persist in the environment for a long time, entering the food supply. In particular, hexavalent chromium is highly toxic to humans, causing kidney damage and increasing the risk of lung cancer in humans. It is also highly toxic to aquatic animals at very small doses. Both workers and local communities are at risk from exposure to these chemicals, particularly those that persist in ground and surface water supplies for long times.

In general, cleaner production can reduce the environmental harm caused by using hazardous chemicals and improve the financial performance of the production process. Cleaner production options in this area are simple techniques, including pre-cleaning, production/inventory planning, substituting less hazardous chemicals and/or processes, and reusing or reclaiming “dirty” chemicals. These methods are described in detail below.

Key Questions to Consider:

- What chemicals are used at the facility?
- How are your chemicals stored?
- How do you manage use of chemicals in your facility? Do you keep an up-to-date inventory? Do you limit employees’ access to chemicals?
- Which processes use chemicals? What quantities of chemicals do they require?
- Can any of the chemicals be replaced with less hazardous chemicals?

- How frequently do you have chemical spills at your facility? What do you do to protect against such spills?
- Can you reuse any chemicals?
- Can any chemicals used for specific purposes be replaced with more multi-purpose chemicals?

Selected Mitigation Strategies:

- **Avoid keeping outdated chemicals.** Chemicals may lose their effectiveness if used past their expiration date, resulting in poor-quality products and wasted bath solutions.

  Recently purchased chemicals should be used after older chemicals (a "first in, first out" policy) in order to prevent accumulation of expired stock. Creating an inventory control system will prevent waste by ensuring that all chemicals are used in order of arrival in the storeroom.

  Label all chemical containers with the name of the chemical, the date it arrived at the storeroom, the name of the manufacturer/distributor, and any appropriate hazard warnings. The manufacturer, and in some cases the distributor, may be able to provide a Material Safety Data Sheet (MSDS), which includes necessary warnings as well as details about proper safety equipment and procedures for handling the chemical. Assistance providers may also be able to find MSDSs via the Internet.

- **Conduct employee trainings** in the proper handling of chemicals, the reasons for using safer techniques, and emergency response. Trained employees will be better able to operate baths at peak efficiency, minimize spills, and improve the consistency of solutions.

  Training can also minimize the number of "bad baths" in which the entire solution must be changed out, which wastes time, materials and water, and may require workers to reprocessi of metal parts. Ensure that only trained employees are responsible for mixing bath solutions and setting flow levels.

- **Reduce the need for chemicals**.
  - Reduce the use of rust inhibitors (a toxic cleaning agent) by ordering metal parts to be delivered only at the time that they are needed, and also by storing them away from moisture if possible. This reduces the chances that they will rust.
  - Pre-clean parts (wipe them with rags, squeeze them, blow air or plastic pellets on them, vibrate them with abrasive media) before applying liquid or vapor degreasing solvents. This can reduce the amount (and cost) of solvents required and extend the life of degreasing solutions. Cold cleaning with mineral spirits can also help reduce the use of solvents by removing oil before vapor degreasing.

- **Optimize solvent-handling procedures.** There are a number of ways to reduce the amount of solvents used throughout a facility; several require little or no investment.
    - Solvents left from “upstream” (earlier) processes can be reused in “downstream” (later) machine operations. For example, solvents used for final wash during equipment cleaning can be reused as paint thinner, eliminating the need to purchase paint thinners.
    - Rotating the treated metal parts before removing them from the degreaser will allow all condensed solvent to flow back into the degreasing unit, reducing the need to refill (top off) solvents.
    - Covering degreasing baths when they are not in use will reduce evaporation of solvents; firms can spend less on solvents and lower the risk of toxic exposures to workers.
    - Alkali washes can be used instead of solvents in degreasing operations. This way, wastes from alkaline cleaners can be chemically treated to reduce toxicity and then discharged into the sewer, which minimizes cleaning costs. (See the description of wastewater treatment systems below.)
    - Extend the life of cleaning solutions and reduce costs by filtering the cleaning solutions to remove sludge buildup. Refresh the solution by topping it off with fresh solution and emulsifiers. For small operators, a single mobile filtration unit can service all caustic and acid solutions. Use cleanable polystyrene or metal filters in the filtration unit and clean the filters by blowing compressed air over them.
    - Use blast media to air-strip paint for line-of-sight stripping, instead of using solvents. Stripping paint using plastic blast media requires only low pressures and does minimal harm to the part substrate. Plastic blast media can be recycled, generate less waste than sand blasting, and can be cheaper and faster than chemical stripping methods.[7] Blast stripping should be performed only in well-ventilated spaces such as a walk-in booth or a large room. As with solvent-stripping methods, workers should wear respirators to protect themselves from airborne particulates and hazardous emissions.
    - Recycle solvents onsite. Use gravity to separate a solvent/sludge mixture and reclaim the clear solvent for equipment cleaning. If reclaimed solvent is pure enough, it can also be used for formulating primers and base coats of paint. For larger volumes of solvents, recycle by using batch distillation. This works well for recovering isopropyl acetate, xylene, and paint thinner from cleanup operations. Residue from solvent recovery processes can be blended with fuel and burned in a combustion unit. Burning is safest for

[7] Northeast Waste Management Officials' Association, 1998.

local communities as long as controls are used to capture toxic metals from the air emissions before they are released into the atmosphere. **Do not burn residue without such controls.** Residue from the burning must still be disposed of properly, as it will be toxic.

- **Use process substitution** to reduce hazards to workers, communities, and the environment.
    - Zinc alloy plating, such as zinc-nickel or zinc-cobalt, can be used to provide corrosion protection instead of cadmium plating, which is highly toxic and carcinogenic. Alkaline zinc solutions can be used with existing equipment, although zinc solutions that do not contain cyanide require more thorough parts cleaning to be as effective as cadmium cyanide solutions. If cadmium plating is necessary, use bright chloride, high-alkaline baths, as they are less toxic than cadmium cyanide solutions.
    - Because cyanide is highly toxic to humans, use cyanide-free systems for zinc plating when possible. Cyanide-free systems include zinc chloride (acid) baths and zinc alkaline systems.
    - Zinc chloride baths have higher operating efficiencies, offer energy savings through improved bath conductivity, and result in better quality of product because hydrogen embrittlement is reduced. (This is a type of metal deterioration that reduces metal strength and ductility.) Zinc chloride baths, however, require that traditional steel tanks be lined with an acid-resistant material, such as hard rubber or polypropylene.
    - Zinc alkaline systems can be used in traditional steel tanks and produce good brightness, but require tighter operational controls to ensure an efficient process.
    - Replace cyanide cleaners with trisodium phosphate or ammonia. Use non-fuming cleaners such as sulfuric acid and hydrogen peroxide instead of chromic acid cleaner.
    - Use trivalent chromium instead of hexavalent chromium, as it is less toxic to humans and aquatic animals, creates less sludge, and is less viscous, therefore causing less drag-out (see below). Trivalent chromium also uses the same equipment as hexavalent chromium, so it requires no infrastructure changes. Unfortunately, trivalent chromium can only be used for a plating thickness no greater than 0.003mm. Trivalent chrome baths may also require additives to correct color differences.
    - For the copper bright-dipping process, use a sulfuric acid/hydrogen peroxide dip instead of cyanide and chromic acid dips. This reduces the toxicity of the bath and allows recovery of copper from the solution.

- **Consider options to reduce drag-out.** Drag-out is the residual solution that adheres to a part when it is removed from a process bath. Drag-out reduces the concentrations of chemicals in the plating bath, requiring more chemical inputs to maintain operating conditions. Methods to reduce drag-out include:
  - *Drainage from baths*: Install rails above process baths to rack pieces for drainage before rinsing. Add drain holes to plated parts to prevent bath solutions from pooling in racked items. Allow 10–20 seconds of drip time before rinsing.
  - *Change bath conditions*: Operate baths at lowest possible concentration to reduce drag-out loss. Using wetting agents to decrease the surface tension of the solution will also help prevent the solution from clinging to the parts. Increasing bath temperatures to make the solution less viscous can also reduce drag-out, but be sure that the higher temperatures do not reduce the effectiveness of any brightener being used. If MSEs choose to increase bath temperatures to reduce viscosity, they should insulate the tanks to reduce heating costs.
  - *Redesign processes*: Insert a drag-out recovery tank before the rinsing stage to minimize metal concentrations in the wastewater. Keep the drag-out that has been recovered from different process steps segregated so it can be used to top off plating tanks. This also streamlines the plating process and reduces drips on the floor.
- **Reduce chemicals needed in painting operations**.
  - Increase transfer efficiency of spray-painting by switching to a high-volume low-pressure (HVLP) system. This can increase transfer efficiency by 30 to 60 percent and thereby reduce supply costs for paint. Siphon-fed HVLP systems produce a fully atomized spray pattern with even surface coverage. Kits for converting conventional siphon sprayers to HVLP sprayers are inexpensive and practical to set up in small operations. All HVLP systems should be used in an enclosed space for maximum efficiency. **Workers should always wear respirators when using spray guns to keep them from inhaling overspray and hazardous vapors.**
  - Schedule paint jobs to start with light colors and end with dark ones so as to minimize cleaning between colors. Also, paint all products of the same color at the same time.
  - Scrape out paint cups and tanks before rinsing with solvent; this will make the solvent go further/last longer.

❑ *Hazardous and Non-Hazardous Waste Generation*

Metal finishing operations have many sources of non-hazardous and hazardous waste, including depleted or contaminated process baths, spent etchants and cleaners, waste from strip and pickle baths, exhaust scrubber solutions, degreasing solvents, and miscellaneous solid wastes (absorbants, filters, empty containers, etc.). Spills and accidental bath discharges, in particular, are an easily correctible source of hazardous waste.

Surface preparation for metal coating generally involves removing soils and imperfections such as oxidation, rust, corrosion, heat scale, tarnish, smut and old paint. The process of removing these flaws generates waste oils and/or greases, as well as waste solvents and cleaners. Clean-up of spray guns, hoses and other paint equipment generates paint sludge and waste solvent. Also, expired chemicals and paints are waste materials that require special disposal considerations.

Cleaner production can help reduce the amount of hazardous and non-hazardous wastes generated by (1) preventing spills and leaks, (2) retraining employees, and (3) maximizing the efficiency of operations to use fewer inputs. These methods are discussed in detail below.

Key Questions to Consider:

- What types of wastes does the facility generate?
- Do these wastes contain hazardous chemicals and/or toxic metal concentrations?
- How are you disposing of these wastes? How much does it cost to dispose of these wastes?

Selected Mitigation Strategies:

- **Use inventory controls.**
  - Ensure materials are labeled with expiration dates; use a first-in, first-out policy to minimize the amount of expired materials.
  - Secure storage areas, and grant access to only a few designated employees.
  - Require a one-for-one exchange policy, where workers must return an empty container in order to receive a new container. This will control the number of open containers, reducing the risk of spills, contamination and wasted materials.
- **Prevent spills**.
  - To prevent losses due to spills, purchase chemicals in the smallest possible quantities. When economic needs require purchasing chemicals in bulk, use spigots or pumps to transfer materials from large storage containers to smaller “working” containers to minimize drips and spills.
  - Keep containers tightly sealed at all times to prevent spills and evaporation of volatile chemicals.
  - Material storage areas should have a spill containment system such as a concrete pad with earthen berms enclosing the area.

- Install drainboards between tanks. (A drainboard is a board that is placed over the lips of two adjacent tanks to catch drag-out.) Ensure that the drainboard is tilted to allow drag-out to flow back into the earlier tank in the process.
- Prevent and contain spills and leaks with drip trays and splash guards around processing equipment.

- **Prevent leaks**. Create regular inspection and maintenance schedules for process equipment and filters. Prevent leaks by frequently inspecting piping systems, racks, storage tanks, tank liners, air sparging systems, and automated flow controls.
- **Make sure process controls are accurate**. Setting up schedules for calibrating all temperature controls , speed controls, and pH meters is a no-cost, preventative measure to ensure that operating conditions meet production requirements, reducing the number of substandard parts as well as energy, water, and raw materials usage.
- **Hold training sessions** to instruct employees on the proper handling of chemicals in order to reduce spillage and to minimize leaks and evaporative losses, which reduces supply and clean-up costs. Training can include low-cost, effective techniques such as:
  - proper use of spouts, funnels, and drip pans during material transfer.
  - use of drainboards to reduce drag-out.
  - maintaining liquids in tanks at the correct levels to reduce spilling from overflows.
  - use of containment berms to contain spills.
- **Prevent substandard parts.**
  - Sort for substandard parts and set them aside before electroplating or painting to prevent unnecessary operations.
  - Preparing surfaces well is key to preventing parts from failing to meet coating requirements; 80 percent of coating adhesion failures can be attributed to improper surface preparation.[8]
- **Reduce contamination of baths.**
  - Reduce contamination of bathwater, and thereby reduce the costs of replacing it with new bathwater, by ensuring that any dropped parts and tools are immediately retrieved. Locate rakes near baths to help pull dropped items out of the bathwater.
  - Clean racks between baths to minimize contamination.
  - Install a rain cover for outdoor tanks so that rain will not dilute chemicals.

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[8] See Northeast Waste Management Officials Association, 1998

- In areas with “hard water” (water with high concentrations of calcium, magnesium, chloride, or other soluble minerals), use softened, distilled, or deionized water for rinsing in order to reduce contaminant build-up in baths. This will result in less drag-out and generate less sludge.
- Use electrowinning to remove unwanted metal contaminants from plating solutions, such as copper contaminating zinc-and nickel-plating baths. Electrowinning involves placing a sheet of metal in a bath and running a low current through it. This allows the copper, for example, to attach to the metal plate, leaving the rest of the solution intact. Although small amounts of the plating metals will be removed along with the copper, generally the cost of replacing them is offset by savings from extending the overall life of the bath.

- **Reduce waste in painting operations.**
  - Use various sizes of paint-mixing and sprayer cups to make it easier to prepare only the amount of paint needed.
  - Use old paint as a base coat or primer.
  - Prevent nozzle tips for spray containers from clogging by inverting the can and spraying the nozzle to clear any residual paint. Repair clogged aerosols by cleaning or replacing the nozzle tip.

- Ensure that a spray gun’s air supply is free of water, oil and dirt. Prevent spray gun leaks by submerging only the fluid control portion in cleaning solvents.

❑ *Air Pollution*

Vapor degreasing operations and hot plating baths generate used solvents that emit volatile organic compounds (VOCs). VOCs can cause serious health problems for workers, and they also contribute to air pollution in the lower and upper reaches of the atmosphere. Poor handling practices can result in the loss of as much as 30 percent of solvents and degreasing agents. This can be a significant cost, as these chemicals would otherwise be re-used. VOCs are also emitted during paint application, curing and drying.

In general, some sort of pollution control investment will be necessary to fully control air emissions from metal finishing facilities. Cleaner production can help to reduce air pollution by preventing solvents from escaping into the air (i.e., volatilizing) and improving the efficiency of pollution control systems. These methods are described in detail below.

Key Questions to Consider:

- What types of air emissions are generated at the facility?
- What methods are being used to control these emissions?

Selected Mitigation Strategies:

- Cover the degreasing unit during idle or down times to prevent solvent from volatilizing.
- Use a speed of 10 feet per minute or less to remove parts from solvent in order to minimize disturbance of the "vapor line"—the volume of air above the surface of the solvent that is saturated with solvent vapor. Rapid movement of the parts or basket disrupts the vapor zone, which allows new air to mix in with the vapor and then to escape the degreaser or bath, taking some of the vapor with it. Increasing the freeboard height above the vapor level to 50–100 percent of tank width will also help keep air from mixing with the vapor and reduce loss of solvent.
- Exhausts should be treated to reduce VOCs and heavy metals before venting to the atmosphere. Carbon filters can both reduce VOC levels and allow employees to recover solvent using steam stripping and distillation.
- Use mist collection and scrubbing systems to control vapors and mists from process baths.
- Use noncaustic paint removers such as alkaline or non-phenolic strippers to reduce phenol emissions.
- Use waterborne, powder, UV-curable, or high-solids paints instead of solvent-borne options. If solvent-based coatings must be used, consider alternative application technologies such as roller/curtain coating; tumbling, barreling, and centrifuging; or HVLP sprays.

❑ *Wastewater Problems*

Metal finishing, especially electroplating, generates large quantities of wastewater, primarily from rinsing between process steps. Because of the hazards to the community associated with the chemicals involved in metal finishing operations, wastewater should always be treated before disposal into ground or surface waters. Improperly treated wastewater can contaminate drinking water and irrigation supplies, with long-term consequences for the health of the local population, including employees.

Cleaner production can best help reduce impacts of wastewater by reducing the toxicity of the wastewater at the source. Once options for reducing source pollution are used, however, it will still be necessary to build or share use of a wastewater treatment plant. In order to be effective, wastewater treatment plants need to be properly designed for the types of wastes to be treated and the volumes of wastes generated. Operating such plants can be costly, although in areas where water is scarce or expensive, treating wastewater may help pay for itself by permitting re-use of water in facility operations.

Key Questions to Consider:

- What are the sources of wastewater at the facility?
- What types of contaminants are in the wastewater?
- How is the wastewater being treated before disposal?
- What options exist for reducing the volume or toxicity of wastewater generated?

Selected Mitigation Strategies:

- A waste treatment plant should treat wastewater to destroy cyanide, equalize flows, neutralize pH, and remove toxic metals.
- Separate waste streams. If cyanide and acidic wastewaters mix, it can generate lethal hydrogen cyanide gas. Also, nickel solutions must be separated from cyanide and ammonium solutions in order to allow nickel to precipitate out of solution.
- Treat degreasing baths separately, since the oils and grease in the wastewater will interfere with any metal precipitation processes.
- Use a reducing agent such as a sulfide to reduce wastewater containing hexavalent chromium, which is water-soluble, to trivalent chromium, which is insoluble. Add lime to the wastewater to precipitate out the chromium, and dispose of the solids in a sanitary landfill.
- Use sodium sulfides and iron sulfates to remove metal from rinsewater instead of tartarates, phosphates, EDTA and/or ammonia.
- Sludge from water treatment operations must be treated before disposal in order to control metals. Use electrolytic methods to recover metals from the sludge when metal concentrations are high. Sludges should be thickened, dewatered, and stabilized with lime before disposal in a controlled landfill. Oxidize chromium acid wastes with sodium bisulfite and sulfuric acid. Use magnesium oxide instead of caustic soda to adjust pH.

❑ *Water Use*

Metal finishing requires water in almost every stage of the process. Many metal finishing businesses have yet to seize major opportunities to reduce their water use. Often, limited water resources in an area must satisfy the needs for public drinking water, sanitation, irrigation, river transport and industrial needs. Inefficient use of these resources for metal finishing can leave insufficient or highly polluted waters in lakes, rivers and wetlands, degrading their ability to perform crucial economic and ecological functions. Water efficiency also has numerous financial advantages for an MSE, most notably the decrease in the water bill and in wastewater treatment costs. There are various cost-effective ways for metal finishing enterprises to reduce their water use that could provide substantial savings.

Key Questions to Consider:

- What type of rinsing technique is currently being employed?
- Is fresh water used in every new bath? Could some water be reused?
- Is there a system in place that measures the number of liters or gallons of freshwater used at various stages of the metal finishing process?

Selected Mitigation Strategies:

- **Ensure the proper design of rinse tanks** in order to improve rinsing efficiency, reduce water use, and reduce drag-out. Tanks should be the smallest size necessary for all parts/products that will be used in them, in order to reduce water usage. Using a static rinse tank before a running rinse tank will reduce drag-out in the running rinse tank, using less water for the same degree of cleanliness.

  Carefully placing water inlets and outlets on opposite ends of the tank will maximize water mixing in the tank, improving the effectiveness of the rinse. Inlet flow baffles, diffusers, distributors or spray heads can also help control the injection of freshwater into the rinsing tank and aid in mixing the water. Also, adding air blowers, mechanical mixing, or pumping/filtration systems can improve mixing by agitating tank water. Mechanical agitation is preferable to air agitation, however, since air blowers can introduce contaminants like oil into the bath.

- **Consider alternatives to tank rinsing.** Tank rinsing may not be the most water-efficient solution for rinsing certain types of parts. Consider spray rinsing instead of immersion for flat-surfaced parts. Ultrasonic rinsing works well for cleaning parts with small crevices or irregular shapes.

- **Employ a flow control technique.** Three effective flow control techniques are flow restrictors, flow cut-off valves, and conductivity meters and controllers. Flow restrictors ensure that excessive water is not fed to the process line. Flow cut-off valves are simple mechanisms that shut off water flow to rinse tanks when the process lines are not in use. Conductivity meters and control valves reduce rinse water flow and retain a set standard of water purity in the tank (electrical conductivity increases as the concentration of contaminant ions increases).

- **Measure usage at individual production points.** Install an inexpensive flow meter or accumulator on the main water feed line (leading to the process line) or on individual rinse tanks. Flow meters indirectly conserve water by allowing careful monitoring of usage and can identify optimum water usage (or excessive waste), leaks, and system failures.

- **Implement an alternative rinsing configuration.**

  Counter-current rinsing: This involves having rinse water circulated through a series of rinse tanks. Fresh water (preferably deionized) is fed into the rinse tank farthest from the process tank and overflows to the rinse tank closest to the process tank. The work piece is dipped in the cleanest water last. Counter-current rinsing uses significantly less water than a single flowing rinse. **Two counter-current rinse tanks can reduce water use by 90 to 97 percent.**

Reactive rinses and reuse: This system diverts the overflow from an acid rinse to an alkaline rinse tank. The reuse of acid rinse baths for alkaline cleaner rinses makes the alkaline cleaner rinse more effective, typically reducing water consumption by 50 percent.

Spray rinsing: Spray rinsing reduces the water needed for final rinsing by spraying drag-out back into its process tank or into a concentrated holding tank. Spray rinsing works best for flat sheets, or in conjunction with immersion rinsing for irregular objects.

- **Change the mechanics of the rinsing process.** Rinsing is more effective when the parts are dipped into the rinsing tank multiple times than when parts are dipped once and agitated while submerged. **Dipping parts twice in rinse baths is 16 times more effective at reducing drag-out than dipping once.**[9]

- **Re-use treated wastewater for minor rinsing steps,** such as after alkaline cleaners and acid pickling steps. Note: Caution should be exercised in re-using wastewater that has been conventionally treated (via hydroxide precipitation) as it can introduce high amounts of dissolved solids into the plating line.

[9] Source: *CP Manual for the Metal Finishing Industry*, 1998.

References and Other Resources

References consulted in preparing this fact sheet:

- *CP Manual for the Metal Finishing Industry* (1998). Developed by the UN Environment Programme Working Group for Cleaner Production and the Cooperative Research Centre for Waste Minimisation and Pollution Control Ltd on behalf of the Queensland Department of Environment and the Brisbane City Council. http://geosp.uq.edu.au/emc/cp/res/Metal%20Finish/Metal%20Finish_manual.htm

  Completed in April 1998, this manual provides information about CP opportunities within the metal finishing industry, to point the way towards greater profitability and improved environmental performance. It focuses on those aspects which are most achievable in the short and medium term, and which require limited effort or expense.

- The International Cleaner Production Information Clearinghouse (ICPIC) at http://www.uneptie.org/PC/cp/library/icpic.htm.

  The ICPIC was developed by the UN Environment Programme's Division of Technology, Industry, and Economics (DTIE) for the effective promotion of CP worldwide. The ICPIC contains a compilation of CP case studies, CP contacts, profiles of CP-related national policies and CP publications. Case studies used in preparing this fact sheet include:

  - *EP3: Pollution Prevention Assessment for a Metal Finishing Facility* http://www.p2pays.org/ref/10/09356.htm

  - *Toxic Waste Reduction in Chrome Plating* http://www.p2pays.org/ref/10/09381.htm

  - *Cleaner Production for Reducing Water Consumption at a Metal Plating Industry* http://www.p2pays.org/ref/10/09110.htm

  - *Eco-efficiency at a Metal Finishing Factory in the Czech Republic* http://www.p2pays.org/ref/10/09160.htm

- *Management Options for Old Paint and Paint-Related Materials* (1995). Minnesota Technical Assistance Program (MnTAP) Fact Sheet. http://www.p2pays.org/ref/01/00609.pdf

  This fact sheet provides information on how to effectively reduce and manage wastes from painting operations. These include (1) *ignitable wastes*, such as solvents and other cleaners; paints and paint thinners; and adhesives and glues, and (2) *toxic wastes* with heavy metals.

- National Metal Finishing Resource Center. http://www.nmfrc.org/

  The National Metal Finishing Resource Center (NMFRC) is an Internet-based organization established in 1995 under a program jointly funded by the U.S. Commerce Department's National Institute of Standards and Technology (NIST) and the U.S. Environmental Protection Agency (USEPA). Their site is a comprehensive collection of environmental and technical resources for pollution prevention in metal finishing, including a searchable technical database containing over 5,000 articles, papers and reports; specifications (with index) used in metal finishing; shop, supplier and people directories containing over 6,000 entries; and online calculators designed for finishing needs.

Their "Ask the Expert Question-and-Answer Archives" on wastewater treatment were used in creating this fact sheet. http://www.nmfrc.org/wwarchive/aug02b.cfm

- North Carolina Department of Environment and Natural Resources, Division of Pollution Prevention and Environmental Assistance. http://www.p2pays.org/

  This Web site offers an extensive collection of resources on CP and pollution prevention for a variety of industry sectors. The page on waste reduction in electroplating (http://wrrc.p2pays.org/industry/electroplating.htm) houses an excellent online collection of technical resources for the metal plating industry. Several "Fact Sheets" linked to this Web site that were used in preparing this CP fact sheet include:

  - *Water Efficiency, Industry-Specific Processes: Metal Finishing*. http://www.p2pays.org/ref/04/03097.pdf
  - *Water Conservation for Electroplaters: Counter-Current Rinsing* http://www.p2pays.org/ref/01/00051.htm
  - *Pollution Prevention Tips: Drag-out Management for Electroplaters* http://www.p2pays.org/ref/01/00222.pdf
  - Ben Graves. *Never Dump Cleaner*. http://www.p2pays.org/ref/02/01366.htm
  - Virginia Waste Minimization Program (1995). *Fact Sheet: Waste Reduction for Metal Finishers*, 1 (4). http://www.p2pays.org/ref/11/10308.htm

- Northeast Waste Management Officials' Association (1998). *Pollution Prevention in Metal Painting and Coating Operations: A Manual for Pollution Prevention Technical Assistance Providers.* http://www.p2pays.org/ref/01/00777/toc.htm

  The Northeast Waste Management Officials' Association (NEWMOA) designed this manual to provide environmental assistance staffers with a basic reference on metal finishing—a single publication to jump-start their research on pollution prevention for companies with which they are working. The manual is explicitly designed to be useful both to assistance professionals with experience working with metal platers and to those who have never encountered metal finishing before. The USEPA Pollution Prevention Division funded this manual as a model of a comprehensive packet of information on a single industry.

- Pallen, Dean (1997). *Environmental Sourcebook for Micro-Finance Institutions*. Asia Branch, Canadian International Development Agency. http://www.microfinancegateway.org/files/1914_Pallen_Dean.pdf

This sourcebook describes the environmental impacts of a variety of important MSE sectors. It is designed to help micro-finance institutions improve the environmental performance of their lending activities, and offers guidance for improving MSEs' economic performance as well.

- Pennsylvania Department of Environmental Protection (1997). *Pollution Prevention Opportunities for Painting and Coatings Operations.* http://www.p2pays.org/ref/01/00151.pdf

  This fact sheet describes alternatives for reducing releases of volatile organic compound (VOCs) from solvents, as well as good operating practices for painting operations.

- U.S. Environmental Protection Agency (1994). *Guide to Cleaner Technologies: Alternative Metal Finishes*. EP/625/R-94/007. http://www.p2pays.org/ref/02/01052.pdf

  This guide presents information on process alternatives that can reduce or eliminate generation of some wastes and emissions from metal finishing operations. It is particularly applicable to firms that apply cadmium and chromium finishes, as well as to finishers that use cyanide-based baths or copper/formaldehyde solutions.

Additional Useful Web sites

- Business Assistance. *Metal Finishing Industry Resources* http://pprc.org/hubs/toc.cfm?hub=24&subsec=7&nav=7

  This site catalogs a variety of metal finishing resource sites. It maintains links to several metal finishing trade associations as well as a database of current research projects. A joint project of the Business Assistance Programs in Alaska, Idaho, Oregon and Washington, the site is funded by a grant from USEPA.

- Cleanerproduction.com offers two catalogs of sites relevant to the metal finishing industry:

  http://www.cleanerproduction.com/Directory/sectors/subsectors/metalplating.html and http://www.cleanerproduction.com/Directory/sectors/subsectors/metalproducts.html.

  The site is run by Hamner and Associates LLC, based in Seattle, Washington, USA, and Manila, Philippines.

- http://www.svti.sk/CleanVOC.htm is an annotated guide to resources available on the Internet for metal finishers.

Chapter 4.5
Small-Scale Mining: Cleaner Production Fact Sheet and Resource Guide

Purpose

This fact sheet offers basic information on the important adverse environmental impacts of small-scale mining, as well as associated health and safety impacts. It also discusses opportunities for mitigating those impacts, with an emphasis upon "cleaner production" strategies that may also provide financial benefits to micro- and small enterprises (MSEs). In addition, each fact sheet offers a substantial, annotated list of resources for organizations seeking more information.[10]

This fact sheet has been prepared for (1) **business development services (BDS) providers**, which offer services such as management training or marketing support to MSEs, and (2) **intermediate credit institutions (ICIs) and direct lenders** that provide financial credit to MSEs. It is intended to be used in concert with other sections in Part III of the *Environmental Guidelines for Small-Scale Activities in Africa: Environmentally Sound Design for Planning and Implementing Development Activities,* which is USAID Africa Bureau's principal source of sector-specific environmental guidance.

Why Focus on Cleaner Production for Mitigation?

Cleaner production is a preventive business strategy designed to conserve resources, mitigate risks to humans and the environment, and promote greater overall efficiency through improved production techniques and technologies. Cleaner production methods may include:

- substituting different materials
- modifying processes
- upgrading equipment
- redesigning products

[10] At the time of writing, USAID cleaner production fact sheets are available for the following subsectors that are likely to have substantial adverse impacts on the environment and/or workers' health: brick and tile production; leather processing; small-scale mining; food processing; metal finishing; wood processing and furniture making, and wet textile operations.

In addition to environmental, health and safety benefits, many cleaner production techniques provide opportunities to substantially reduce operating costs and improve product quality. MSEs can profit from CP through more efficient use of inputs and machinery, higher quality goods that can command higher prices, and reduced waste disposal costs. Improved safety measures can also help MSEs avoid costly accidents and worker absences.

Experience has demonstrated that, with assistance, MSEs can frequently identify cleaner production opportunities that produce a positive financial return, sometimes with little or no investment. Many enterprises that change to CP methods may realize substantial financial and environmental benefits, indicating that CP should be the first option considered in addressing MSEs' environmental problems.

Yet, although this approach can offer tremendous advantages, readers should also recognize that cleaner production options showing clear financial benefit will only be available to varying degrees among different enterprises and often may not completely mitigate environmental problems. In some cases, even when pursuing CP techniques, some businesses may need to use solutions that offer no measurable financial return—if such solutions are required by USAID's Regulation 216 or local regulations or desired for other reasons, such as community goodwill.

Small-scale mining activities can generate many kinds of environmental damage. It is important to ensure that they use resources more efficiently and that they prevent serious health problems from occurring.

Adverse Environmental Impacts and Mitigation Opportunities

Several key environmental issues associated with small-scale mining are listed in the box at right and discussed below. For each environmental impact, the fact sheet provides a list of questions to assist in the assessment of individual MSEs. These questions are followed by a number of mitigation strategies that can be considered, with an emphasis on cleaner production strategies where possible. The strategies presented typically represent a range of available options, from profitable activities that require no investment to other activities that may increase MSE costs.

Important Environmental Issues Addressed by This Fact Sheet

- Open pit mining
- Mercury use
- Inefficient extraction
- Dust
- Noise
- Underground hazards
- Long-term hazards

❑ *Open pit mining*

Open pit mining activities can alter the landscape in ways that are potentially dangerous and costly. Excessive land clearing or steeply sloped pits can lead to landslides that destroy working sites, harm workers, or block waterways. Costly work stoppages, loss of future mining sites, or damage to water bodies may result.

Key questions to consider:

- Is the structure of the pit stable?
- How much loose rock or soil is above the work site?
- Does each rainfall move significant amounts of soil?

Selected mitigation strategies:

- Before mining starts, assess the site and see how close it is to sensitive resources (e.g., unique ecological, cultural, historical or archeological sites or areas of scenic value). Assess the full range of alternatives for avoiding or minimizing impacts on these resources, including selecting an alternative site or taking no action at all.
- Once a mining site has been selected, assess the full extent of the resource. Devise a engineering plan for reclaiming and restoring the mined area at the same time the resource is being extracted. If owners or managers do not know the extent of the resource, many mines remain open longer than is useful and restoration is delayed indefinitely. If possible, engage a geotechnical engineer and landscape architect to help develop the mine extraction and reclamation plan.
- If land is being cleared, try to leave enough trees and vegetation to prevent soil erosion. Use cleared brush or other materials to create erosion barriers.

- Ensure that the road leading to the mine is well-designed, with low slope and good drainage to keep water off the road. (See the chapter on rural roads in the *Guidelines*.) Avoid creating roads that pass close to sensitive resources (e.g., forests or wetlands).

- While mining, where feasible, avoid creating pits that will accumulate water, presenting health and safety hazards (e.g., dangers from drowning and creation of breeding grounds for mosquitoes).

- Plant vegetation on the site before leaving the area. Bare soil causes landslides, which can occur both before and after mining activities are completed. Landslides may destroy working sites and make future mining more difficult. Landslides may also kill workers, innocent community members, and animals, and they can seriously damage the local ecology.

- Angle the mine's pit faces to prevent unexpected collapse. This preserves the investment in excavation, guaranteeing a longer life to the working site and less danger for those working inside. It may be necessary to disturb additional land in order to make the angle less steep, but take care to disturb as little land as possible.

- Retain topsoil for later use in reclaiming the site. Segregate other subsurface materials which might have potential value in construction or road works. Store these materials away from water bodies to reduce the potential for cumulative siltation, interference with water flows, and subsequent damage to ecosystems, as well as to the people who depend on these for their livelihood.

❑ *Mercury*

Using mercury to extract gold or silver from ore can severely affect worker and community health. Mercury entering the human body may cause kidney problems, headaches, tremors, comas and other serious health problems. It is especially hazardous to children. Mercury exposure can occur directly, through physical contact, or indirectly, through contaminated water or fish. Mercury poisoning will result in the loss of skilled labor and long-term damage to communities. Reducing mercury use may also lower production costs, although in many countries the cost of mercury is low.

Key questions to consider:

- Do managers or workers experience tingling or tremors in fingers or toes?

- Does the business use mercury to process ore near a water source or in your home?

- Where does the business dispose of water with mercury in it?
- Does the business use extra mercury to speed up the extraction process?

Selected mitigation strategies:

- Recognize mercury poisoning. In the short term, high levels of mercury exposure result in tingling and tremors in fingers or toes. Be aware of the signs and reduce contact before long-term damage occurs.
- Dispose of mercury-contaminated water far away from water sources, fish-bearing waterways, and human settlements. Make sure rain cannot wash away mercury or mercury-contaminated materials.
- Avoid inhaling mercury vapor. Try to recycle mercury, and avoid emissions by using an open oven to capture and condense mercury vapor for reuse. This method can save money on the purchase of mercury. In addition, heat amalgam in a well-ventilated room or outside, to allow any mercury vapor to disperse.
- Reduce mercury use through more efficient production. For example, miners frequently overuse mercury during amalgamation. Miners should use only the correct amount of mercury, since additional mercury does not speed or improve the amalgamation process—it only increases costs and risks. Miners should avoid grinding and amalgamating at the same time. Separating these processes helps ensure that mercury is not overused.

❑ *Inefficient extraction*

Mining wastes often pose serious threats to human health and wildlife, and have persistent and hazardous impacts to groundwater, surface waters, and soils. Small-scale mining often uses inefficient extraction methods that result in substantial loss of the product. Finding and removing ore from pits with inadequate or poorly operated machinery reduces yields. Crude processing technologies can lead to lost earnings and more waste.

Key questions to consider:

- How often does the business conduct maintenance or repairs on machinery?
- How much waste is produced for a given amount of product? Could this waste be reduced?
- Have workers been trained in operating machinery efficiently and safely?

Selected mitigation strategies:

- Maintain machinery. To maximize efficiency, make sure machinery is working properly and train workers in operating and maintaining it. Ensure that operators are keeping maintenance logs.

- If little or no machinery is used, consider low-cost technologies that may increase yields. Improving separation methods, such as by using sluices or gravity centrifuge machines, increases productivity and reduces waste.

- Evaluate mining techniques to see if product is being lost in the extraction process. Check rock waste or the extraction area to see if mineral is being wasted or if potentially valuable mineral veins are being destroyed. Train workers in proper techniques for identifying and removing ore.

❑ *Dust*

Dust generated by rock, metal and coal mining can be harmful. Using wind to separate metal from ore, or using machinery that generates rock dust, can lead to silicosis. Silicosis is a disease caused by inhaling silicates in the dust of crushed rocks; it can severely decrease workers' lung capacity and productivity, and it sometimes results in their deaths.

Key questions to consider:

- How much dust is produced in a typical working day?

- What protective materials are available?

- Is ore being ground or crushed by hand?

Selected mitigation strategies:

- Small-scale mines can produce a substantial amount of dust; maintain tree or vegetation cover to capture dust and prevent dust clouds from traveling long distances.

- Ventilate underground mines so dust can escape and ease working conditions.

- If possible, wet materials so less dust is produced. Use water when running a pneumatic drill. Dampen ore before crushing in a mortar and pestle. However, use water conservatively to avoid wasting this resource, and prevent water used in these activities from contaminating other water sources.

- Avoid crushing or grinding ore in the home. The transport of raw ore to the home can be inefficient. In addition, this practice produces a great deal of dust since it is often done by hand, and most homes are not properly ventilated. This makes workers and their families, especially small children, particularly vulnerable to silicosis.

- Provide all workers with face masks and instruct them to wash their hands after working so they will not ingest dust with their food.

❑ *Noise*

Mining activities can involve equipment that can be very noisy or cause strong vibrations. This can affect workers' hearing and health, as well as the community around the working site. This may work against the enterprise's ability to expand production in the future.

Key questions to consider:

- Are some machines louder than others?

- Is machinery left running when not in use?

Selected mitigation strategies:

- Provide earplugs for workers.

- Repair and maintain machinery so that excessive grinding or squeaking is minimized. Frequent repair and maintenance will typically also make the machinery operate more efficiently, reducing fuel costs.

- Provide protective insulation or cushioning to those working with vibrating machinery.

- Use machinery efficiently. Do not run machinery longer than necessary. This saves energy and reduces environmental damage.

- Try to use noisy machinery only at times when the surrounding community is least likely to be disturbed. For example, it may be better to operate such machinery during the daylight hours.

❑ *Underground hazards*

Underground mines are often hazardous to work in and are extremely susceptible to major accidents. Poorly constructed mining spaces can lead to injuries that reduce productivity, as well as large-scale accidents that destroy working sites.

Key questions to consider:

- How old is the mine?
- What kind of supports are in the walls and ceilings? Are these supports in good condition?
- How are explosives used to clear new spaces?
- Is the site for the mining operation geologically stable?
- Is the site subject to periodic flooding?

Selected mitigation strategies:

- Eliminate minor safety hazards. For example, construct underground space so that falls are minimized. Make passageways wide and tall enough to accommodate workers comfortably. Workers who cannot walk or stand normally are apt to suffer from debilitating chronic musculoskeletal injuries that reduce their productivity.
- Use explosives wisely. Explosions can weaken underground structures and cause cave-ins. Any worker using explosives should have training in their proper and safe use. Take care to evacuate the mine before detonating any explosives, even when trained personnel are using them.
- Ventilate coal mines well to reduce excessive heat and dust and minimize chances of spontaneous fires. Sink new shafts or widen existing mine openings to increase airflow. Doing so can improve worker health and productivity and decrease the risk of destroying the mine through an accidental explosion.
- Reinforce walls and ceilings to avoid an unexpected collapse of the mine. When working in older and abandoned mines, be aware that removing pillars or wall supports to extract ore can quickly lead the mine to collapse.

❑ *Long-term hazards*

The environmental impacts of even a short-term mining operation often last many years, even centuries, beyond the working life of the mine. Unless they are mitigated, contaminated waste, hazardous mine structures and disturbed land can pose problems long after mining operations close. Adequate waste disposal and careful mine closure represent additional cost to the mining operation, but may reduce community and government opposition to future mining activities.

Key questions to consider:

- How will time affect waste disposal sites or mine structures?
- Has the landscape significantly changed as a result of mining activities?
- How will the community use the mine area in the future?

Selected mitigation strategies:

- Seal underground mines. Cover entrances to underground mines so they do not present safety hazards.
- Construct waste disposal sites that will last. Make sure tailing ponds or chemical waste dumps are secure and can withstand severe weather.
- Plant trees. This prevents landslides and keeps remaining topsoil on the land.

Mining is dangerous for both workers and local communities. Be sure that small mining operations are aware of safety measures and protect workers and community health.

❑ *Mining camps and mine workers*

Mining activities are sometimes undertaken by transient groups of laborers who come in from outside and can indirectly lead to social and sanitation problems. Unsanitary living conditions in mining camps can spread contagious diseases like dysentery and typhoid. Epidemic disease disrupts work and can destabilize communities. Unsafe sex practices can promote the spread of AIDS. Social problems may occur, including gambling, alcohol abuse, theft, violent behavior and prostitution.

Key questions to consider:

- Where is human and food waste disposed of?
- How often do people get sick? Are there any nearby medical facilities?
- What water sources are available?
- What kinds of social problems exist at other small-scale mining sites in the region?

Selected mitigation strategies:

- Improve sanitary measures. Construct enough toilet facilities and make sure they cannot contaminate water sources. Ensure that there are enough water sources for workers to wash themselves, and promote clean food preparation.
- Educate workers about HIV/AIDS and other sexually transmitted diseases (STDs). Encourage the use of safe sex practices.
- Establish miners' committees for health, safety and welfare. Create mechanisms for democratic self-policing.

References and Resources

- *Developments in Small-Scale Mining* (1996). Committee on Natural Resources, Report of the Secretary-General, United Nations.

- Jennings, Norman S. ed. *Small-Scale Gold Mining: Examples from Bolivia, Philippines and Zimbabwe*. Industrial Activities Branch Working Paper, International Labour Organization (ILO). <date available?>

  http://www.ilo.org/public/english/dialogue/sector/papers/goldmine/index.htm. This document is a case study of three pilot projects in small-scale mining. A practical example of problems and solutions in mining activities; it includes a section on lessons learned as well as examples and diagrams of alternative amalgamation machinery.

- "Mercury." *The Pollution Prevention Abatement Handbook* (1998).World Bank.

  http://www.ifc.org/ifcext/enviro.nsf/Content/PPAH. A good explanation of the hazardous characteristics of mercury and the different health impacts of mercury exposure.

- *Social and Labour Issues in Small-Scale Mines*. Report for discussion at the Tripartite Meeting on Social and Labour Issues in Small-Scale Mines, in Geneva, 17–21 May 1999. International Labour Organization (ILO).

  http://www.ilo.org/public/english/dialogue/sector/techmeet/tmssm99/tmssmr.htm. An excellent discussion of health issues associated with small-scale mining. Attention is paid to solutions to occupational health and safety issues, including reducing mercury use and decreasing the incidence of silicosis.

- "Surface Mining." In *Environmental Handbook: Documentation on Monitoring and Evaluating Environmental Impacts,* Vol. 2.German Federal Ministry for Economic Cooperation and Development (GTZ).

  http://ces.iisc.ernet.in/energy/HC270799/HDL/ENV/enven/vol212.htm. A short discussion of two different methods of surface mining—wet and dry extraction—and the environmental impacts associated with them. Contains information more relevant to medium than small mining operations.

Other Resources

- Acquah, Peter Claver. *Natural Resources Management and Sustainable Development: The Case of the Gold Sector in Ghana* (1996). Ghana: Environmental Protection Council. United Nations Conference on Trade Development.

  http://www.mineralresourcesforum.org/docs/pdfs/G9552829.PDF. A case study of natural resource management and sustainable development in the gold mining sector of Ghana. This document sets out the main environmental and socioeconomic impacts of gold mining, including water pollution, land degradation and effects on coastal and marine resources.

- *Chemicals Management: DAC Guidelines on Aid and Environment* (1993). The Organisation for Economic Co-operation and Development (OECD).

http://www.oecd.org/dataoecd/37/5/1887724.pdf. This document targets aid agencies and the need for chemical management programs. It briefly discusses the dangers of certain chemicals, including mercury, and the capacities required for adequate chemicals management.

- Maponga, Oliver and Anderson Mutemererwa (1995). *Management of Natural Resources and the Environment in Zimbabwe: The Case of Gold.* University of Zimbabwe, The Institute of Mining Research. United Nations Conference on Trade and Development.

  http://www.mineralresourcesforum.org/docs/pdfs/g9550334.pdf. A case study of natural resources management and sustainable development in the gold sector of Zimbabwe. A description of the main environmental impacts from gold mining is followed by a discussion of economic development and legislation.

- McDivitt, James F. (1990). *Small-Scale Mining: A Guide to Appropriate Equipment*. Intermediate Technology Publishing.

  http://styluspub.com/Books/BookDetail.aspx?productID=20833. A guide to available equipment on all aspects of small-scale mining, from prospecting and surveying through haulage, handling and transport. It includes a discussion of safety equipment. The book features world-wide coverage, with particular relevance to the developing world, and costs around US $28.

- McMahon, Gary, Jose Luis Evia, Alberto Pasco-Font and Jose Miguel Sanchez (1999). *An Environmental Study of Artisanal, Small, and Medium Mining in Bolivia, Chile, and Peru*. World Bank Technical Paper.

  http://www-wds.worldbank.org/servlet/WDSContentServer/WDSP/IB/1999/10/13/000094946_99092905340059/Rendered/PDF/multi_page.pdf. This paper synthesizes a study examining the environmental performance of artisanal, small, and medium mining in Bolivia, Chile and Peru. Includes summaries of the three country studies. Significant emphasis is placed on the viability of artisanal, small, and medium mines if environmental costs are taken into account, as well as policy actions to improve the environmental performance of viable mines.

- Priester, M., T. Hentschel and B. Benthin (1993). *Tools for Mining*. GTZ: Information and Advisory Service on Appropriate Technology, 537 p.

  http://sleekfreak.ath.cx:81/3wdev/CD3WD/APPRTECH/G10TOE/INDEX.HTM. This handbook serves as an information source for technicians, engineers and advisors associated with small-scale mining in developing countries. In the part of the handbook devoted to techniques, special attention is paid to (1) ensuring local production in developing countries, (2) offering environmentally friendly technologies and (3) taking into account the social and cultural conditions of the miners when selecting the techniques.

- *Regularizing Informal Mining: A Summary of the Proceedings of the International Roundtable on Artisanal Mining* (1996). Roundtable organized by the World Bank, Washington, D.C. May 17–19, 1995. World Bank Industry and Energy Department Occasional Paper No. 6.

  http://www.natural-resources.org/minerals/cd/ssm.htm#Workshops. A general discussion of the challenges associated with small-scale mining activities that often occur outside the reach of environmental or financial regulation.

- Zamora, Armando (2000). “Small Scale Mining: A Social and Environmental Problem Turned into an Opportunity for Economic Development.” *Internet Journal of the Centre for Energy, Petroleum and Mineral Law and Policy*, Vol. 6–6.

  http://www.dundee.ac.uk/cepmlp/journal/html/vol6/article6-6.html. This article discusses the economic development implications of small-scale mining in developing countries and possible sustainable and legal solutions to the industry’s social and environmental problems.

Chapter 4.6
Wet Textile Operations:
Cleaner Production Fact Sheet
and Resource Guide

Purpose

This fact sheet offers basic information on the important adverse environmental impacts of wet textile operations, as well as associated health and safety impacts. It also discusses opportunities for mitigating those impacts, with an emphasis upon "cleaner production" strategies that may also provide financial benefits to micro- and small enterprises (MSEs). In addition, each fact sheet offers a substantial, annotated list of resources for organizations seeking more information.[11]

This fact sheet has been prepared for (1) **business development services (BDS) providers**, which offer services such as management training or marketing support to MSEs, and (2) **intermediate credit institutions (ICIs) and direct lenders** that provide financial credit to MSEs. It is intended to be used in concert with other sections in Part III of the *Environmental Guidelines for Small-Scale Activities in Africa: Environmentally Sound Design for Planning and Implementing Development Activities,* which is USAID Africa Bureau's principal source of sector-specific environmental guidance.

Why Focus on Cleaner Production for Mitigation?

Cleaner production is a preventive business strategy designed to conserve resources, mitigate risks to humans and the environment, and promote greater overall efficiency through improved production techniques and technologies. Cleaner production methods may include:

- substituting different materials
- modifying processes
- upgrading equipment
- redesigning products

In addition to environmental, health and safety benefits, many cleaner production techniques provide opportunities to substantially reduce operating costs and improve product quality. MSEs can profit from CP through more efficient use of inputs and machinery, higher quality goods

[11] At the time of writing, USAID cleaner production fact sheets are available for the following subsectors that are likely to have substantial adverse impacts on the environment and/or workers' health: brick and tile production; leather processing; small-scale mining; food processing; metal finishing; wood processing and furniture production, and wet textile operations.

that command higher prices, and reduced waste disposal costs. Improved safety measures can also help MSEs avoid costly accidents and worker absences.

Experience has demonstrated that, with assistance, MSEs can often identify cleaner production opportunities that produce a positive financial return, sometimes with little or no investment. Many enterprises that change to CP methods may reap substantial financial and environmental benefits, indicating that CP should be the first option considered in addressing MSEs' environmental problems.

Dyes and other chemicals from textile processing can be recycled and reused, saving resources and costs for micro- and small enterprises.

Yet, although this approach can offer tremendous advantages, readers should also recognize that cleaner production options showing clear financial benefit will only be available to varying degrees among different enterprises and often may not completely mitigate environmental problems. In some cases, even when pursuing CP techniques, some businesses may need to use solutions that offer no measurable financial return—if such solutions are required by USAID's Regulation 216 or local regulations or desired for other reasons, such as community goodwill.

Important Environmental Issues Addressed by This Fact Sheet

- Water use
- Chemicals
- Improper use and poor maintenance of machinery and equipment
- Poor production practices
- Inefficient energy use
- Wastewater

Adverse Environmental Impacts and Mitigation Opportunities

Several key environmental impacts associated with wet textile operations are listed in the box at left and discussed below. For each impact, the fact sheet provides a list of questions to aid in the assessment of individual MSEs. These questions are followed by a number of mitigation strategies that can be considered, with an emphasis on cleaner production strategies where possible. The strategies presented typically represent a range of available options, from profitable activities that require no investment to other activities that may increase MSEs costs.

❑ *Water use*

Wet textile production requires water at almost every stage of the production process. If well or pump water is used, excessive water use can deplete water sources for future production or community use. Energy costs for pumping, as well as environmental impacts from energy consumption, will be higher than necessary. Excessive water use can lower the water table and require frequent redrilling of wells.

If the enterprise pays by volume for the water it uses, reducing water usage can be expected to provide substantial savings. Using water more efficiently guarantees less costly production and reduces the risks of water shortages that could interrupt production.

Key questions to consider:

- Is water left running when it is not in use?
- Is fresh water used in every stage of production? Could some water be reused?
- How much money does the business pay for water, and how much could it reduce that cost through more efficient use?

Selected mitigation strategies:

- Reuse water from “cleaner” stages of production in “dirtier” stages of the next production cycle. For example, use rinse water from the final stage of one production cycle in the first-stage rinsing of the next batch.
- Decrease water usage through “dry cleanup.” Dry cleanup involves initial cleaning without water (by sweeping or wiping down) before washing. This method reduces the amount of water required to dislodge solid or semi-solid wastes from floors or machinery.
- Regulate water flow. Using high-pressure water hoses can ease cleaning and cut water use; often this can be accomplished simply by adding a new nozzle to the end of a hose.
- Limit water loss between production stages. Turn off water when transferring materials from one bath to another, since leaving the water running causes substantial water loss. Prevent baths from overflowing by monitoring water levels closely or installing an automatic shut-off mechanism.

❑ *Chemicals*

Chemical dyes and solvents may represent a significant part of production costs; costs rise if chemicals are overused due to inefficient production methods. Excessive chemical use also increases risks of contamination and may affect the health of workers. Efficient chemical use lowers production costs and lessens environmental impacts.

Key questions to consider:

- Where are chemicals stored? In what quantities?
- Are workers trained in correct measurement and application techniques?
- Are different kinds of chemicals available for the same application? Are any more efficient, safer, or less harmful to workers' health or the environment?

Selected mitigation strategies:

- Improve chemical application techniques. Spot-apply solvents instead of pouring; this helps avoid spills and stops excessive chemical use. Use correct measurements to reduce waste or spoilage.
- Consider using less dangerous or damaging chemicals. Replace potentially carcinogenic (cancer-causing) chemical inks with vegetable-based inks. To reduce pollution, use lower-foaming detergents or solvents with less isopropyl alcohol.
- Reuse certain chemicals. Investigate which chemicals can be reused or recycled. Caustic soda, for example, can be recaptured from the mercerizing process (an intermediate step in textile refinishing) through evaporation.
- Improve chemical storage. Monitor storage area for signs of chemical leakage. Make sure containers are well built and have no cracks.

❑ *Improper use and poor maintenance of machinery and equipment*

Improper use of machinery or equipment can increase waste, raising costs for inputs and, often, for waste disposal. Chemical or fuel leaks from machinery waste energy, can contaminate water supplies, and may threaten workers' health. Better management of machines and equipment lowers costs and reduces losses.

Key questions to consider:

- How well are workers trained in machine operation and maintenance?
- Are machines used to their full capacity?
- Is equipment well maintained? Is there a regular maintenance schedule and checklist?

Selected mitigation strategies:

- Train workers in proper maintenance and operation of machines. Use machines at full capacity. This increases output and saves fuel.

- Use appropriately sized equipment. Equipment that is too large wastes water; equipment that is too small may lead to waste and spills.

- Minimize leakage and blockage in equipment. Monitor machinery to prevent fuel or water leakage; clean debris from sumps and screens to improve efficiency.

❑ *Intermittent Production*

Intermittent textile producers—job shops that produce textiles on a contractual basis—face production inefficiency and pollution problems similar to those of permanent producers, but these are made worse by the temporary nature of production. Advance planning can lessen waste that occurs in between production stages and reduce some of the inefficiencies.

Key questions to consider:

- How unpredictable are production requests? Do they follow a pattern?

- How are inputs or machinery stored in between production cycles?

Selected mitigation strategies:

- Increase production efficiency through improved record-keeping. Documenting production requests helps producers determine if there are any general production trends over time—for example, during certain seasons—and makes it easier for producers to anticipate demand. Maintaining a logbook of inputs also allows producers to check stocks and replace inputs if they are no longer effective.

- Maintain equipment even if it is not in use. Check equipment for leaks and repair immediately so that production will not be delayed when it restarts. Ensure that chemicals and dyes are stored in tightly sealed containers that do not leak.

- Plan input purchases to minimize leftovers (of chemicals, materials, etc.) once production has ended. Use minimum amounts of chemical or fuel inputs to increase efficiency and reduce losses in between production stages.

❑ *Working conditions*

Textile production may result in hazardous working conditions—excessive heat caused by operating machinery, lack of ventilation, skin-irritating chemicals—that can damage workers' health. Unhealthy workers may be less productive, miss work too often and make costly mistakes.

Key questions to consider:

- What kinds of fumes are produced in the different stages of production?
- Are there any by-products from production that cause skin, eye or breathing irritation, even occasionally?
- Are any of the chemicals used known to be potentially cancer-causing?
- Are gloves, boots, face masks or other protective clothing available for workers?

Selected mitigation strategies:

- Develop and implement a health and safety plan. Sometimes small changes such as buying face masks or rubber gloves can dramatically reduce potential harm to workers. Find ways of preventing accidents.
- Train workers in accident prevention. Designate one person as the safety trainer and have that person train others. Check existing safety equipment regularly; replace elements like filters frequently.
- Provide tight-fitting covers for chemical baths, to reduce sickening fumes and minimize evaporation of costly chemicals.
- Increase ventilation inside buildings and around chemical baths. Fumes from chemicals, even if the chemicals are outside, can sicken workers. Inside, increase ventilation by improving the building's layout. Outside, orient chemical baths downwind from workers and from other production areas. The use of fans, covers and/or chimneys can help minimize fume inhalation outdoors or indoors.
- Consider reorganizing production, such as by rotating shifts, so that individual workers do not spend too much time at once exposed to fumes.

Working conditions that guard workers' health and safety can help to increase productivity, lower costs, and make a small enterprise a better neighbor to the community.

❑ *Poor production practices*

Some common production practices use resources inefficiently and cause more pollution. For example, two common mistakes can cause unnecessary waste of inputs and extra water pollution: using too much salt in color fixing, and not properly matching colors among different batches. Salt is particularly damaging to water sources used for drinking water and agriculture, and can be difficult and/or expensive to remove from wastewater. Changing textile production in simple ways can reduce environmental harm, lower costs, and raise output.

Key questions to consider:

- How well are workers trained in production methods?
- Can two stages of production be combined into one?

- Where can improvements be made in the production process?

Selected mitigation strategies:

- Improve machines' efficiency. Controlling drafts and improving firing techniques in boilers saves fuel and speeds production.

- Train workers in proper use of salts and dyes. Require all workers to measure salts, and provide simple measuring equipment, e.g., measuring cups. To prevent wasting material from a bad dye mix, make a small test batch to determine whether a dye will yield the desired colors.

- Investigate alternative production strategies. Using hot water instead of cold to process fabric can save a scouring stage; note, however, that this may result in higher fuel costs. Improving the scouring process can reduce alkali consumption.

- Institute housekeeping measures to speed production, such as putting screens on drains, preventing boil-overs, and improving the vessels in which dyeing takes place to avoid leaks.

❑ *Inefficient energy use*

Most energy used in textile production occurs in heating dye baths and in rinsing and drying fabrics. Inefficient use or overuse of fuel during these production stages contributes to pollution and higher operating costs. Reducing use can save costly or scarce resources.

Key questions to consider:

- What type of fuel is used in production? In what quantities?

- What various fuel sources are available in your area? At what cost?

- Which production stages use the most fuel?

Selected mitigation strategies:

- Use alternative fuel types. Organic wastes, such as rice husks and bagasse, can supplement scarce fuel sources such as wood. Renewable energy sources, such as solar hot water heating or photovoltaic (solar) cells, may be a cost-effective option in some cases, but cost, availability and applicability of the technology should be carefully assessed.

- Improve heat transfer and insulation. Insulate pipes and bath containers to reduce energy loss and decrease fuel needs.

- Regulate fuel use to meet needs. Use only enough fuel to meet production requirements.

- Implement energy conservation methods. Use a thermometer to maintain the most efficient bath temperature. Make more efficient use of production time, and prevent excessive use of fuel (due to overheating or reheating baths). Consider planning the facility's production cycles to reuse bathwater that is still hot from a previous use.

❑ *Wastewater*

Wastewater from textile production is often contaminated with chemical dyes, solvents or salts. Contaminated water endangers the health of workers and the surrounding community. Wastewater can also gather in stagnant pools and create breeding grounds for insects, particularly mosquitoes. In the long run, contaminated wastewater can make the local water supply undrinkable and ruin local farmers' crops. These problems may force textile operations to pay for procuring clean water from other locations or to clean the water on-site before using it.

Key questions to consider:

- Where is wastewater discharged?
- What treatment methods are currently used in production?
- What kinds of chemicals are used and what dangers do they pose?

Selected mitigation strategies:

- Separate chemically contaminated water from organic wastewater. Water with undyed fibers or dirt in it does not present a health hazard and can even be used as fertilizer. However, water that is contaminated by chemicals or other substances will need some type of treatment to make it safe for release into the environment. Consult with an expert to determine what treatment methods are appropriate for the individual facility's wastewater.
- Minimize contaminated water. Ensure that dyes or chemical-coated materials are cleaned away from water sources and with as little water as possible.
- Avoid spills that can contaminate water supplies.

Resources and References:

- *Cleaner Production in Cloth Printing and Dyeing Operations*

  http://www.p2pays.org/ref/10/09351.htm. Useful description of general cost-effective pollution prevention tips (ranging from limiting chemical use to saving water or fuel costs).

- *Cleaner Technology Transfer to the Polish Textile Industry: Idea Catalogue and Selected Options* (1999). Danish Cooperation for Environment in Eastern Europe (DANCEE).

  http://www.mst.dk/udgiv/publications/1999/87-7909-255-1/html/helepubl_eng.htm. This study was commissioned by the Danish environmental protection agency for improvements in the Polish textile industry. Although the report refers to medium-scale producers, it provides an excellent example of diagnosis and options for cleaner production. The report discusses different methods of improving resource efficiency, chemical substitution, and optimization.

- *Energy Conservation in the Textile Industry* (1992). United Nations Industrial Development Organization (UNIDO) and Ministry of International Trade and Industry (MITI), Japan.

  http://www.unido.org/userfiles/PembletP/sectorstextile.pdf. This manual presents a lengthy discussion of textile production in a variety of subsectors—yarn and fiber production, knitting, weaving, clothing, dyeing and finishing—and provides guidance on energy-saving technologies for each one.

- *Pollution Prevention Tips for Wet-Processing Textile Mills*. Georgia Pollution Prevention Assistance Division. Georgia Department of Natural Resources.

  http://www.p2pays.org/ref/09/08015.htm. This report gives specific cleaner production guidelines for improving textile processing. Concentrates mostly on water conservation methods and improving chemical use.

- *Sectoral Profile of the Textile Industry* (1998). United Nations Industrial Development Organization (UNIDO) Sustainable Development Program. January.

  http://www.p2pays.org/ref/11/10489/sectors701.html. An extensive overview of textile production, including subsectors. Also includes a very detailed technical description of cleaner production techniques such as chemical substitution, water conservation and waste minimization.

- Smith, Brent and Vikki Bristow. *Indoor Air Quality And Textiles: An Emerging Issue.* Raleigh, North Carolina: School of Textiles, North Carolina State University.

  http://www.p2pays.org/ref/03/02906.pdf. Fairly technical discussion of possible air pollutants present inside textile processing buildings.

- "Textiles" (1998). *Pollution Prevention and Abatement Handbook.* World Bank Group.

  http://www-wds.worldbank.org/external/default/main?pagePK=64193027&piPK=64187937&theSitePK=523679&menuPK=64187510&searchMenuPK=64187511&siteName=WDS&entityID=000094946_99040905052283. This chapter is part of a larger pollution prevention handbook published by the World Bank. The document discusses major sources of pollution and lists technical requirements for limiting chemical pollutants.

- *The Textile Industry and the Environment* (1993). United Nations Environmental Program (UNEP) Technical Report No.16.

  http://www.uneptie.org/pc/cp/library/catalogue/related.htm. This booklet gives an overview of environmental impacts associated with textile production and strategies for cleaner production. For sale at earthprint.com for US $35.

- *The Textiles Industry: Improvement of Resource Efficiency and Environmental Performance* (2000). CleanerProduction.com, Hamner and Associates LLC.

  http://www.cleanerproduction.com/Directory/sectors/subsectors/textiles.html. A short discussion of cleaner production issues and a checklist of possible areas of attack. This Web site also includes links to a number of other textile sites.

- Wanucha, David J. *Land Application of Textile Biosolids: North Carolina's Experience.* North Carolina Division of Pollution Prevention and Environmental Assistance.

  http://www.p2pays.org/ref/02/01124.pdf. A low-tech discussion of the beneficial reuse of textile wastewater treatment sludge in agriculture.

- *Water Conservation for Textile Mills: A Waste Reduction Fact Sheet*. North Carolina Division of Pollution Prevention and Environmental Assistance.

  http://www.p2pays.org/ref/01/00026.htm. Methods of conserving water at various points in the production process. Although primarily aimed at large-scale producers, it contains a useful discussion on reuse and water conservation relevant to the small-scale producer.

4.7
Wood Processing and Furniture Making: Cleaner Production Fact Sheet and Resource Guide

Purpose

This fact sheet offers basic information on important adverse environmental impacts of wood processing and furniture making, as well as associated health and safety impacts. It also discusses opportunities for mitigating those impacts, with an emphasis upon "cleaner production" strategies that may also provide financial benefits to micro- and small enterprises (MSEs). In addition, each fact sheet offers a substantial, annotated list of resources for those organizations seeking more information.[12]

This fact sheet has been prepared for (1) **business development services (BDS) providers,** which offer services such as management training or marketing support to MSEs, and (2) **intermediate credit institutions (ICIs) and direct lenders** that provide financial credit to MSEs. It is intended to be used in concert with other sections in Part III of the *Environmental Guidelines for Small-Scale Activities in Africa: Environmentally Sound Design for Planning and Implementing Development Activities,* which is USAID Africa Bureau's principal source of sector-specific environmental guidance.

Why Focus on Cleaner Production for Mitigation?

Cleaner production (CP) is a preventive business strategy designed to conserve resources, mitigate risks to humans and the environment, and promote greater overall efficiency through improved production techniques and technologies. Cleaner production methods may include:

- substituting different materials
- modifying processes
- upgrading equipment
- redesigning products

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[12] USAID cleaner production fact sheets are available for the following subsectors that are likely to have substantial adverse impacts on the environment and/or workers' health: brick and tile production; leather processing; small-scale mining; food processing; wet textile operations; wood processing and furniture making; and metal finishing.

In addition to environmental, health and safety benefits, many CP techniques provide opportunities to substantially reduce operating costs and improve product quality. MSEs can profit from cleaner production through more efficient use of inputs and machinery, higher-quality goods that command higher prices, and reduced waste disposal costs. Improved safety measures can also help MSEs avoid costly accidents and worker absences.

Experience has demonstrated that, with assistance, MSEs can frequently identify cleaner production opportunities that produce a positive financial return, sometimes with little or no investment. Many enterprises that change to CP methods may realize substantial financial and environmental benefits, indicating that CP should be the first option considered in addressing MSEs' environmental problems.

Yet, although this approach can offer tremendous advantages, readers should also recognize that cleaner production options showing clear financial benefit will only be available to varying degrees among different enterprises and often may not completely mitigate environmental problems. In some cases, even when pursuing CP approaches, some businesses may need to use solutions that offer no measurable financial return—if such solutions are required by USAID's Regulation 216 or local regulations or desired for other reasons, such as community goodwill.

Adverse Environmental Impacts and Mitigation Opportunities

Important Environmental Issues Addressed by This Fact Sheet

- Air pollution from adhesives
- Air pollution from coating material
- Wastewater
- Hazardous waste
- Wood waste

Several key environmental impacts associated with wood processing and furniture making are listed in the box at left and discussed below. For each environmental impact, the fact sheet provides a list of questions to aid in the assessment of individual MSEs. These questions are followed by a number of mitigation strategies that can be considered, with an emphasis on cleaner production strategies where possible. The strategies presented typically represent a range of available options, from profitable activities that require no investment to other activities that may increase MSE costs.

❑ *Air Pollution from Adhesives*

Adhesives, either synthetic or natural, are used in assembling wooden furniture parts. Adhesive formulations used in this industry contain toxic solvents (for upholstered wood furniture) and hot melts (for non-upholstered wood furniture). Adhesives are also used to apply veneer (a thin piece of wood of uniform thickness) to the piece of furniture. For both assembly and veneer, the use of adhesives releases solvents into the air and damages the environment and health of workers. Alternative approaches to adhesives could reduce both production costs and environmental harm. [13]

[13] This fact sheet specifically discusses air pollution from adhesives and coating materials. Readers should also recognize that similar air pollution can be caused by poor handling and inefficiency related to wood preservatives and industrial solvents. Many of the mitigation strategies presented for adhesives and for coating materials are also relevant to wood preservatives and industrial solvents.

Key questions to consider:

- What types of adhesives are used in production? What less toxic alternatives are available?
- How are adhesives usually applied?
- Is waste of adhesives a common occurrence?

Selected mitigation strategies:

- Employ the variable application rate strategy (VARS). The VARS adjusts the glue-spread rate for each individual plywood panel according to its moisture content. The primary benefit of VARS is lower adhesive consumption, which reduces both input costs and emissions.
- Minimize overspray of adhesive. Of the four conventional ways that glue is applied to wood, the most efficient is foam extrusion—a technique in which foamed adhesive is forced under pressure to the extrusion head. The result is less wasted adhesive.
- Replace existing adhesives with less toxic substitutes: e.g., switch to naturally derived adhesives to replace the petroleum-derived chemicals currently used in the manufacture of wood adhesives. Two non-petroleum options that are currently in the experimental phase are furfuryl alcohol resin and lignin adhesives, both of which reduce harmful pollution. The naturally derived adhesives may also be more cost-effective than their petroleum-based counterparts.
- Equip workers with masks or respirators. Masks and respirators may be available to keep workers from inhaling toxic emissions from adhesives and coating material (covered in next section), and can also protect against the inhalation of small airborne particles, such as wood dust, that damage the lungs.

❑ *Air Pollution from Coating Material*

Applying coating material (i.e., stains, paints and finishes) in furniture making generates air emissions that can cause potentially serious health problems. The source of these air emissions is the solvents in the coating material, which in turn emit volatile organic chemicals (VOCs). The VOCs escape into the air when the coating is applied or when containers of liquids containing VOCs are left open. There are various options that could reduce VOC emissions and thereby reduce harm to workers' health.

Key questions to consider:

- What technique is being used to apply coating? Is there a more efficient option?
- Are workers adequately trained in the application of coating material?
- Are containers of coating material covered when not in use?

Selected mitigation strategies:

- Use reformulated coating materials that contain fewer VOCs to finish wood furniture. Alternatives include waterborne, ultraviolet-curable, polyurethane, and polyester coatings.[14]
- One method used for spray coating involves a high-volume low-pressure (HVLP) spray system. This uses a high volume of air delivered at low pressure to turn the coating material into a very fine spray. The use of low pressure results in less overspray, and therefore uses less coating material used and emits fewer VOCs.
- Consider investing in a spray booth equipped to recirculate air, to decrease the volume of exhaust emitted to the atmosphere. This process has lower operating costs than other VOC control systems.
- Ensure that containers of coating material are tightly sealed when not in use.

❑ *Wastewater Problems*

Furniture making requires the use of wood preservatives and coating materials, all of which contain solvents. Both preservatives and coating material can contaminate wastewater if they drip from the wood surface, leak from the drums where they are stored, or are discarded after use. In the long run, contaminated wastewater can raise the concentration of toxins in the local water supply to levels that harm people's health and the firm's productivity. This may require wood processing operations to pay for the clean water they need or to clean and recycle their used water on-site.

Key questions to consider:

- What kinds of chemicals are used?
- Which of these chemicals are the most harmful? Are less toxic alternatives available?
- Where are chemicals stored?
- Are methods in place to control spills and leaks?
- How is wastewater discharged? Is it separated into hazardous and non-hazardous wastewater?

Selected mitigation strategies:

- Increase efforts to dry the wood before finishing. This will lessen the need for surface treatment, because high water content leads to sap stain. In drying wood, try to choose the most energy-efficient option.

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[14] These options are described in EPA (1995a), page 58.

- Spray preservatives or coating materials on the wood using a high-velocity spray system. This system results in fewer process residuals and less drippage.

- Install a drainage collection device on rooftops to divert rainwater away from process wastes.

- Store additives, solvents, wood treatment chemicals and fungicides in drums with a spill collection system to reduce the risk of leakage. An effective way to collect spills is to build a berm (e.g., a mound of earth) around the floor of the storage area that could potentially contain more than the stored volume of liquids. If the spill collection system is non-porous (e.g., with a plastic lining on the berm), recaptured spills can most likely be reused.

- Minimize drippage from sprayed-on preservatives or coating materials in two wayas: (1) by mechanically shaking the furniture piece to remove extra preservatives/coating from the wood surface, and/or (2) by allowing enough time for dripping in a catchment area after the preservatives/coating is applied. The drippage should be recaptured so that it does not eventually enter the drainage system. Treated wood should be sent to storage once dripping has stopped.

- Use concrete pads for the wood treatment area and intermediate storage areas to ensure that all drippage is collected.

- Do not store materials in sites that are prone to flooding or that are next to water intake points or groundwater resources.

- Switch to water-based preservatives, which are less toxic and damaging than typical solvent-based preservatives.

❑ *Hazardous Waste*

The waste from wood processing and furniture making is often thrown away like trash—but should not be, because of its hazardous nature. Hazardous waste cannot be safely disposed of without carefully following procedures for protecting the environment. Unfortunately, proper hazardous waste disposal facilities are typically unavailable in African countries. Therefore, preventing or recycling such waste is most desirable. Two prominent sources of this waste are **paints** and **industrial solvents**.

The spray-painting of furniture objects has a transfer efficiency of approximately 40 to 65 percent (depending on the spraying technique, the shape of the object and whether it is sprayed manually or automatically). The remaining paint—“overspray”—is considered hazardous waste.

In wood-coating and painting operations, industrial solvents (e.g., lacquer thinnier, xylene, or isopropyl acetate) are used to clean application equipment, such as spray guns, spray nozzles, etc. Such equipment must be cleaned often, including each time there is a color change. Contaminated solvents are a by-product of cleanup operations and are considered hazardous. Processing contaminated solvents using recovery units can allow the solvent to be reused, which lowers supply costs and lessens the volume of hazardous waste that must be dealt with.

Key questions to consider:

- How well are workers trained in machine cleaning and maintenance?
- What is the storage procedure for solvents?
- Are solvent containers covered as often as possible?
- How are solvents currently disposed of? Is solvent recycling a viable option?

Selected mitigation strategies:

- Strategies for reducing paint waste:
    - Place a recovery screen behind the object when spray painting. The overspray can be captured onto the screen, scraped off with a special knife and deposited into a container. This recovered paint can be reused without further processing.
    - Save unused or lower-grade paint to be used as undercoat in future jobs.
    - Train spray gun operators in proper spray techniques to minimize waste generation.
- *Strategies for solvents:*
    - Keep solvent containers and equipment containing solvents covered as often as possible to reduce loss of solvent through evaporation. For example, if equipment is soaked in a solvent bath, place an airtight cover over the bath to minimize evaporation. This makes solvent last longer and reduces environmental and health damage from airborne VOCs.
    - Plan the painting process to minimize color changes, if possible, by (1) doing all work related to one color at once, and (2) finishing a color before the shop closes for the day, if possible. The latter suggestion allows the end-of-day cleaning to also serve as a color-change cleaning. Such strategies will decrease waste, increase productivity by decreasing the time spent cleaning, and decrease the amount of money spent on both paint and solvents.

Use distillation equipment to treat contaminated solvents. Distillation involves heating the contaminated solvent until it boils and then evaporates. The evaporated solvent is cooled and recovered as clean product. The residue should be removed and handled as hazardous waste. (See the chapter on solid waste in the *Guidelines*.) Regular distillation is capable of treating solvents with a boiling point of 40°–200° C. Vacuum distillation can treat those with a boiling point of 140°–250° C. For flammable solvents, the equipment should be explosion-safe. Recycling solvent in this way may be more cost-effective than purchasing new solvent all the time.

- ### *Wood waste*

Wood waste in wood processing and furniture making contributes to the problem of unsustainable timber use. This wood waste includes sawdust and end pieces of various materials, including wood, particleboard, and various types of fiberboard. Wood waste is largely created by inefficient sawing and cutting of wood, as well as improper storage practices. Another cause of wasted wood is inadequate drying of the wood, which causes the boards to split, reducing their usefulness. Improvements in all of these areas can enhance the cost-effectiveness of these operations while reducing environmental problems.

Key questions to consider:

- How does wood become ruined/unusable?
- What contributes most to wood waste?
- How can production processes be changed to reduce waste?

Selected mitigation strategies:

- Train workers in efficient wood-cutting techniques.
- Consider redesigning the product so that wasteful cuts may become unnecessary.
- Order into inventory only wood products that are commonly used or needed for a specific job. Avoid over-ordering. Return unused, damaged or obsolete materials to the supplier for a refund, if possible.
- Store wood so that it is protected from the elements, to avoid spoilage.
- Designate a central cutting area at the work site so reusable wood pieces can easily be collected and stored for future use.
- Find new, productive uses for wood scrap. For instance, dry wood residues can be bonded together with a synthetic resin to form particleboard.
- As a last option, identify and segregate scrap wood available for fuel use by the business or others, if more productive uses cannot be found. However, avoid using laminated materials, as the glue may form toxic emissions when burned. Use sawdust and log ends as fuel for boilers that fire up the drying kiln or oven used to dry raw lumber.

References and Other Resources

References Used in Preparing This Fact Sheet:

- "Distillation of Spent/Contaminated Solvents" and "Recovery of Paint Overspray Using a Recovery Screen." Green Profit (a not-for-profit initiative of BECO Environmental Management, cleaner production consultants based in the Netherlands and Belgium).

  http://www.greenprofit.net/cases.html The two case studies used from the wood and furniture sector provide concise information on the environmental effects and mitigation measures of specific aspects of the industry. Each case study briefly summarizes one company's experience using a particular mitigation technique.

- *EPA Office of Compliance Sector Notebook Project: Profile of the Lumber and Wood Products Industry* (1995a). U.S. Environmental Protection Agency (EPA). September.

  http://www.epa.gov/compliance/resources/publications/assistance/sectors/notebooks/lumber.html This sector notebook provides a comprehensive assessment of the lumber and wood products industry. The publication is one of a series of sector publications published by the EPA and posted on the EPA Web site.

- *EPA Office of Compliance Sector Notebook Project: Profile of the Wood Furniture and Fixtures Industry* (1995b). U.S. Environmental Protection Agency (EPA).

  http://www.epa.gov/compliance/resources/publications/assistance/sectors/notebooks/wood.html This is another of the EPA's series of sector publications.

- "Improved Wood Processing Saves Money and Forest Resources." Winrock International

  http://v1.winrock.org/reed/ftf/mercury.htm This success story was culled from the Winrock Volunteer News and Information section of the Web site. The feature articles provide useful information about Winrock's volunteer projects.

- "Integrated Life Cycle of Wood: Tree Quality, Processing and Recycling." U.S. Department of Agriculture, Forest Service.

  http://www.srs.fs.usda.gov/research/rwud/rwud/rwud_4702.pdf This project description is structured as a government report. The scope of the project is national, but the themes addressed could be relevant to other countries that have a substantial wood processing industry.

- *Pollution Prevention and Abatement Handbook: Wood Preserving* (1998). World Bank Group. July. This handbook was prepared to update and replace the 1988 World Bank *Environmental Guidelines.*

  http://www.ifc.org/ifcext/enviro.nsf/Content/PPAH This handbook can be downloaded, section by section, from the above Web site. The Industry Sector Guidelines cover 40 industries, including wood preserving.

Other Resources:

- *Best Practices in Wood Waste Recycling* (1997). Clean Washington Center.

http://www.cwc.org/wood_bp.htm This note offers detailed and technical information on wood waste recycling as it relates to sourcing, processing and product manufacturing.

- *Integrated Pollution Prevention and Control, BAT Guidance Note: Wood and Furniture* (1999). Prepared by IPPC project, Estonia.

  http://www.envir.ee/ippc/docs/wood_and_furniture_bat.pdf This note provides an overview of the best available techniques regarding the wood and furniture industry in Estonia.

- *Investment Projects in Wood Works and Furniture in Tanzania.* United Nations Industrial Development Organization (UNIDO).

  http://www.envir.ee/ippc/docs/wood_and_furniture_bat.pdf A database of specific projects related to wood processing and furniture manufacturing in Tanzania. Includes links to information on individual companies and proposed projects.

- Susilo, Kasru and Achmad Djani. *Cleaner Production Assessment at an Indonesian Plywood Facility: A Case Study* (1997). Forum KMB Indonesia (Indonesian Pollution Prevention Roundtable).

  http://www.encapafrica.org/documents/Cleaner_Production_Plywood_fac.pdf This paper discusses how cleaner production diagnosis and assessment was conducted for one of six plywood facilities, located in East Kalimantan, Indonesia.

Chapter 5 References and Resources

Resources and References

This section offers resources that BDS and credit organizations may find useful in developing their own context-specific guidelines for MSE activities. The best resources are likely to be found under "General Resources." These most often link to a variety of subsectors, and are likely to be kept updated by their operators. Only a few additional subsector-specific sites have been provided.

Please note that Internet links are constantly changing. If the link given here does not function properly, try to find the resource by typing its name into a search engine such as Google (www.google.com), which caches Web pages, frequently enabling searchers to locate documents or pages that have been removed from the Internet. Alternately, visit the home page of the organization that created the document, and use their search engine to locate the document. For organizations that do not have search functions on their Internet sites, one can use advanced search features with most of the major search engines to conduct searches within single Web sites. As a last resort, of course, one can contact the appropriate organization to request a copy. (Contact information is usually one of the hyperlinks on an organization's home page.)

In visiting the resources below, readers should note that cleaner production is also sometimes referred to as pollution prevention, waste minimization, and/or eco-efficiency.

Highlighted Resources

- *The Environmental Colours of Microfinance: Theory and Practice.* This Web site offers information and links on the following six topic areas: workplace safety; economically viable solutions to environmental challenges; environmental management practices for microcredit program; community development and participatory practices; technological innovation; and promoting environmentally based microenterprises. (http://www.gdrc.org/icm/environ/environ.html)

- *Global Pollution Prevention/Cleaner Production Network.* Organized by the U.S. National Pollution Prevention Roundtable, this effort creates a global network of pollution prevention/cleaner production professionals. (http://www.p2.org/intl/activities/new/main.html#activities)

- *Information Resources on Industrial Pollution Prevention. CD Version* (2000). United States Agency for International Development (USAID). Contains guides, case studies, and articles focused on pollution prevention in food processing and other subsectors.

- *International Cleaner Production Cooperative*. Connects users to a network of international cleaner production expertise, as well as linking into many other U.S. networks. (http://es.epa.gov/cooperative/international/)

- *International Cleaner Production Information Clearinghouse. CD Version 1.0* (1999). United Nations Environment Program, Division of Technology, Industry and Economics (UNEP-TIE). Contains case studies, country profiles and cleaner production strategies for various subsectors.

- *International Web Site on Environmental Management Accounting.* Excellent starting point for information on EMA. Offers a searchable library, contacts and links. (http://www.emawebsite.org/library.htm)

- *New Ideas in Pollution Regulation*. Offers links to all World Bank environmental resources, plus annotated links to non-Bank sites. Also offers search engine for environmental Web site links and information. (http://www.worldbank.org/nipr/)

- *North Carolina Department of Environment and Natural Resources, Division of Pollution Prevention and Environmental Assistance Service* (joint effort with United States Environmental Protection Agency Waste Reduction Resource Center). Offers a "Web library" of links on cleaner production (pollution prevention) practices and case studies in more than 20 subsectors (and growing), as well as tips for water and energy conservation. Mostly focused upon developed country cases. (http://www.p2pays.org)

- Pallen, D. *Environmental Sourcebook for Micro-Finance Institutions.* Canadian International Development Agency. 1996. (http://www.acdi-cida.gc.ca/microcredit)

- *Pacific Northwest Pollution Prevention Resource Center.* Fact sheets and reports on pollution prevention for a variety of subsectors. Mostly focused on developed country cleaner production strategies, which may not all be relevant to MSEs in developing countries. (http://www.pprc.org)

- *Small Business Environmental Home Page*. Offers publications and links regarding environmental issues at small enterprises in a wide range of subsectors. Many of the documents relate to U.S. environmental regulations, but a number offer cleaner production tips. (http://www.smallbiz-enviroweb.org/pubsector.asp)

- *United Nations Environment Programme.* Offers a wealth of resources on relevant environmental impacts and mitigation strategies. (http://www.UNEP.org)

- *UNEP Division of Technology, Industry and Economics—Cleaner Production Activities.* Provides a library and links to cleaner production networks. (http://www.uneptie.org/pc/cp/home.htm)

- *UNEP—Financing Cleaner Production.* Offers resources designed to increase investments in Cleaner Production by helping financial institutions understand the value of cleaner production activities, and helping cleaner production experts prepare credit-worthy investment proposals. Includes a library and training materials. (http://www.financingcp.org/index.html)

- *United Nations Industrial Development Organization*. Offers resources on cleaner production, energy efficiency and other environmental issues, with information on different industrial subsectors. (http://www.unido.org)

- *USAID: Environment.* Home page for USAID's environmental information. Most notably, provides links to USAID environmental publications and to USAID and non-USAID environmental sites, organized by region and topic area. (http://www.usaid.gov/environment/)

- World Bank (1998). *Pollution Prevention and Abatement Handbook*. This document, available online, is an excellent starting point for anyone looking to learn about the adverse environmental impacts of particular industrial subsectors and a wide variety of mitigation options available to address those impacts. Readers should note that the handbook is not specifically oriented toward MSEs. (http://wbln0018.worldbank.org/essd/essd.nsf/Docs/PPAH)

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Chapter 6

Annexes

Contents

Annex A: Sample Environmental Screening/Report Form for MSE Assistance Programs 6-2

Annex B: Classifying MSEs as Damaging or Not 6-9

Annex C: Sample Screening Form for Individual MSE Loans 6-15

Annex D: Sample Environmental Commitment Statement for MSEs 6-19

Annex E: Sample Terms of Reference for Specialized Consultants 6-21

This chapter presents several tools to help BDS and credit providers with screening, mitigation and monitoring. First, the sample program-level screening form in **Annex A** will help identify those proposed programs which may not be allowed or for which mitigation is required by USAID Regulation 216. However, USAID Regulation 216 does not directly address many of the activities undertaken by MSEs that may be damaging to the environment—or raise awareness of many of the cleaner production opportunities that could cost-effectively mitigate those impacts and improve financial viability of enterprises. **Annexes B and C** are designed to help users of these guidelines identify those potentially damaging enterprises not expressly covered under Regulation 216, and to focus in on critical adverse impacts and a more complete range of mitigation opportunities.

To help readers orient themselves, **Annex B** lists dozens of types of enterprises that commonly receive development assistance and divides them into three groups: (1) those that are expected to have beneficial impacts on the environment, (2) those expected to have minimal adverse environmental effects, and (3) those that are expected to have potentially significant adverse effects. Some BDS and credit providers will likely wish to develop much more targeted lists for subsectoral screening purposes, depending upon the types of enterprises with which they work frequently and about which more information is available. For instance, BDS and credit providers could focus most screening activities upon types of MSEs covered in the Cleaner Production Fact Sheets (see Chapter 4).

For those BDS and credit providers wishing to conduct a more detailed screening, **Annex C** provides a sample enterprise-specific questionnaire, because knowing only the type of enterprise may be insufficient to fully understand the scope and scale of its potential environmental impacts. Several important enterprise-specific factors may also be considered, including the nature of the proposed activities and their magnitude, scale, location, duration of impact, importance, and environmental context. Helping MSEs fill out a screening questionnaire facilitates this evaluation for a second level of screening, which may be most useful in unusual cases, given the additional resources required to conduct such an assessment. The Cleaner Production Fact Sheets in Chapter 4 could be used to develop custom sector-specific screening forms.

Annexes D and E provide supplemental tools to assist BDS and credit providers in improving MSEs' environmental performance. **Annex D** is a sample Environmental Commitment Statement for MSEs, because assistance providers may wish to obtain such mitigation commitments from those assistance applicants whose activities are likely to have impacts of concern. **Annex E** provides sample terms of reference that may be modified when hiring environmental consultants.

Annex A: Sample Environmental Screening/Report Form for MSE Assistance Programs[1]

> This form is intended to help you quickly assess which of your proposed MSE development programs that present relatively high risks for harm to the environment and will require a formal Environmental Review under USAID regulations. This form can be used to assess program- or project-level activities or could be adapted to review enterprise-specific actions.
>
> First, the form will help you classify the proposed activities into one of three categories:
>
> (A) those activities that do not require a formal Environmental Review,
>
> (B) those activities that require an Environmental Review and are likely to require some mitigation and monitoring to control adverse impacts and receive a negative determination under Regulation 216, and
>
> (C) those activities that require an Environmental Review and are likely to invoke a positive determination under Regulation 216 and require a full environmental assessment.
>
> For activities in Categories B and C, the form also explains the suggested format for the Environmental Review document. The Environmental Review will help you began to identify preventative, mitigating and/or monitoring measures to be taken to minimize the risk for unintended harm to the environment.
>
> Readers are cautioned that the generic form below is illustrative. Its final contents can be refined and jointly determined among the affected partners – including USAID program officers, business development services (BDS) and credit providers, and host country agencies.
>
> As discussed elsewhere in these guidelines, readers should also recognize that even those activities under Category A may have significant adverse environmental impacts. They may also offer excellent opportunities to encourage MSEs to recognize and implement cleaner production opportunities -- potentially sparking improved quality and profitability in these enterprises and enhancing your organization's mission. Other tools in these guidelines (e.g., Box 3.3g, and subsector-specific cleaner production fact sheets) are intended to help you address those activities.

Program information

Program name: ____

Type of Enterprise(s) to be supported:____

Geographic Location:____

Business Description: Describe purpose/outputs of the enterprise and environmental impact of the business. Attach extra pages if more space is needed.

[1] Adapted from IEE for Eritrea Program/Activity # 661-0009, Investment Objective (IO) 2: Increased Income of Enterprises, Primarily Rural, with Emphasis on Export. 1996.

Description of Support for Enterprise(s): Describe proposed support to be provided to the enterprise or enterprises (e.g., financing or services to be provided). Note anticipated environmental impacts of support. Attach extra pages if more space is needed.

Step 1. Determine Category of Request:

Follow the checklists in this section to determine which one of the following three categories applies to the MSE activity. In considering potential adverse environmental impacts, program planners should be careful to consider collective impacts of MSEs and the potential for MSE programs to exacerbate existing environmental problems.

- **Category A: No Further Environmental Review May Be Required.** Is the request exclusively to provide technical assistance, training, institutional strengthening, or research, education, studies or other information analysis, awareness-building or dissemination activities *with no foreseeable negative impact on the biophysical environment*? This probably qualifies as a Category A activity—no further environmental review or action may be necessary. Complete form to establish this circumstance.
- **Category B: An Environmental Review Report Is Needed.** Does the request include funds or technology transfer to support any physical natural resource management activities, or any community and rural development services, infrastructure, public facilities or road rehabilitation? Does it involve development of income-generating or resource management systems, or certain kinds of applied ecological or natural resources research? If so, it will likely require an Environmental Review of the kind described in Step 4 of this form. Determine which Category the request falls under, to establish the type of environmental review that may be required.
- **Category C: Significant Environmental Impacts Likely; Environmental Review Required, and Environmental Assessment Likely to Be Required.** Is the activity one that normally requires an environmental assessment, as defined by USAID Regulation 216?

Category A—No Formal Environmental Review Needed:
If you answer "yes" to any of the following questions, this assistance request will probably not require a formal Environmental Review. However, it is recommended that you proceed to review of the Category B and C checklists, to ensure entire assistance request qualifies for Category A. Then proceed to Step 2.

Does the assistance request ONLY involve (yes, no, N/A):

______Provision of education, technical assistance, or training. Does *not* qualify for "Category A" if such programs include activities directly affecting the environment.

______Support for intermediate credit arrangements (only when *no* significant biophysical environmental impact can reasonably be expected).

______Community awareness initiatives.

______Controlled experimentation exclusively for the purpose of research and field evaluation confined to small areas (normally under 4 ha., i.e., 10 acres) and carefully monitored (when no protected or other sensitive environmental areas could be affected).

______Technical studies and analyses and other information generation activities not involving intrusive sampling of endangered species or critical habitats.

______Document or information transfers.

______Nutrition, health care or family planning. Such programs do *not* qualify for "Category A" if (a) some included activities could directly affect the environment (construction, water supply systems, etc.) or (b) biohazardous (esp. HIV/AIDS) waste is handled or blood is tested.

______Rehabilitation of water points for domestic household use, shallow, hand-dug wells or small water storage devices (when no protected or other sensitive environmental areas could be affected).

______Construction or repair of facilities if total surface area to be disturbed is under 10,000 sq. ft. (approx. 1,000 sq. m.) (*and* when *no* protected or other sensitive environmental areas could be affected).

______Studies or programs intended to develop the capability of recipients to engage in development planning. Do *not* mark "yes" if these involve activities directly affecting the environment.

Category B: Adverse Environmental Iimpacts Possible, Environmental Review Required (Specific Conditions, Including Monitoring, May Be Applied):
Note: The Environmental Review (Step 4 below) must address why there will be no potential adverse impacts on protected areas, endangered or threatened species or their critical habitat; or relatively undegraded forest. I.e., justify your conclusion that the proposed Category B activities do not belong in Category C. Even for activities designed to protect or restore natural resources, the potential for environmental harm exists (e.g., re-introduction of species, controlled burning, fencing, wildlife water points, spontaneous human population shifts in response to loan or technical support activities undertaken, etc.). *If you do not find an exact match listed here for the activity you are undertaking, and it is not in Category A or C, then use the last item in Category B to describe the activity and treat it as Category B for purposes of environmental review.*

***Does the loan involve (yes, no, N/A)*:**

______Small-scale activities in agriculture, natural resources management, sanitation, etc. (list and scale to be defined mutually among the appropriate partners, whether donor or host country agencies).

______Controlled experimentation exclusively for the purpose of research and field evaluation (areas of 4 ha. or more, i.e., 10 acres) and carefully monitored, when neither protected or other sensitive environmental areas could be adversely affected, nor threatened and endangered species and their habitat jeopardized.

______Small-scale construction or rehabilitation of facilities or structures in which the surface area to be disturbed exceeds 10,000 sq. ft and funding level is not in excess of $200,000 and where no protected or other sensitive environmental areas could be affected.

______Minor construction or rehabilitation of rural roads of less than 10 km in length (with no change in alignment or right of way), with ecologically sensitive areas at least 100 m away from the road and not affected by construction or changes in drainage; likewise, no protected areas or relatively undegraded forest should be within 5 km of the road.

______Nutrition, health care or family planning, *if* (a) some included activities could directly affect the environment (construction, water supply systems, etc.) or (b) biohazardous (esp. HIV/AIDS) waste is handled or blood is tested.

______Construction or rehabilitation of small-scale water points or water storage devices for domestic or non-domestic use, not covered in Category A, when neither protected or other sensitive, environmental areas could be adversely affected nor endangered and threatened species jeopardized.

______Quantity imports of commodities such as fertilizers.

______Technical studies and analyses and other information generation activities that could involve intrusive sampling, including aerial surveys, of endangered species or critical habitats.

______Small-scale use of USEPA-registered least-toxic general-use pesticides, limited to supervised use by farmers, demonstration, training and education, or emergency assistance. Environmental review must be carried out consistent with USAID Pesticide Procedures as required in Reg. 16 [22 CFR 216.3(b)(1)].

______Other activities not in Category A or Category C. *These may include many sorts of small-scale manufacturing.*

Category C: Significant Environmental Impacts Likely. Environmental Review Required, and Environmental Assessment Likely to Be Required:

The below Category C activities are consistent with USAID criteria for activities that normally require an Environmental Assessment, as defined by USAID's Regulation 216. It is recognized that some of these categories are ambiguous. Mark "yes" if they apply, and show in the Environmental Review (Step 4) the extent and magnitude of activities and their impacts, so that USAID and its partners can determine if an EA is necessary or not.

Does the assistance request involve (yes, no, N/A):

______*Light industrial plant production or processing (e.g., sawmill operation, agro-industrial processing of forestry products)*

______River basin or new lands development

______Planned resettlement of human populations

______Penetration road building, or rehabilitation of roads (primary, secondary, some tertiary) over 10 km length, and any roads which may pass through or near relatively undegraded forest lands or other sensitive ecological areas

______Substantial piped water supply and sewerage construction

______Major borehole or water point construction

______ Large-scale irrigation

______ Water management structures such as dams and impoundments

______ Drainage of wetlands or other permanently flooded areas

______Large-scale agricultural mechanization

______Agricultural land leveling

______Procurement or use of **restricted use** pesticides, or wide-area application in non-emergency conditions under non-supervised conditions

______Potential to significantly degrade protected areas, such as introduction of exotic plants or animals

______Potential to jeopardize threatened & endangered species or adversely modify their habitat (esp. wetlands, tropical forests)

Step 2. Summarize and Itemize Activites:

List ALL activities in the category A, B and C checklists to which to which YES was answered.

Category	**Funding**	**Activity/Sub-Activity**

(expand this table as required)

Step 3. Determine Need to Prepare Environmental Review.

- If all activities are in Category A, sign and date the form. Your development project does not require a formal Environmental Review under Regulation 216.
- For any activities in Category B and C, prepare an Environmental Review Report assessing all of these activities' impacts. For all Category B and C activities, proceed to Step 4 to prepare Environmental Review.
- Note that if USAID confirms the Category C determination, further documentation will be required.

Step 4. Prepare Environmental Review

Environmental reviews must be prepared for all Category B and C Activities.

Suggested Format for Environmental Review: The Environmental Review should be about 3–5 pages long (more if required) and consist of following sections:

1. **Background, Rationale and Outputs/Results Expected**
   Summarize and cross-reference proposal if this review is contained therein.
2. **Activity Description**
   Succinctly describe location, siting, surroundings (include a map, even a sketch map). Provide both quantitative and qualitative information about actions needed during construction, how intervention will operate and any ancillary development activities that are required to build or operate the primary activity (e.g., road to a facility, need to quarry or excavate borrow material, need to lay utility pipes to connect with energy, water source or disposal point or any other activity needed to accomplish the primary one but in a different location). If various alternatives have been considered and rejected because the proposed activity is considered more environmentally sound, explain these.

3. **Environmental Situation**
   Affected environment, including essential baseline information available for all affected locations and sites, both primary and ancillary activities.

4. **Evaluation of Activities and Issues with Respect to Environmental Impact Potential**.
   Include impacts that could occur before construction starts, during construction and during operation, as well as any problems that might arise with restoring or reusing the site, if the facility or activity were completed or ceased to exist. Explain direct, indirect, induced and cumulative effects on various components of the environment (e.g., air, water, geology, soils, vegetation, wildlife, aquatic resources, historic, archaeological or other cultural resources, people and their communities, land use, traffic, waste disposal, water supply, energy, etc.). Indicate beneficial impacts and how the natural resources base will be sustainably improved.

5. **Environmental Mitigation Actions (including monitoring and evaluation**
   For example, indicate means taken to avoid, reduce or compensate for impacts, such as restoration of borrow or quarry areas, replanting of vegetation, compensation for any relocation of homes and residents. Indicate how mitigative measures will be monitored to ensure that they accomplish their intended result or what monitoring might be needed for impacts about which there is uncertainty. Provide specifics on who will be responsible for mitigation and monitoring.

6. **Other Information** (as appropriate)
   Where possible, include photos of the site and surroundings; list the names of any reference materials or individuals consulted.

Note: Specific plans for monitoring of key environmental indicators and mitigation of impacts during activity implementation are especially important; these must be addressed in the review. Information on monitoring results and mitigation of impacts are to be included in all progress reports. The review should also assess the degree to which the activity or activities are part of an integrated natural resource planning and management framework framework that considers the appropriate use of multiple resources.

Drafted by: ____ Date: ______

Reviewed by: ____ Date: ______

Annex B: Classifying MSEs as Damaging or Not[2]

This annex presents a simple scheme for identifying sectors with potentially adverse impacts. Such a scheme could be quite valuable in allowing field staff to readily identify MSE activities that require review by a more expert staff member, without having to become environmental experts themselves. For instance, field staff might be asked to consult this list before providing support to any MSE, and referring high-risk MSEs to qualified environmental staff for specialized support that complies with USAID regulations.

This annex may not be exhaustive and is intended to familiarize readers with the kinds of MSEs that may be likely to create adverse environmental impacts. In practice, PVOs may wish to have a customized list. The final criteria for classification should be refined and jointly determined among the affected partners—including USAID program officers, Business Development Services (BDS) and credit providers, technical experts and host country agencies.

MSE Classification Scheme

In MSE assistance programs, it is recommended that MSEs receiving services or credit be classified as follows with respect to their environmental impact:

Group I	Activities designed to have beneficial impacts on the environment (Note that such activities can have adverse impacts if poorly designed)
Group II	Activities that typically have no, or limited, adverse effects.
Group III	Activities expected to have potential adverse environmental impacts.

Group I: MSEs Designed to Have Beneficial Impacts on Environment (Can Have Adverse Impacts)

- Environmental and natural resource protection institutions
- Environmental education services
- Fish hatcheries of native species for repopulation of public watercourses
- Green (environmentally friendly) businesses
- Management of microwatersheds
- Nurseries and reforestation with native species
- Professional environmental and ecological services (waste collection, urban beautification)
- Protection of historical monuments
- Protection of public areas
- Public libraries, museums, botanical gardens
- Raising of endangered species

[2] Quoted/Adapted From Inter-American Development Bank (IADB) 1997

- Sanitary and similar service activities
- Surveillance of national parks and reserves

Group II: MSEs Expected to Have Minimal Adverse Environmental Effects

- Authors, composers and artists
- Barber and beauty shops
- Communications
- Domestic services
- Exhibition of films and video tapes
- Public instruction
- Radio and television broadcasting
- Repair of footwear and leather articles
- Retail trade
- Sale of foods and beverages
- Sale of furniture and other household articles
- Sale of hardware and electrical appliances
- Sale of machinery for maintenance, industry, etc.
- Sale of textiles and clothing
- Services for companies
- Stores and shops
- Theatrical productions
- Watch, clock and jewelry repair

Group III. MSEs Expected to Have Potential Adverse Environmental Impacts

- Agricultural machinery and equipment manufacturing
- Agricultural production (see *Small-Scale Guidelines* on agricultural production)
- Animal feed manufacturing
- Bakery products manufacturing
- Batteries manufacturing and repairing
- Candles, matches manufacturing
- Canning of fruits
- Carpets and rugs manufacturing
- Cement, lime and plaster manufacturing
- Chemical products manufacturing

- Chocolate and sugar confectionery manufacturing
- Clay, china, porcelain objects manufacturing
- Construction
- Containers and boxes of paper and paperboard manufacturing
- Cordage manufacturing
- Cutlery and general hardware manufacturing
- Dairy products manufacturing
- Distilling and rectifying of spirits
- Drugs and medicines manufacturing
- Electric equipment manufacturing
- Electrical appliances manufacturing
- Electrical repair shops
- Engines and turbines manufacturing
- Fertilizers and pesticides manufacturing
- Fishing
- Footwear, except rubber footwear manufacturing
- Fur dressing and dying
- Furniture and fixtures, except of metal manufacturing
- Furniture and fixtures primarily of metal manufacturing
- Gas manufacturing and distribution
- Glass and glass products manufacturing
- Grain mill products manufacturing
- Hunting, trapping, repopulation
- Industrial chemicals, except fertilizers manufacturing
- Industrial machinery and equipment, except woodworking machinery manufacturing
- Iron and steel basic industries
- Jewelry and related articles manufacturing
- Knitted fabrics manufacturing
- Leather products, except footwear manufacturing
- Livestock farming (not covered by these guidelines)
- Machinery and equipment except electrical
- Manufacturing industries
- Medical, dental, paramedical, and veterinary services
- Metal and woodworking machinery manufacturing

- Metal products manufacturing
- Motorcycles and bicycles manufacturing
- Musical instruments manufacturing
- Nonferrous metal basic industries
- Nonmetallic mineral products manufacturing
- Other repair shops
- Other textiles manufacturing
- Paints, varnishes and lacquers manufacturing
- Paper and paperboard articles manufacturing
- Pharmacies
- Photographic and optical goods manufacturing
- Photographic studios, commercial photography
- Plastic footwear manufacturing
- Plastic products manufacturing
- Printing, publishing and allied industries
- Products of petroleum and coal manufacturing
- Pulp, paper and paperboard manufacturing
- Radio, television and communications equipment manufacturing
- Repair of motor vehicle, motorcycles, bicycles
- Resins and plastics materials, except glass manufacturing
- Restaurants, cafes, and other eating and drinking places
- Rubber products manufacturing
- Sale of industrial minerals, metals, chemicals
- Sale of raw agricultural materials
- Sawmills, planing and others
- Scientific research institutions
- Ship building and repairing
- Slaughtering and preparing meat
- Soap, perfumes and cosmetics manufacturing
- Soft drinks manufacturing
- Sports goods manufacturing
- Storage and warehousing
- Straw hats manufacturing
- Structural clay products manufacturing

- Structural metal products manufacturing
- Tanning and dressing of leather
- Textiles, except straw hats manufacturing
- Textiles (spinning, weaving, and finishing textiles, including bleaching and dyeing)
- Transport equipment manufacturing
- Various food products manufacturing
- Vegetable and animal oils and fats manufacturing
- Veterinary medications manufacturing
- Wood and cork products manufacturing
- Wooden and cork containers manufacturing

Annex C: Sample Screening Form for Individual MSE Loans[3]

Annexes A and B present program- and sector-level tools for evaluating whether an activity might be potentially environmentally damaging. This appendix presents a sample screening/application form that credit institutions could use to evaluate individual loans—perhaps only for those MSEs that have been pre-screened as belonging to sectors potentially having adverse impacts. This form could be adapted for use by BDS providers in reviewing potential environmental impacts of their clients.

An individual screening form can help organizations consider several variables, including the nature of proposed activities, their magnitude, scale, location, duration and extent of impact, and the environmental context. For example, it is important to understand what particular locational impacts each individual MSE will have. As mentioned above, even an MSE with a small impact may exacerbate an existing problem by locating in an already sensitive area or by concentrating with other MSEs.

Having initial screening criteria of this kind will help MSE credit organizations be efficient in applying environmental guidelines to their operations. For example, for those enterprises with no adverse impact, no further environmental review is necessary. Perhaps even certain enterprises with adverse impacts might be allowed a "fast track" if they can demonstrate they will put in place certain pre-specified mitigation measures. This overall pre-assessment effort can also help minimize the costs of incorporating environmental concerns into the smallest projects.

While all MSEs should be screened in some fashion, the form below is illustrative. Its final contents and use should be refined and jointly determined among the affected partners—including USAID program officers, business development services (BDS) and credit providers, other technical partners and host country agencies. In addition, credit officers should be properly trained to assist identifying and understanding potential adverse environmental impacts.

Number:______________________ Environmental classification:[4]

Financial entity: _______________________

Name of credit officer: _________________________

Place and date of processing: ___________________________

Is this category of MSE, in general, expected to have potential adverse impacts?

____

[3] ***quoted/adapted from IADB 1997***

[4] I.e., based on potential to have adverse environmental impacts.

A. GENERAL INFORMATION

1. Name of enterprise & owner/operator
2. Address
3. Activity
4. Location of the enterprise (lot, settlement, town, district, province, etc.)
5. Area: (a) rural (b) urban (c) semirural
6. Zone: (a) industrial (b) residential (c) commercial

B. GENERAL DESCRIPTION OF THE ENTERPRISE

7. Number of employees (including family members)
8. Use of the premises: (a) workshop-house (b) workshop-store (c) workshop only
9. Products manufactured in order of importance
10. Services provided for clients
11. Machinery and equipment used (number of units, types, age in years)
12. The company performs the following activities: gluing, painting, polishing, dying, stamping, smelting, welding, applying lead, type setting, diluting acids, tanning, washing, rinsing, galvanizing, etc. (mark the activity)

C. POSSIBLE IMPACTS ON PERSONNEL AND FAMILY

13. What raw materials and other inputs are used (glues, solvents, catalysts, preservatives, etc.)? What quantities are used each month?
14. Do you know if any of the products used contain toxic substances? If so, what are the products and the toxic substances they contain?
15. Are combustibles kept out of the sun?
16. What other precautions do you usually take at your workplace to prevent injury to health?
17. Do your employees use protective gear (mark the equipment used)? (a) masks (b) goggles (c) earplugs (d) hard hats (e) gloves (f) protective clothing (g) respirators (h) boots
18. Do you have first aid equipment? Yes ( ) No ( )
19. Who knows how to use the first aid equipment?
20. Do you have a properly charged fire extinguisher? Yes ( ) No ( )
21. Do you and your employees know how to use it? Yes ( ) No ( )
22. If you use substances that could be harmful to health do you keep them in a safe place out of the reach of children? Yes ( ) No ( ) Do not use ( )

D. IMPACT ON WATER RESOURCES

23. Is there potential for contaminating ground water with oil or chemical spills from your operations?
24. Could your operation result in degradation or contamination of ground or surface water?

25. Does your used water contain contaminating substances? Please list them (none, alkalies, acids, coloring agents, oils, poisonous substances, etc.)

26. How do you dispose of your liquid waste (acids, oils, toxic substances, etc.)?

    a. Pour it untreated down the drain
    b. Treat it prior to pouring them down the drain
    c. Dump it in the ground
    d. Place it in the garbage in sealed containers
    e. Reuse it
    f. Sell it or give it away for recycling

27. If you have a system for the treatment of liquid waste or used water, please describe it.

28. Where do you dispose of waste? (a) down the drain (b) in a ditch or river

29. Do you create areas of standing water?

E. POSSIBLE IMPACT ON CONSUMERS

30. Do the products you make contain any toxic substance that could pose a risk to consumer health? If so, have you affixed a warning to the packaging? Have you posted warning notices in your premises?

31. Are your inputs, products, or processes registered with the competent authorities (e.g. health permit, permits for certain substances)? Please list them.

F. POSSIBLE LOCAL NOISE, AIR AND SOIL IMPACTS

32. Is there housing nearby? Yes ( ) No ( )

33. Do you produce noise that disturbs your neighbors? Yes ( ) No ( )

34. Do you have a noise-reduction system?

35. Does your operation produce gas or foul odors that affect neighbors? If so, do you use any system to attenuate them? Please describe.

36. Do you work during the night? Yes ( ) No ( )

37. Do you have trash collection? Yes ( ) No ( )

38 If not, how do you dispose of your trash? (a) burn it (b) dump it (c) bury it (d) dump it in a river

39. Does your trash contain chemical waste? Yes ( ) No ( )

40. Do you reuse or sell any of your scrap or waste? Yes ( ) No ( )

41. Could your operation result in degradation or contamination of soils? Yes ( ) No ( )

G. CLEANER PRODUCTION REVIEW

42. Do you follow standard “good housekeeping” procedures that reduce waste, minimize accidents, and reduce costs? Yes ( ) No ( )

43. Have you assessed your facility for cleaner production possibilities? Yes ( ) No ( )

44. Are you aware of the cost of waste produced by your operations, and the potential cost savings of reducing the waste? Yes ( ) No ( )

45. Is your enterprise using substantial amounts of resources that are becoming less and less available, and more and more expensive (e.g., clean water, fuelwood, etc.)? Yes ( ) No ( )

H. SUBSECTOR-SPECIFIC QUESTIONS

46. [Entrepreneurs should respond to any subsector-specific questions at this point. (See cleaner production subsector fact sheets for examples, and customize this questionnaire accordingly.)]

I. COLLECTIVE IMPACTS

47. Are there other facilities in the nearby community that are also polluting the air, water or soil? Yes ( ) No ( )

48. Are there other facilities that are depleting resources important to the long-term sustainability of your business (e.g., clean water, fuelwood, etc.)? Yes ( ) No ( )

I. ADDITIONAL INFORMATION OR COMMENTS

I formally declare the above information to be true.

____

(Signature of the microentrepreneur)

COMMENTS BY THE CREDIT PROVIDER:

COMMENTS BY THE ICI:

Annex D: Sample Environmental Commitment Statement for MSEs[5]

> When providing loans, MSE credit organizations may wish to obtain formal written commitments from MSEs to follow good environmental practices and to address the most adverse impacts. To that end, support and credit organizations should ensure that MSEs follow both general environmental guidelines and sector-specific guidelines. This appendix offers a sample form that MSEs could sign to commit to environmental mitigation measures, required in order to receive a loan.
>
> The form is illustrative, with its final contents to be refined and jointly determined among the affected partners—potentially including USAID program officers, BDS and credit providers, technical partners, MSEs, community members and host country agencies.

I have been informed about the importance of environmental protection in protecting the health and economic interests of my enterprise, my workers, and community. I understand that there may exist many cleaner production opportunities that offer me the chance to improve my environmental performance and to save money.

I, ____________________., undertake to carry out my business in a way that avoids, reduces, and compensates for damage to nature, public services, or the well-being of the individuals who work with me and who live in the vicinity, by continuing with or taking the following actions:

(Mark the applicable actions with an X)

a. Reduce the amount of waste by improving the production process or recycling. Specific opportunities are described below. ( )

b. Take the necessary precautions in waste disposal; not dump liquid or solid waste that could potentially harm human health in public places (sewers or rivers). ( )

c. Avoid, reduce, or control processes that pollute the air and not burn waste in the open. ( )

d. Take the steps required to protect my own health and that of my employees and neighbors. ( )

e. Comply with municipal regulations on environmental protection, health, and hygiene. ( )

f. Comply with the pertinent government regulations. ( )

I will undertake, wherever possible, to implement the following specific measures as soon as possible:

(List the measures recommended for the specific MSE activity.)

[5] Quoted/adapted from IADB 1997.

I agree that the entity granting me the loan or its agent may make a visit to evaluate whether the above commitments have been met, and that I may only obtain a new loan if, in addition to complying with the specific financial conditions, I also comply with my environmental commitments.

____________________ ____

Date Signature

Approved by the Lender

____________________ ____

Date Signature

Approved by the ICI

____________________ ____

Date Signature

Annex E: Sample Terms of Reference for Specialized Consultants[6]

Credit and business development services (BDS) organizations may wish to partner with specialized consultants or technical organizations to provide staff with environmental training and/or to train clients in proper environmental procedures or cleaner production. Partners might also help develop customized environmental review tools, oversee implementation of mitigation measures by MSEs, and conduct environmental evaluations of clients.

Credit and BDS organizations may already be partnering with other experts to provide high-quality services to clients, making this a relatively easy add-on.

The document that follows is one that an intermediate credit institution (ICI) might use to contract with a consultant for environmental services. This sample is illustrative and may not reflect all contract solicitation requirements faced by PVOs. Its final contents should be refined and jointly determined among the affected partners—including USAID program officers, BDS and credit providers, technical partners/consultants and host country agencies.

A. Functions

Responsibilities of the consultant to the ICI will be:

1. With the ICI, preparing a classification of microentrepreneurial activities eligible for financing under lending programs, based on a detailed analysis of their environmental impact, as follows: category I, activities that do not have an adverse impact on the environment; and category II, activities that could potentially have adverse impacts.
2. Prepare an information booklet on MSEs and the environment in critical subsectors that receive loans from the ICI’s satellite institutions. The information should be designed for use by non-technical people, and offer an understanding of critical adverse impacts and potential mitigation strategies.
3. Recommend environmental procedures for direct lenders, including the content of the environmental commitment statements for granting subloans in category II.
4. Prepare short general training programs for credit staff working on all microentrepreneurial activities, in addition to specific programs for category II activities, describing for the latter potential adverse environmental impacts and concrete measures to eliminate or mitigate them. Prepare such programs in cooperation with environmental protection, industrial safety, hygiene, and occupational health authorities in (name of country) and with agencies/NGOs/consultants that provide support for the microentrepreneurial sector so that the latter can incorporate the programs into their regular training activities for microentrepreneurs. Programs should focus on cleaner production mitigation opportunities.
5. Advise the ICI on the design and implementation of procedures and criteria for monitoring and evaluating the environmental impact of microentrepreneurial activities that could be financed under the program. Assist the ICI in defining procedures for the selection of statistically significant random samples of the microentrepreneurial activities financed under the program in order to evaluate compliance with environmental impact mitigation measures and make any necessary adjustments.
6. Submit progress and final reports.

[6] Quoted/adapted from IADB 1997.

The consultant shall complete these functions in consultation with the government agencies responsible for environmental protection and natural resource conservation and industrial safety, hygiene, and occupational health, and in accordance with the following: relevant legislation in (name of country); USAID regulations; and USAID's *Environmental Guidelines for Small-Scale Activities.*

B. Qualifications

Legally established entity specializing in environmental protection, in existence for a minimum of three years. It should have professionals with broad and recognized experience in carrying out technical-assistance and training programs on environmental protection, natural resource conservation, industrial safety, hygiene, and occupational health. Current expertise in cleaner production folks' techniques for MSEs. Proven experience in developing effective performance-management systems.

U.S. Agency for International Development
Bureau for Africa
Office of Sustainable Development
Economic Growth, Environment and Agriculture Division
Washington, D.C. 20523