NATURAL RESOURCES IN SUB-SAHARAN AFRICA

REVIEW OF PROBLEMS AND MANAGEMENT NEEDS

Peter H. Freeman

Principal author

Bureau for Africa
Agency for International Development
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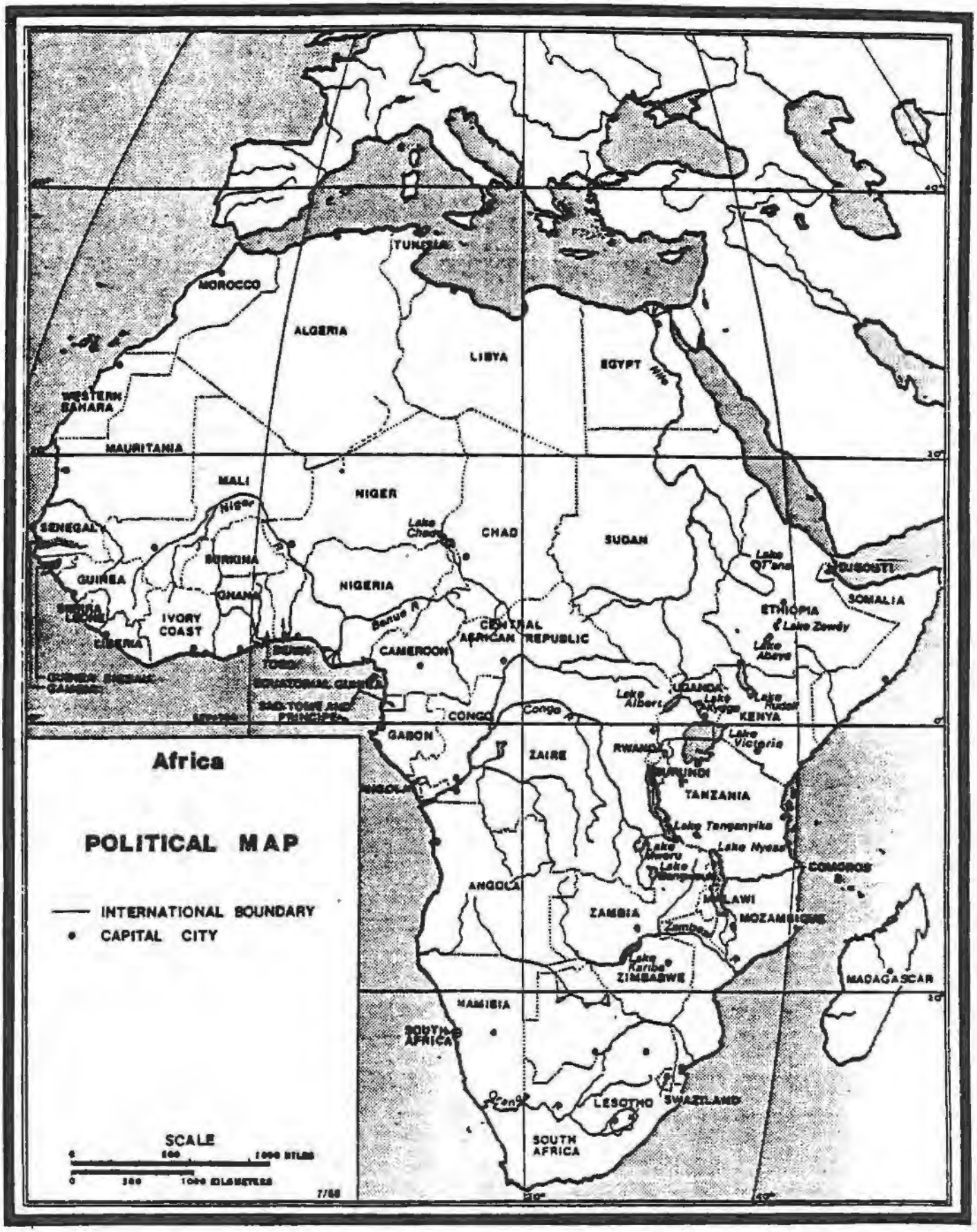
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PREFACE

This technical background document contains the results of a review of natural resource management problems in sub-Saharan Africa. The review responds to the Administrator's directive in 1985 to develop a Plan for supporting the management of these resources. This background document was used in developing the Plan, which was approved in February, 1987, as the "Plan For Supporting Natural Resources Management in Sub-Saharan Africa." It is based upon secondary materials, both published and unpublished, as well as contributions from over forty reviewers of two working drafts.

The document's preparation was overseen by a Working Group with representatives from the Bureau for Africa and the Bureau for Science and Technology. Members of the Intra-Agency Working Group were as follows:

Bureau for Africa:

Marcus Winter
Abdul Wahab
Edward Toth
Ken Prussner
Tom Catterson

Bureau for Policy Programs:

Pat Koshel
Patrick Fleuret

Bureau for Science and Technology:

Molly Kux

Several external experts also participated in initial planning of the work:

Leonard Berry
Provost
Clark University
Worcester, MA

Jeffrey Gritzner
BOSTID
National Academy of Sciences

James Thompson
Associates in Rural Development
Washington, DC

Tim Resch
Africa Region Coordinator
Forestry Support Program
U.S. Forest Service

In a series of working meetings in late 1985 and early 1986, the Working Group identified the basic problems to be reviewed and initiated arrangements for the review work. The first draft report was prepared during March - August, 1986, and reviewed in three, one-day workshops in September, 1986, convened by the International Institute for Environment and Development, with A.I.D. sponsorship. Workshop participants, listed in Annex A, provided extensive commentary. A second draft was then prepared and circulated within A.I.D., Washington, in November, 1986, and to USAIDs in Sub-Saharan Africa in early 1987. Reviewers from AID/Washington of the second draft included:

Bureau for Africa:

Larry Abel
Ans Burgett
Wilbur Scarborough
Norman Sheldon
Larry Harms
Joyce Turk
Marc Winter
Tom Catterson
Ken Prussner
Abdul Wahab

Bureau for Science and Technology:

David Atwood
Worth Fitzgerald
Carl Gallegos
Molly Kux
John Malcolm
Richard Neal
Mark Shaffer

The principal author of the first, second and final drafts is Peter H. Freeman, Consultant to the Office of Environment and Natural Resources, Bureau For Science and Technology. Edward Toth, wildlife biologist, U.S. Forest Service, and Tahir Qadri, forester and agronomist, under contract to the A.I.D. Mission in Sudan, drafted material related to biological diversity, coastal zone resources and forestry. Gregory Booth, natural resources advisor, ~~Bureau of Land Management~~ Office of International Cooperation and Development, assisted in the final editing of this document. Mr. Toth, Mr. Qadri and Mr. Booth were on assignment to the Bureau for Africa's Division of Agriculture and Rural Development. Tom Catterson, forester, on assignment to the same office, contributed introductory material.

Part I describes the background problems, the methods, and the rationale of the review. Part II presents reviews of seven resource management problems identified by the Working Group. Part III analyzes the same problems in different sub-regions of sub-Saharan Africa. Recommendations for possible actions are presented by problem or by sub-region and appear in Parts II and III. Appendix B presents the results of a limited survey of

development assistance activities in 1986 related to natural resources management in Sub-Saharan Africa.

The Agency for International Development and the editor wish to thank all those who reviewed the working drafts and offered comments and additional materials. Special thanks also are extended to UNDP for information supplied on UN development assistance in Africa and to FAO for materials on the Agro-ecological Zones Project and on the project on Land Resources for Populations of the Future.

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Washington, DC

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I. INTRODUCTION

Nowhere in the world are natural resources and their management so immediately linked to peoples' livelihoods as in sub-Saharan Africa. The great majority of Africans are subsistence or near-subsistence farmers or herders whose numbers are exceeding the capacity of the natural resource base. Also, nowhere does the condition of natural resources, and the environment in general, present such formidable constraints to socio-economic development. Only on the African continent have food production and available natural resources been on the decline while the population increased.

The link between human suffering and environmental degradation — was clearly visible in the televised images of famine victims fleeing the ravages of drought in 1984. Their plight dramatized the devastating impact of prolonged drought combined with years of over-cultivation, over-grazing and deforestation.

Population projections, development trends, and reports from soil, forestry, rangeland, water and wildlife experts all point to a steady decline of the renewable resource base throughout sub-Saharan Africa. Concern among African governments over the condition of the natural resource base for agricultural development is also very high. At the First African Ministerial Conference on the Environment, held in Cairo, Egypt, in December, 1985, a decision was made to strengthen cooperation among African governments in order to halt and reverse the degradation of the African environment.

Development responses to the diverse and unique problems of natural resource management in sub-Saharan Africa are complicated by the number, the size and the diversity of the nations within this huge portion of the continent. Also, the fact that a balance must be achieved between conservation of the resource base and commodity production has not yet been fully integrated into development assistance efforts. Nevertheless, much has been learned from the achievements and failures that have been recorded thus far. Knowledge has also been steadily accumulating on the workings of various ecosystems and environments in Africa.

THE DYNAMICS OF AFRICA'S ENVIRONMENTAL DECLINE

As famine struck in 1984/85 after several years of drought, 10 million people in 20 African countries were forced to abandon their land and seek relief. Another 20 million in the extensive semi-arid zone were judged to be at risk by the United Nations' Office of Emergency Operations in Africa. Two billion dollars in relief assistance was needed to stem the tide of death sweeping the region.

One can only speculate on how many of these people were ultimately victims of environmental degradation rather than of drought. It is certain, however, that the impact of drought is most severe in degraded areas. Many areas in Africa are stripped of vegetation as a result of intensive land clearing, over-grazing and fuelwood collection. Soils which are eroded by wind and water and depleted of organic matter and nutrients by continued cropping without soil-conserving practices cannot absorb rain nor sustain plant life.

Desertification is perhaps the most visible of Africa's environmental problems. Other processes and problems are slower, less dramatic: decline of watershed vegetation, loss of species, inherently poor soils, and steady loss of estuarine habitats to name a few. Together, they are inexorably unravelling the ecological fabric on which Africa's future must be built.

Semi-arid Africa's precious water resources present complex management problems. Three of the major rivers of West Africa, the Senegal, the Niger and the Gambia, which represent a significant portion of this sub-region's future irrigation potential, rise in the Fouta Djallon Plateau of central Guinea. Yet, this area too, ~~with its fragile soils,~~ has been a victim of the attempts of too many people to survive by cultivating the impoverished and acidic soils of these uplands. This is only one of Africa's major watershed areas in which negative impacts are directly affecting development potential.

The promise and potential of East Africa's highlands (where soil quality and favorable climatic conditions result in high productivity) have already been severely undermined by population pressures that have led to smaller farms, reduced fallow areas, and heavy erosion.

In contrast to Africa's modest and fragile soil resources, the wildlife is unparalleled in richness and splendor; however, it too has been in steady decline as farming and herding activities encroach onto wildlands, and as poachers, some armed with automatic weapons, take their toll. Elephant populations

in Kenya have declined from 160,000 in 1963 to 60,000 in 1983 despite the country's extensive system of parks and preserves. The African rhinoceros in Tanzania and Kenya, reduced from over 6,000 in the mid-1970's to less than 350 in 1980, now must be intensively nurtured by man to survive as a species.

A more fundamental concern is the safe guarding of the region's genetic endowment in the face of expanding agricultural frontiers and mounting human needs. Nowhere is the world's biological diversity more acutely threatened than in Madagascar, where the destruction of only a few hundred hectares may mean the extinction of an endemic plant or animal species. Much of this loss in diversity has been the result of fires and shifting cultivation practices. After decimating the rich flora and fauna, these practices will also ultimately weaken the existence of what may be considered another threatened African species: Man himself.

These few examples indicate the scope and the complexity of managing natural resources on the vast African continent. A more systematic treatment of natural resource issues (e.g., soils, vegetation, etc.) is presented in subsequent chapters.

A.I.D ASSISTANCE SINCE THE 1950'S

Agency For International Development projects dealing with natural resources in Africa date back to the 1950's, when PL-480 ~~(see Glossary)~~ funds were used for a variety of reforestation and range management efforts in North Africa and natural forest management in Liberia.

The Sahelian drought that began in 1968, coupled with a recognition of the limitations imposed on development by environmental degradation, gave new impetus to A.I.D.'s work in natural resource management, particularly in the areas of forestry, river basin development, and resource surveys using satellite imagery.

Fuelwood harvesting leading to deforestation was considered to be a particularly important cause of environmental degradation in semi-arid Africa, and numerous projects to plant fuelwood trees were launched. Large-scale irrigation was viewed as a key element in "drought-proofing" food crop production. As indicated later in this document, many of these efforts failed to achieve their goals.

Between 1978 and 1986, A.I.D. supplied or had committed a total of approximately $300 million (more than a third through the PL-480 program) to forestry and closely related natural resource and renewable energy projects for sub-Saharan Africa. The sum does not include development efforts in soil and water

management carried out through agricultural and rural development projects. Training, education, institution-building, improved planning, land-use surveys, and limited amounts of research for soils and water resources were supported.

During the period from 1978 to 1981, the Agency commissioned 21 environmental profiles of African countries that were prepared in conjunction with the US/MAB program ~~(see Glossary)~~. These reports, largely desk studies, were seen as early steps in a process to develop better information (for A.I.D. missions, host-country officials, and others) on the environmental situation in each country and to identify critical areas of concern.

A LONG-TERM PLAN FOR AFRICA

A series of policy statements, and general guidance and planning documents issued since 1981 provides a framework, both specific and general in nature, for planning natural resource projects. Many of the statements listed below address the issues worldwide; others are specific to Africa.

* Policy Determination 74 - A.I.D. Forestry Programs and Policies (April 1981),

* The Agency Sector Strategy For Environment (November 1983),

* The Agency Sector Strategy for Forestry (February 1984),

* The Africa Bureau Strategic Plan (July 1984), and

* Plan for Supporting Agricultural Research and Faculties of Agriculture in Africa (May 1985).

There was nevertheless no single over-arching plan which integrated natural resources, rural development approaches and socio-economic progress in Africa.

Under the direction of the Administrator, an intra-agency group was set up to establish an A.I.D. Plan for Supporting Natural Resources Management in Sub-Saharan Africa (A.I.D., 1987). The purpose of this Plan is to guide A.I.D. (at all organizational levels) in analyzing, selecting and integrating natural resources programs and activities in sub-Saharan Africa.

PURPOSE AND PRESENTATION OF THIS REVIEW

This review of natural resources in Africa was intended to be the technical foundation for the Plan and can now serve as a

technical supplement to it. Initially, it was aimed at creating a common understanding of the various natural resources management problems as a basis for preparation of the Plan. It can now serve as an analytical benchmark and baseline for future assessments of the Plan and its priorities.

The process by which this document was developed is outlined below.

1. Identification of the priority natural resources management issues in sub-Saharan Africa, namely:

   * soil erosion

   * soil productivity -- loss

   * vegetation -- loss or degradation

   * water resources -- degradation by pollution, salinization, etc.

   * biological resources -- loss, decline of diversity

   * coastal resources -- loss, degradation

   * stresses on natural resources due to drought

2. Interviews and communications with other donor organizations in order to identify the present scopes and primary concerns of their African environmental programs

3. Division of sub-Saharan African into sub-regions

4. An assessment of the major environmental and natural resources issues within each sub-region

5. A comparison of this problem assessment with those of ongoing development efforts and experiences to date

6. Identification of possible actions

Part II of this document presents summary analyses of the six primary natural resources issues that were identified by the Working Group.

Part III reviews these issues for six sub-regions that were identified on the basis of agro-ecological criteria, population pressures on natural resources, and biological uniqueness and diversity.

Part VI presents information on international assistance in

natural resources management.

OTHER PLANNING STUDIES

At the time that this review was being prepared, two other important reviews were also being undertaken. The first was a review by the Food and Agricultural Organization (FAO) of the agricultural situation in Africa, published in October, 1986 (African Agriculture: The Next 25 Years). The second, not yet published as of November, 1986, was a review by the U.S. Congress Office of Technology Assessment of low-input agricultural technologies for Africa. Both are impqrtant works which should be consulted in future planning and programming efforts related to African natural resources management.

Also of value is IUCN's The Sahel Report, published in 1986, which sets forth a strategy and program for environmental rehabilitation in the Sahelian states.

CAVEATS

This review was intended to compile and synthesize relevant literature, A.I.D. documents and studies, and other work in progress. A special effort was made to take into account recent evaluations by A.I.D. and other donors of natural resources project assistance in sub-Saharan Africa.

An attempt was made to strike a balance between precision and comprehensibility. At the mission level, this survey will likely be found wanting in detail, while at the central bureau level, it may be deemed too technical and/or too lengthy. In addition, there are, unfortunately, important gaps in this review. The institutional situation in the sub-Saharan African nations in which A.I.D. presently has development assistance programs could not be reviewed adequately from Washington, D.C. Also, all donor activity could not be surveyed, nor could adequate justice be done with respect to the explanations of various A.I.D. projects at the country and regional levels.

II. NATURAL RESOURCES MANAGEMENT ISSUES IN SUB-SAHARAN AFRICA

1. Soil Erosion and Decline in Productivity
2. Loss of Vegetative Cover and Productivity
3. Water Resources
4. Coastal Resource Degradation
5. Decline in Biological Diversity and Ecological Resilience
6. Stress on Natural Resources and the Environment Coincident with Drought

A. INTRODUCTION

The ~~issues listed above~~ are analyzed in this part. For each issue, the following aspects were treated:

* short definition or summary description

* review of the current state of knowledge of the issue

* implications for development

* development responses and lessons learned from past experiences

* actions recommended

The nature of, and management responses to, these various issues are treated generally in terms of the entire region. Important differences from one sub-region to another do exist, however. The sub-regional descriptions in Part III treat these differences and the corresponding development assistance possibilities.

B. THE CRITICAL NATURAL RESOURCES MANAGEMENT ISSUES

~~1.0~~ A. SOIL EROSION AND DECLINE IN PRODUCTIVITY

CONTENTS

1.1 Background
1.2 State of knowledge
1.3 Soil loss
1.4 Erosion control methods
1.5 Soil productivity decline
1.6 Responses to productivity problems
1.7 Development assistance responses
1.8 Constraints and gaps
1.9 Agenda of possible actions

Two major areas of concern related to soil resources in Africa were initially identified by the A.I.D. Working Group:

1. soil loss due to erosion by wind and water

2. reduction in soil productivity through such processes as desertification, leaching (in humid zones), salinization, and over-cultivation

These two problems often occur together, and are therefore reviewed together in this section. Although erosion and productivity loss can be defined separately, development responses tend to address both at once since, with few exceptions, soil loss by erosion results in loss of soil productivity.

Extreme erosion and productivity loss in arid environments lead to desertification; however, the process of desertification involves vegetation as well as soils, and is ecologically highly complex. It is therefore reviewed separately in Section II.B.6., below.

1.1 BACKGROUND

The soils of sub-Saharan Africa are rather poor compared to those of other tropical continents. The richest soils are found in steep, volcanic highlands or in lower river valleys with erratic, seasonal floods. Most Africans farm soils of only low to moderate fertility and can ill afford to lose productivity through erosion or other mechanisms.

The driving forces which cause erosion and loss of fertility are: (1) extension of cultivation into marginally productive lands that are susceptible to erosion, and (2) increasing frequency of cropping in fields that in the past were fallowed to restore fertility. Both forces are driven by rural population growth and, to a lesser extent, by the addition of commercial crops (e.g., peanuts, cotton, tobacco, maize) to the traditional mix of food crops. The drought exacerbated the effects of these trends on the land resources.

Most of Africa's growth in agricultural production has been achieved by means of increasing the surface under cultivation, rather than by increasing production per unit area. Sub-Saharan cropland expanded from 113 million hectares to 142 million hectares during the period between 1966 and 1985. Much of this expansion took place in arid and semi-arid regions; typical increases during this period were as follows:

Senegal	+	768,000 hectares
Mali	+	1,220,000 hectares

Burkina Faso	+	548,000 hectares
Niger	+	1,267,000 hectares

Large increases also occurred in densely populated nations (WRI, 1986):

Rwanda	from 21% to 26% of the total land base
Burundi	from 39% to 41% of the total land base

In the West African Sahelo-Sudanian belt, 3.8 million additional hectares were put into cropland, at a time when wind and occasional water erosion were especially serious (WRI, 1986). In Ethiopia, 2.2 million additional hectares were cultivated during 1966-85, probably including steep uplands (WRI, 1986).

The degree to which this expansion of cultivated surface took place in marginally productive steeplands, at the expense of fertility-restoring fallows, or at the margins of rainfed cultivation in the former domain of pastoralists cannot be quantified. It is a central issue in the degradation of African lands, however.

There is keen awareness in Africa of soil erosion, especially in the East African and southern African highlands. Colonial administrations, as well as newly independent African governments, have taken steps to arrest soil erosion. Yet apart from several recent successes in combatting erosion -- including, among others, A.I.D.-supported watershed treatment in Cape Verde, World Food Programme erosion control work in Ethiopia, and SIDA-supported work in Kenya -- it continues to be a grave threat to the sustainability of agriculture in most of Africa's agricultural land.

Less well understood than erosion is the problem of declining (and inherently poor) soil fertility, which occurs even where there is no erosion. It is a more widespread, insidious problem which lies directly in the path of agricultural progress in Africa. Improved, traditional methods of restoration can help (e.g., manuring); however, innovative techniques must be developed for fertility maintenance and restoration under the conditions of intensified production and a variety of environments and livelihood systems.

Recent agroforestry research results indicate that there may be substitutes for the traditional forest fallow as a means of restoring soil fertility (Kang, Wilson and Lawson, 1984).

During 1986, the Congressional Office of Technology Assessment was in the process of surveying low-input means of agricultural

production in sub-Saharan Africa, and the results should be an important fund of additional ideas.

1.2 STATE OF KNOWLEDGE

Africa's soils are neither well described nor well-mapped, except in scattered areas. The FAO's 1:1,000,000 soil map of Africa, is for the moment, the continent- wide standard; however, the scale is far too small for any but the most general planning. Additional, larger-scale surveying is currently taking place, based on either the French (Aubert's) soil taxonomy or the USDA taxonomy, whose use is being constantly extended with assistance from A.I.D.'s Soils Management Support Service (Bureau for Science and Technology).

The observed variability of soils over short distances, as well as the small size of most farms and fields (used mainly for subsistence foods), elevate the costs and depress the benefits of soil mapping in Africa. It appears that inexpensive, efficient techniques of soil mapping and description (perhaps through increased use of aerial photography) are a needed response.

There are no comprehensive statistics on intensity of cultivation that quantitatively describe the shortening or abandonment of fallow periods and the resulting loss of soil productivity. In computations of population supporting capacities for various agro-ecological regions in Africa, however, FAO assumed a cropping:fallow ratio of 1:5. This ratio has narrowed in many places, and certainly isn't large enough for the more humid tropics. The result of a 1:5 crop-to-fallow ratio can only be a decline in productivity if other means are not found to maintain it.

The threat of erosion from wind and water, as well as of desertification in general, have been assessed and mapped by (or for) FAO in recent years (FAO and UNEP, 1984). The FAO soils degradation studies, however, had not yet been brought into a useful, analytical or cartographic form by the latter half of 1986.

1.3 SOIL LOSS BY EROSION

Generally speaking, in Africa, the soils most susceptible to erosion are those on the lands that are also most heavily populated, i.e., tsetse-free semi-arid regions and the highlands of East, Central and Southern Africa.

Because most soils in Africa are very old and highly weathered, i.e., with deep, relatively infertile horizons, loss of topsoil

is of the gravest consequence. Newer, more fertile soils tend to occur in steep landscapes, i.e., the East African and South African highlands, where they are susceptible to disastrous erosion (3 centimeters or more of topsoil per year) (Sfeir-Younis, 1985). Only the deepest, most fertile volcanic soils can withstand such erosion for any significant period of time without productivity loss.

In 1984, the potential loss of African rainfed cropland to wind and water erosion between 1975 and 2000 was estimated by FAO as follows: if no conservation measures are taken, a total of 203 million hectares will have been lost, or 16% of the total (estimated for all Africa to be 1,268 million hectares). Erosion will also have impaired the productivity of the remainder of these lands.

The foregoing very broad estimate is not very helpful in program design, however. For a problem so grave and whose solution is so important for the well-being of the African people, there is a striking paucity of solid information in the development community.

Very little research on, or measurements of, rates of soil loss—and formation have been carried out in Africa. In 1984, FAO and the International Institute of Applied Systems Analysis computed estimates of productivity losses due to erosion, based on 160 sites in Africa, but the results were not available during this review (Shah, Fisher, Higgins and Kassam, 1984). Similarly, there has been little research done on the effect or impact of erosion control on long-term soil productivity in Africa. Part III notes some of the work that has been done in various sub-regions.

Paradoxically, erosion by water, not by wind, is the principal cause of soil loss in arid and semi-arid, as well as sub-humid, Africa. This is due both to the unusual intensity of some storms and the sparseness of vegetation in the more arid climatic regimes. Raindrop impact is the single most important erosive agent; hence, knowledge of storm intensity and raindrop size is of crucial importance to the understanding and prediction of erosion. Such data are rarely recorded in Africa.

A few measurements of soil loss have been made. In the gently sloping lowlands of West Africa's Sahelo-Sudanian region, where storm intensity is great, water erosion is considered to be a major threat, especially where it exposes lateritic soil horizons (WMO, 1983). Losses of up to 40 tons per hectare per year from peanut fields with only 2% slope were measured in Senegal's Casamance Region; this figure is 30 times greater than erosion losses on similar landscapes in the temperate zone (WMO, 1983). In Ethiopia, by comparison, rates of 152 to 165

tons/ha of erosion per year have been measured, or about 3 c per year. In Lesotho, 224 tons/hectare, or 3.5 cm. per year, have been measured (Sfeir-Younis, 1985).

Given the critical importance of the first 8 to 10 centimeters of soil, which contain organic matter (humus and most of the microbial life that lends productivity to soils), and given the time and effort required to reconstitute this layer of "living soil," the loss of even a few centimeters is equivalent to a loss of farm capital over several generations.

1.4. EROSION CONTROL METHODS

Techniques of soil erosion control are well known and have been widely published by FAO and others (FAO,1965, and, for example, Weber and Hoskins,1983). They include the use of bunds, infiltration ditches, terraces, gully plugs and low dams to arrest the energy of run-off water, the use of palisades and windbreaks to arrest wind energy, and the use of ground cover of various sorts, according to the ecological possibilities.

Water erosion-control works often serve multiple purposes: they retain soils, but also slow run-off and increase percolation, thereby conserving soil moisture. Finer sediments of clay and loam, which are important to soil productivity, are retained.

Large-scale projects, i.e., those for entire watersheds, entail proven planning and layout techniques, especially in areas of diverse soils that require a variety of techniques in order to achieve one overall purpose. Less straightforward are the processes by which to engage small farmers and villages in soil erosion works that they can plan and carry out on their own.

Increased vegetative cover (trees, crops, grasses) may be needed to prevent erosion by raindrop splash and run-off. Ground cover consisting of grassy or herbaceous vegetation can effectively control water erosion. Trees and other woody plants may be established on terrace walls and bunds in order to stabilize them. Also, tree crowns intercept rain drops and thereby lessen their erosive impact. An over-grazed tree plantation or fallow plot, however, can become seriously eroded if the terrain is steep. Very steep, humid catchments may require total withdrawal from all uses in order to prevent erosion.

Section III of this review describes successful soil erosion projects in Burkina Faso, Ethiopia and Kenya; these projects mainly involve the use of earthworks.

Soil conservation programs have tended to focus on preventing water erosion more than wind erosion. In Africa, the effects

of wind are dramatically illustrated by moving sand dunes. Concern over sand dunes' encroaching onto croplands or settlements and wind damage to crop ~~vigor~~ has motivated establishment of control works more than has concern over actual soil losses; nevertheless, the blowing away of smaller particles of clay, loam, and organic matter insidiously reduces soil fertility.

Solutions to the problem of soil erosion must also resolve soil fertility limitations in order to render the efforts worthwhile. In humid environments, for instance, bench terracing may initially decrease soil fertility because it disorganizes the soil horizon, and terrace walls may remove up to 25% of the land surface from cultivation. In some situations, therefore, fertilizers may be needed to compensate for initial losses of production resulting from control works, or to render economical the labor input.

1.5 SOIL PRODUCTIVITY DECLINES

Many of Africa's soils are inherently poor; this circumstance makes declining productivity all the more serious. The application of chemical or organic fertilizers is, at first glance, the appropriate response; however, the rate of chemical fertilizer use in Africa is the lowest of any continent because of a variety of factors. Moreover, the productivity of cultivated soils, including soils used for growing trees, is a function of more than fertility as measured by the major nutrients, i.e., nitrogen, phosphorus, and potassium. It is also determined by the amount of organic matter and humus, cation exchange capacity, amounts of micro-nutrients (e.g., magnesium and sulfur), levels of salts and of other elements that can be toxic (e.g., aluminum and manganese), number and variety of soil organisms, and various physical features, e.g., porosity, drainage, and field capacity (for water). These characteristics vary widely as a function of the various soil-forming factors: parent material, climate, vegetation, time, and mankind's actions.

Leaching of nutrients, formation of laterite, phosphorus fixation, loss of cation exchange capacity, salinization or water-logging, infestation by soil-dwelling plant parasites or ineradicable weeds: these are some of the diverse ways in which soil productivity can be lost, temporarily or permanently.

Knowledge of soil productivity loss due to causes other than erosion is patchy. No general surveys for Africa were found, outside of Nye and Greenland's 1960 classic, The Soil Under Shifting Cultivation. For semi-arid French West Africa, a comprehensive review of knowledge on soils up to 1974 is contained in Claude Charreau's 1979 Cornell University lectures.

Detailed knowledge of African soils, i.e., at the level of the farmer's field, is very poor. Knowledge of chemical and microbiological aspects of productivity in Africa is also very sparse. Knowledge of crop responses to various kinds and levels of fertilization is scarce, although it is beginning to accumulate as a result of various research projects (e.g., the World Bank's Western Sudan Agricultural Research Project, A.I.D.-sponsored soils research at ICRISAT/Sahel in Niger, and ORSTOM-sponsored research on soil microbiology in Dakar, Senegal).

The FAO has convened numerous seminars and conferences on the theme of soil fertility in Africa:

1970. Conference on Soil Fertility and Fertilizer Use in Africa (Addis Ababa) (FAO, 1970)

1977. FAO/SIDA Workshop on the Use of Organic Materials as Fertilizers in Africa, Buea, Cameroon (FAO, 1977)

1980. Seminar on Recycling of Organic Agricultural Residues in Lome, Togo

African soils are extremely diverse, but a few generalities can be made. The productivity of older soils (i.e., in lowlands or on plateaus) is highly variable, even within small fields in Africa. In the sub-humid tropics, both phosphorus fixation in clay minerals and laterization, which follows exposure to the air resulting from cultivation and erosion, are general problems. Toxic levels of aluminum ~~and manganese~~ may also affect older soils, and can result from continuous cultivation with fertilizers.

In the different sub-regions, the mechanisms of productivity loss vary, since they are functions of soils, climate and related agricultural uses. These mechanisms are treated in further detail in the sub-regional descriptions.

6.6 RESPONSES TO PRODUCTIVITY PROBLEMS

Responding to the range of problems besetting soil productivity in Africa is far more complex than responding to soil erosion alone. Many more interacting technical factors are involved, in addition to the socio-economic ones regarding farmers' motivations to do something about erosion and productivity loss. The high cost of chemical fertilizers is a major obstacle to correction of some infertility problems.

The use of manure and plant materials has been traditional in many parts of Africa for the enrichment of soils, especially in fields adjoining settlements or groupings of houses. An

additional technique in the semi-arid tropics of West Africa is the seasonal corralling of migrating herds (managed by pastoral nomads) on the fields of sedentary farmers to concentrate manure and enrich the soil. In the tsetse-infested humid lowlands, cattle manure is not available, of course, because of the disease threat to the cattle. Fallowing has therefore been the main means of restoring fertility, especially that of outfields, throughout humid as well as semi-arid zones. Land shortages have shortened fallow periods to the point of no longer being effective, however.

Chemical fertilizers have been too expensive for most crops grown by African farmers, at least under current commodity pricing policies. Beyond the farmers' actual lack of money to buy fertilizers, additional lacks are the fertilizers' timely availability in the correct formulations and the existence of private or public institutions that could supply and/or finance them. Even when farmers can afford them, namely for export crops, fertilizers may be unavailable or their delivery delayed. Nevertheless, soils scientists and agronomists are continuing to seek improved ways to manage African soil fertility with chemical fertilizers.

The need for soil productivity management through means other than chemical fertilizers has begun to introduce major new elements into assistance projects and research. New and traditional agroforestry systems offer promising solutions to fertility loss, and also to other problems:

* Acacia albida in sandy soils can boost millet production; provide pods and leaves for fodder, and twigs for fuel; and attenuate dry season winds and solar radiation. This unique tree retains its leaves during the dry period and sheds them during the short rainy season.

* Leuceana planted in rows in corn or other crop fields (alley cropping) supplies nitrogen when tops are cut and worked into the soil, thereby making continuous cropping feasible without inorganic sources of nitrogen.

* Stall feeding of livestock with cut fodder makes the conservation and management of manure possible, reducing losses of nitrogen to the atmosphere.

7. DEVELOPMENT ASSISTANCE RESPONSES TO SOIL EROSION AND PRODUCTIVITY LOSSES

The international community has come to the assistance of nations, such as Ethiopia and Lesotho, with serious, even catastrophic, soil erosion problems. Much is being accomplished through the soil and watershed conservation

program of the World Food Programme; however, little is being done to arrest the widespread, but less dramatic, erosion losses occurring on gently sloping terrain.

Development assistance responses to productivity declines have been limited mainly to research. Phosphate deposits are found in many African nations, including those in the semi-arid and sub-humid zones where soil phosphorus deficiencies have been identified; however, the costs of converting phosphate into fertilizer are too high for the average African farmer, and the phosphate rock or the fertilizer is therefore exported rather than used locally (e.g., phosphate fertilizers exported from Senegal, phosphate rock exported from Togo).

The IFAD (International Fund for Agricultural Development) recently contracted the International Fertilizer Development Center, based in Alabama, to set up a research program in Africa. This program will be designed to work with various national and international research centers in order to:

* evaluate the potential of indigenous phosphate deposits with respect to direct application of phosphate fertilizer at minimal cost,

* study the role and efficiency of nitrogenous fertilizers, and

* study the effect of cropping systems and farm management practices on the maintenance of soil productivity and fertilizer use efficiency.

Partially acidulated phosphate rock was found in field trials to be a viable alternative to single superphosphate, which is presently imported from outside the continent. It could be produced and supplied at 80% of the cost of single superphosphate.

The building of soil surveying and analysis capabilities has been largely the work of FAO and a few European donors, such as France and Belgium. During 1986, FAO assisted Benin, Burkina Faso, Cameroon, the Central African Republic, Ethiopia, Niger and Nigeria in surveying soils or building soils services.

A.I.D. RESPONSES

A.I.D. has responded intermittently over the years to soils and water conservation needs in Africa, but without discernible or purposeful cohesion and momentum. To date, no programmatic framework has existed for attacking the aforementioned problems of erosion and productivity loss (and related fertility management). Various recent or ongoing projects are, however,

dealing with some of the causes. The brief review presented here is supplemented by additional details in the sub-regional treatments.

On-going or recently completed A.I.D. actions include support to World Food Programme soil and watershed conservation projects; grants to private voluntary organization (PVO) efforts in soil erosion control; technical assistance in soil surveying and classification; and various PL-480 projects managed by A.I.D. missions that support erosion control.

The latter have included a ~~very effective~~ project of total watershed treatment on Cape Verde's Santiago Island; and dune stabilization with vegetation in Mauritania and along Senegal's coastal zone north of Dakar. In Kenya and Rwanda, a sub-project activity within the Environmental Training and Management for Africa project measured actual erosion losses from a number of farmers' fields for the first time in that country (Lewis, 1985). CARE's Majjia Valley Windbreak Project is partly supported by A.I.D., as was CARE's Acacia albida agroforestation project in Chad in the late 1970's.

The A.I.D. Bureau for Science and Technology's Soil Management Support Service is addressing the African soils information base. There is currently a need for additional soil surveys and an assessment of the potential for agricultural technology transfer. Short-term technical assistance on survey and classificatory procedures has been provided to Zambia, Rwanda, and Burundi. Also, the problems of dryland agricultural soils are being addressed in a project that includes Africa's Arid and Semi-Arid Tropics sub-region (Project on Dryland Agriculture).

Several A.I.D. projects have supported national, small-scale soil mapping and evaluation in Senegal, Mali, and Mauritania. With some A.I.D. support, the U.S. Soil Conservation Service is updating and extending 1:1,000,000 soil maps that were made of certain portions of Africa 40 years ago. The updates are being accomplished on the basis of interpretation of small-scale aerial photographs. The result will be a land systems map based on geomorphological traits.

1.8 CONSTRAINTS AND GAPS

A number of constraints have limited the response of both governments and farmers to soil erosion and productivity loss: lack of data on benefits, small farm size, high labor costs, and the difficulties of intensifying production.

Evaluations of soil erosion control projects are rare, since a long-term perspective is needed. In Somalia, for example,

A.I.D. recently evaluated a soil and water conservation project that was undertaken in the early 1960's (A.I.D., 1985a). Bunded fields were still producing 50% more than those not treated (initially, production had doubled), even though in many places the bunds had deteriorated as a result of lack of maintenance. Bunded farms also dropped the traditional grain/pasture rotation in favor of continuous cultivation of sorghum and increased amounts of maize.

The predominance of subsistence agriculture in rural Africa creates a paradox for soil management programs. There is little apparent pay-off for government investment in stabilizing the soils of subsistence farmers. Still, subsistence farmers will and do produce commercial crops such as peanuts and cotton as well as food staples, they live in watershed areas, and they will move to cities or other areas if their soils are exhausted or ruined by erosion.

Farmers also must be motivated. Additional labor is implied for conservation work, e.g., for the construction of berms or infiltration ditches along contours. Also, there is the "opportunity" cost incurred as a result of having to construct earthworks after the onset of rains, when the soil can be worked, but at a time when other tasks require labor. For poor farmers, the increased production of subsistence food would have to clearly compensate for the needed extra labor; thus, conservation measures must increase production. In fact, soil conservation normally does increase yields, if not initially, then within a few years.

The need to intensify agriculture, while at the same time reversing land degradation in the same field, requires that development responses and soil improvement interventions at the farm level be coordinated, e.g., better seed spacing and more timely weeding along with erection of erosion control structures. Involved government services and institutions must assist the farmer in a coordinated fashion as well. This coordination and integration of services (such as forest services and agricultural or rural development services) is, in practice, difficult to achieve.

The needed innovations in the administration of services will be exploratory in some nations, while in others some progress is already being made. In all likelihood, a partnership must be developed between government institutions, and between governments and donors.

With regard to the political climate for such change, the World Bank is presently undertaking a series of studies on policy instruments which are supportive of soil conservation and other conservation management efforts.

A recent Worldwatch Institute publication, Reversing Africa's Decline, compares Africa's and Asia's land degradation problems (Brown and Wolfe, 1985):

> Restoring the productivity of African soils will require a different approach than the Green Revolution in Asia. The restoration of land productivity in Africa depends on restraining cultivation on marginal and steep lands and on making the most suitable land more productive. In contrast to Asia, where the overriding goal was to combine abundant water and artificial fertilizers to raise crop yields, the immediate target in Africa must be to restore vegetation and soils to make the most of limited water supplies. Africa's own green transformation will depend on breaking the cycle of land degradation. If soils are secured and vegetation is restored, crop yields will begin to rise toward their potential.

1.8 AGENDA OF POSSIBLE ACTIONS

REVIEW OF PAST EXPERIENCES

* Catalogue, evaluate, publish and distribute information on past efforts in Africa in the areas of soil conservation, fertility management and land rehabilitation, with editorial focus at the field technician and project planning level.

RESEARCH

* Evaluate and carry out applied research on the economic costs and benefits of soil erosion control and other productivity-restoring techniques.

* Expand research on use of leguminous plants for managing soil nitrogen, in sub-humid as well as humid environments.

* Undertake soils management research and trials for different stages of soil degradation in the major soils of the different sub-regions.

* Agricultural research agendas need broadening in order to develop improved soil and crop husbandry techniques. The integration of additional land and crop productivity- enhancing techniques should be sought, e.g., use of agroforestry species such as *Acacia albida*, use of rock phosphate fertilizer, legume/cereal crop rotations, sowing of improved forage species, and more effective use of crop residues and manure to maintain soil productivity. Different combinations and configurations must be researched.

SOIL CLASSIFICATION

* Map and describe Africa's agricultural soils with the aid of satellite imagery and aerial photographs, as well as ground surveys, with priority in the semi-arid and sub-humid agro-ecological zones (90- to 270-day growing seasons) and the tropical highlands.

PROJECT DEVELOPMENT

* In collaboration with the ongoing IFAD project, develop local phosphate fertilizers and set goals for research on and development of phosphate fertilization for the next 10 years.

* Support an expanded soil management component of national and international agricultural, range and forestry research in sub-Saharan Africa.

2.0 LOSS OF VEGETATIVE COVER AND PRODUCTIVITY

CONTENTS

2.1 The vegetation resource
2.2 Losses and degradation
2.3 Fuelwood as a limiting factor
2.4 Responses in Africa
2.5 Development assistance responses
2.6 Agenda of possible actions

In Africa, perhaps more than in any other continent, the productivity and sustainability of agrarian and pastoral livelihoods depend upon natural vegetative formations and trees: trees left to grow in the agricultural landscape, in small fallow plots and wooded grazing areas, and in the extensive, diverse, wooded grazing lands that sustain wild animals and livestock alike.

The Africans' long co-evolution with the environment has generated an intimate dependency on various tree species: for fuelwood; for tools, construction, and canoes; for medicinal properties found in roots, bark or leaves; for edible fruits, nuts, gum, oils and leaves; for insecticides; for blossoms and fronds; and for the habitat trees provide wild game, still an important part of the diet in many places.

To this impressive array of products must be added the important ecological services rendered by trees and other vegetation. The role of vegetation in supplying organic matter to Africa's soils and in arresting wind and water erosion was discussed in the previous section. The important role of vegetation in providing resistance to aridity and drought is described in section II. B.6., below. In this section, the state of vegetation, the fuelwood question and various management approaches are reviewed.

2.1 THE VEGETATION RESOURCE

The vegetative formations of Africa have been mapped at the 1:5,000,000 scale, and described by UNESCO (White, 1983). Maps of present vegetative cover, however, do not exist except at scales too small to be of analytical value, e.g., GEMS images of Africa on page-size graphics. The FAO was in the process of preparing maps of present vegetative cover at the 1:1,000,000 scale in 1986, using satellite and aerial photographic imagery.

According to FAO (1981), the woody vegetation in Africa is comprised of the following:

	million hectares	%
closed forests	217	16
open woodlands	468	36
scrublands	443	34
open wooded fallow	104	8
closed forest fallow	62	5
plantation forests	1.8	1

In sub-Saharan Africa, woody formations also serve as rangelands and occupy an area of 1,945 million hectares (range and pasture), or about 65% of the total land area (WRI, 1986).

2.2 LOSSES AND DEGRADATION

Africa's forests have been reduced in area by half during this century as a result of a combination of agricultural expansion, fires, fuelwood cutting, and commercial logging (Clausen, 1986). The natural forest resources of countries such as Ethiopia, Rwanda, Burundi, and the Ivory Coast have been almost totally depleted, and these countries are now dependent largely on planted trees.

In those countries that still have forests, many are being cut at a faster rate than they are regenerating or being planted; however, Africa's extensive humid tropical forests in the Congo basin are being cut and cleared at a slower pace than are the humid forests in tropical Asia and Latin America.

It is estimated that over the past 10 years, 1.3 million hectares of closed forest were cleared annually in Africa (WRI, 1986). Clearing of Africa's vast stock of closed humid forests has been fastest on the West African coast, where only approximately 10% of the original forests remain. The rate of logging and export of timber from the Ivory Coast has been especially high. Another 2.3 million hectares of open woodland were also deforested each year in Africa between 1980 and 1985 (WRI, 1986). The majority of Africans live in semi-arid to sub-humid climates, where degradation of vegetation causes the greatest ecological and social impacts.

The degradation of wooded areas defies generalization and quantification. In the semi-arid zone north of the equator, the long drought killed many species that had become established during the preceding decades of good rains, but were actually more typical of moister zones (NAS, 1983). Forests and wooded areas become degraded when ground fires, browsing and trampling prevent regeneration, rendering the soil less porous and the site less productive. Over-browsing causes a shift in species to those that are less palatable to browsing animals. Wooded fallows contain fewer plant species and smaller trees as fallow periods are shortened.

Degradation is thus measured by the disappearance of desirable species, loss of site productivity, loss of diversity, and reduction in biomass, all of which diminish the number of products and ecological values of wooded areas. None of these trends, however, are revealed in existing statistical overviews of Africa's vegetative resources.

The degradation of rangeland in semi-arid to arid areas, which are too dry for farming (less than approximately 300 mm of rain per year), is perhaps less serious than the loss to farmers of pasture in low-lying, seasonally flooded areas where grasses

remain green well into the dry season. Such areas marked important traditional grazing reserves along transhumant stock routes. Encroachment of dryland farming into these areas has seriously unbalanced the seasonal pattern of forage for migrating herders.

Pastures are also giving way to cultivation in the highlands of East Africa. For lack of pasture, some farmers are shifting their livestock from cattle to goats and sheep, which can be stall-fed with diverse fodder sources.

Range degradation is most serious in the environs of stock watering points in semi-arid zones, where the sheer number of animals during the dry season creates mini-deserts, devoid of brush, trees, or grasses. Of greatest consequence is the reduction in perennial browse species (mostly acacias). This has been caused by over-browsing, loss of regeneration, and drought, which killed many trees in the Sahel. Arid zone range, however, displays great resilience and regenerative capacity, and will quickly recover if protected (NAS, 1983; GTZ, 1986).

2.3 FUELWOOD AS A LIMITING FACTOR

About 50 million Africans are coping with acute fuelwood scarcity (Clausen, 1986). Fuelwood scarcities underlie declines in soil productivity and may ultimately determine the numbers of people the land can support.

To the casual observer, fuelwood scarcity in Africa is not apparent. In the rural landscape, the presence of trees, bushes and brushland is deceptive. Some trees, such as baobab, are useless as fuelwood. Wild fruit trees are also spared if at all possible, and fruit trees, such as mango, located around compounds aren't used for fuel. Extensive areas of brushy woodland may actually be forest reserves, accessible only by permit, and possibly reserved for urban fuel needs. Small, easily cut branches and regrowth are of the most convenient size for small cooking fires or charcoal. Very large trees are not preferred fuelwood resources.

The rate of growth determines the rate at which a stand can be cut. If growth is 1 cubic meter per hectare per year, and rate of cutting (consumption) is 3 cubic meters per hectare per year, a hectare of trees with 20 cubic meters of wood will be depleted in something less than 9 years. Depletion would be much faster during drought periods, such as the one that Africa has recently been experiencing, since trees essentially stop growing in the absence of moisture, even though they may not die. Both the gradual thinning of trees on the agricultural landscape and the disappearance of fallow brushland directly

affect soil productivity. Lacking fuelwood, people burn dung and crop residues, and the soil is thereby deprived of these sources of recycled nutrients. The fuelwood crisis is thus part and parcel of the food production crisis; however, research to increase fuelwood production capacity has not yet been undertaken to a degree commensurate with the link between fuelwood and soil productivity.

Predictions of fuelwood availability all point to declines. FAO has assessed and mapped the fuelwood situation of Africa (FAO, 1981a). Nowhere in the arid and semi-arid zone of Africa is there enough fuelwood to supply present needs on a sustainable basis. There are such severe shortages of fuel in the Ethiopian highlands that fuelwood consumption has dropped.

Other regions of acute shortage are north-central Nigeria and south-central Burkina Faso. Only in thinly populated southeast Senegal are fuelwood resources sufficient for the local population; however, charcoal production for the Dakar city market has begun to cause encroachment on the woodlands of this zone. In the adjacent sub-humid zone, there is also a fuelwood deficit, especially in the sub-humid portions of Kenya, Ethiopia, and Angola.

2.4 RESPONSES IN AFRICA

Historically, forest and range exploitation, as opposed to management for sustained yield, has been the pattern. Many modern-day forest services have been shaped by a colonial legacy of uniformed guards enforcing the state's dominion over all forest reserves. Tree and land tenure laws have discouraged the planting and conservation of trees. In addition, some African governments have fsvored plantations over management of natural forests.

Forestry and range research has a fairly short history in Africa, and has had only tenuous support from governments. In recent years, this general situation has begun to improve; however, many (if not most) African forestry, range management and research institutions are currently far from able to fully address the vast and complex tasks that face them.

A few countries have made important progress in reversing or slowing deforestation. They include Rwanda and Malawi, where planting on individual farms has reached a level at which, some experts believe, the fuelwood and construction-wood scarcities may be solved over the long run.

The scale of tree planting in many parts of Kenya is impressive. With modest beginnings in the early 1970's, tree planting and soil conservation, through a strong initiative of

the present government, have reached the proportions of a national crusade. Strong local actions (especially by women's groups, backed up by governmental resources) have made significant progress in this area.

2.5 DEVELOPMENT ASSISTANCE RESPONSES

Development assistance in forestry has recently focused on: (1) the use of trees to combat desertification; (2) reforestation (in the Arid and Semi-Arid Tropics and Sub-Humid Tropical Uplands countries) to resolve the fuelwood crisis; (3) industrial forestry assistance in the more humid nations, and, (4) agroforestry.

Much has been learned in the past 10 to 15 years, as project results have come under the scrutiny of organizations such as A.I.D., the World Bank, FAO and others (Weber, 1984; A.I.D., 1984; World Bank, 1985). The process whereby forestry actions are identified and planned emerges as an important prerequisite of success. Planners have often misunderstood the role of trees in traditional agricultural systems.

Lack of participation by the ostensible beneficiaries has been a common weakness of earlier forestry projects. Supposed beneficiaries usually had little input in the planning process, and project design suffered as a consequence. In addition, their views were not regularly solicited nor acted upon during implementation.

Lessons have been learned by donor organizations and governments alike. Natural forest management and small-scale community forestry are now favored over large-scale plantations in the semi-arid zone.

A macro-level blueprint for development assistance in African forestry is contained in FAO's Tropical Forestry Action Plan of 1985, which was developed by the multinational Committee on Forest Development in the Tropics. For every continent, it sets forth action proposals and estimates investment requirements for the following five priority areas:

1) forestry in land use;
2) forest-based industrial development;
3) fuelwood and energy;
4) conservation of tropical forest ecosystems; and
5) institutions (research, training and extension).

According to this plan, five-year (1987-91) investment requirements for Africa are estimated to be over $1 billion. Follow-up action to the FAO Plan is taking the form of multi-donor forestry sector reviews, which in Africa were initially scheduled as follows:

1986	1987
Cameroon	Botswana
Ghana	Ivory Coast
Guinea	Madagascar
Kenya	Burkina Faso
Mali	Ethiopia
Tanzania	Niger
Zaire	Somalia

A somewhat parallel macro-planning effort for tropical forestry was undertaken by the World Resources Institute (WRI) in 1985. The resulting report is entitled Tropical Forests: Call for Action.

WRI estimated support needed for forestry in Africa as follows:

Fuelwood and agroforestry	$507 million
Land use in upland watersheds	$191 million
Industrial forestry	$210 million
Ecosystem conservation	$130 million

The FAO and WRI planning documents are important contributions, and constitute useful points of departure for A.I.D. forestry support planning in Africa.

Research priorities were recently reviewed at the International Union of Forestry Research Organizations meeting, which took place in January, 1986,in Nairobi, Kenya. Participants stressed the need for greater cooperation among African countries in forestry research. Priority research efforts were oriented towards:

--natural regeneration in silvipastoral systems,
--genetic improvement of multipurpose trees, and,
--agroforestry research.

Training, extension and data dissemination networks were strongly supported.

RANGE MANAGEMENT

Range management experiences have been less promising than those in forestry in defining more effective development approaches. Range management (not including livestock production) has been largely in the form of range rehabilitation projects (e.g., fencing, planting of browse species, research, range surveys and monitoring experiments).

There is now a broad consensus among biological and social scientists that the technology of range management, as

developed in the United States and in commercial schemes in the tropics, cannot work among pastoralists. This consensus involves more than just a concern for the appropriateness of forage species and planting methods. It also applies to a wide variety of Western range management techniques, e.g., grazing blocks, stocking rates, group ranches, and individual and group land management institutions. All of these management techniques conflict with traditional methods of managing herds and grazing, which have been adapted to the very high variability of forage and water supplies that characterizes Africa's dry rangelands (Gilles, 1982; GTZ, 1986).

U.S. RESPONSE

Between 1976 and 1986, the U.S. extended substantial support to reforestation in the Arid and Semi-Arid Tropics sub-region and in the African Highlands sub-region (in East Africa) with emphasis on combating desertification and solving the fuelwood crisis. Reforestation, soil and water conservation, and the integration of agriculture and forestry have been important themes. No forestry assistance has been provided to the sub-humid and humid tropical nations, however.

The PL-480 program has been increasingly employed to finance forestry activities: $36 million in 1982 compared to only $6 million in bilateral forestry projects (Clement, 1984).

Like most other donors, A.I.D. has shifted support since 1984 almost entirely to small-scale forestation efforts. A.I.D. has also developed partnership arrangements with the U.S. Peace Corps, as well as several Private Voluntary Organizations (such as CARE and Catholic Relief Services) as a means of expanding assistance in forestry. Specific projects are listed in Appendix A and in the sub-regional descriptions.

Since 1983, a modest amount of support has been provided to the International Center for Research on Agroforestry in Nairobi, for the purpose of financing a review of agroforestry systems and the establishment of a portion of a research network throughout Africa.

A.I.D. has supported African forestry species trials, which were carried out by the Board on Science and Technology in International Development at the National Academy of Sciences.

An important complement to forestry activities is fuel conservation. A.I.D. is supporting (directly or through PVO's and Peace Corps volunteers) the development and diffusion of wood-conserving stoves.

A.I.D. support to range management has been minimal, and has

usually been a sub-activity within livestock production projects. These activities have typically included veterinarian support, research on livestock diseases, vaccine production facilities, ranch and range development, market route development, slaughterhouse construction, water point development, and training. Support, however, has been declining. In 1978, there were 17 active and 8 proposed livestock projects, representing a total cost of $127 million. In 1986, the numbers had declined to 11 on-going projects at a total cost of $87 million.

2.6 AGENDA OF POSSIBLE ACTIONS

Multi-donor forestry sector reviews, which are being undertaken in 1986 and 1987 in Africa under the aegis of FAO, will supply important guidance for mission-level actions. These reviews can be utilized to elicit a broader development assistance response from donors.

There are several categories of support in the fields of forestry, agroforestry, etc., that African missions could consider. The following have been supported already by various A.I.D. missions:

* PVO forestation and fuel conservation work;
* agroforestry plantings;
* village forestation;
* conservation forestry (e.g., windbreaks, terrace and field edge plantings, etc.);
* forestry training and research;
* research in natural forest management;
* watershed rehabilitation and conservation;

Additional activities that merit support include:

* forest resources policy and legal analysis;
* management of natural forests;
* rangeland rehabilitation and research on range resources and ecology.

Other recommendations appear in the sub-regional treatments, Part III.

3.0 WATER RESOURCES

CONTENTS

3.1 Background
3.2 Sub-Saharan water resources
3.3 Issues in water development: Sudan as a case study.
3.4 Development assistance responses
3.5 Agenda of possible actions

The A.I.D. Working Group identified ground and surface water pollution and salinity build-ups as the most important management issues which affect water resources.

This review of sub-Saharan Africa's water resources uncovered, in addition, a multiplicity of present and foreseeable management problems. Aside from pollution problems, which are rather spotty and poorly documented, there are the problems of water-related diseases associated with irrigation development, dilapidated irrigation schemes, weak or totally absent water management during the development process, and weak planning of water and related land development. These have persisted even though international organizations, including A.I.D., have attempted to build institutional and technical capacities for water resources management.

The exceptions to this situation are the many, fairly well-functioning electrical generating authorities (e.g., the Volta River Authority), a few well-functioning, large-scale irrigation schemes (e.g., Madagascar), and countless small irrigation projects that are evolving (with international assistance) along major rivers, swamps, and seasonally flooded depressions.

3.1 BACKGROUND

A.I.D. has not financed a major African dam since the Akosombo Dam on the Volta River. A.I.D. has, however, assisted water resources development through projects that strengthen development authorities; survey and plan irrigation projects; assess or research groundwater, rivers and lakes; and assess the environmental impacts of river basin development.

Historically, water resources development in Africa has consisted of large-scale, post-World War II dams, irrigation projects, and stock-watering holes. These projects have generated high financial, environmental, and social costs. Large dam and irrigation projects, in particular, have been plagued with a wide spectrum of social and environmental problems. The environmental backdrop is one of deforestation and erosion of watersheds. Many river water regimes have also been affected by below-normal rains and drought over the past 18 years. The meteorological, hydrological, and sub-surface geological information needed for assessment and design is often not available.

Large dams and irrigation systems have been sharply criticized (Goldsmith and Hilyard, 1984). The cumulative effect of African river damming on estuarine productivity is unknown and as yet unstudied. The effects of the drought on West African estuaries is similar to the impacts of impoundments on

estuaries. This drought has reduced or stopped the flow of fresh water to estuaries in the Sine-Saloum and Casamance Rivers in Senegal, and the Gambia River in Gambia. This has placed stress on and disrupted mangrove habitats and wildlife breeding habitats. The unique West African estuarine rice fields are planted only in the rainy season when the estuaries are replenished by run-off.

3.2 SUB-SAHARAN AFRICA'S WATER RESOURCES

Most of Africa's rivers are shared by several nations. International rivers number 57, although there are only 15 main drainage systems in Africa.

Sub-Saharan Africa's surface waters are unique in comparison to those of other continents in several ways, as indicated in Figure 3.1.

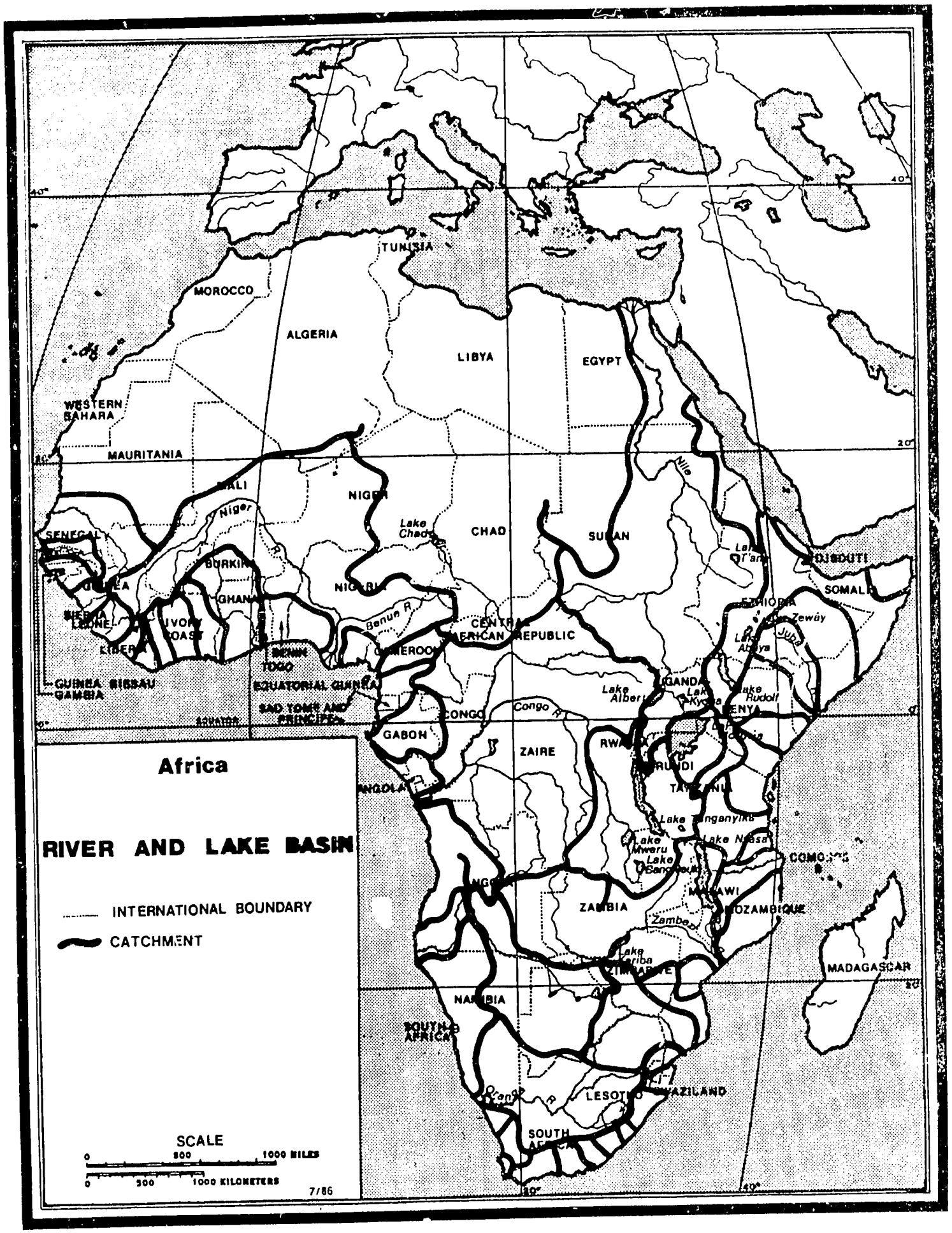
--International cooperation is imperative for proper river basin development in Africa; however, the existing multi-state river basin commissions in Africa are generally weak institutions.

--The upper tributaries of most of Africa's rivers arise not in rain forests or cloud forests, as is the case in South America and Asia, but rather in sub-humid uplands. Almost everywhere, these uplands are populated, over-cultivated, over-grazed and subject to seasonal burning. These activities increase the sharply seasonal flows and contribute to sediment loads. Flooding, wandering river channels, and heavy sedimentation of river beds, reservoirs, and irrigation feeder canals are frequent results.

--Irrigation in semi-arid and arid sub-region is restricted by the region's relatively flat terrain north of the equator and limited opportunities for dam sites and gravity irrigation.

--The vast inland deltas of a number of African rivers support fisherfolk, farmers and pastoralists. There is also a diverse array of indigenous fauna and over-wintering waterfowl from Europe. Development within the delta areas has the potential to destroy irreplaceable habitats and to disrupt traditional cultures.

--The presence of the disease schistosomiasis has invariably accompanied impoundments and irrigation developments in Africa. Only the Cape Verde Islands are exempt. Waterweeds are a related problem affecting lakes and canals. Both problems are difficult to manage and result in human suffering and loss of productivity.


Africa
RIVER AND LAKE BASIN
INTERNATIONAL BOUNDARY
CATCHMENT
SCALE
0 500 1000 MILES
0 500 1000 KILOMETERS
7/86
TUNISIA
MOROCCO
ALGERIA
LIBYA
EGYPT
WESTERN SAHARA
MAURITANIA
MALI
NIGER
CHAD
SUDAN
SENEGAL
GUINEA
BURKINA
GHANA
NIGERIA
SIERRA LEONE
LIBERIA
IVORY COAST
BENIN
TOGO
CAMEROON
CENTRAL AFRICAN REPUBLIC
EQUATORIAL GUINEA
SAO TOME AND PRINCIPE
GUINEA BISSAU
GAMBIA
CONGO
GABON
ZAIRE
ANGOLA
UGANDA
KENYA
RWANDA
BURUNDI
TANZANIA
ZAMBIA
MALAWI
MOZAMBIQUE
ZIMBABWE
NAMIBIA
SOUTH AFRICA
LESOTHO
SWAZILAND
COMOROS
MADAGASCAR
DJIBOUTI
SOMALIA
ETHIOPIA
Niger R.
Benue R.
Congo R.
Orange R.
Nile
Zambezi
Zewáy
Juba
Lake Chad
Lake Albert
Lake Kyoga
Lake Rudolf
Lake Abaya
Lake Tanganyika
Lake Nyasa
Lake Mweru
Lake Kariba
EQUATOR

As with African soils and vegetation, water resources and aquatic environments are, with few exceptions, very poorly known; this is due to a lack of research and surveys. Man-made lakes (e.g., Lake Volta and Lake Kariba) are an exception to this rule.

WATER DEVELOPMENT FOR IRRIGATION

Irrigation experience and prospects in sub-Saharan Africa were reviewed by FAO in 1985 and are summarized below.

Table 3.1 PRESENT IRRIGATION DEVELOPMENT IN SUB-SAHARAN AFRICA

	million hectares
Government-developed irrigation	2.2
Traditional irrigation (flood, swamp, low lift and surface)	2.7
Modern, private sector	0.4
Total presently irrigated	5.3

Source: FAO, 1985

Nigeria, Chad and Sudan have large areas of potentially irrigable soils, but other countries in the arid and semi-arid sub-region are not so well-endowed. Also, the largest areas of potentially irrigable soils are not in arid and semi-arid nations, but in the sub-humid to humid ones, e.g., Angola (6.7 million hectares), the Central African Republic (1.9 million hectares), Mozambique (2.4 million hectares), and Zaire (4.0 million hectares).

Table 3.2 PRESENT AND POTENTIAL IRRIGATED SURFACES IN SEMI-ARID AND ARID SUB-SAHARAN AFRICA, 1985 ~~(FAO, 1985)~~

	Irrigated	Irrigable
	(000's hectares)	
Botswana	12	100
Burkina Faso	29	350
Chad	46	1,200
Ethiopia	113	670
Gambia	26	72
Kenya	49	350
Mali	150	340
Mauritania	23	39
Niger	24	100

Table 3.2 (continued)

	Irrigated	Irrigable
	(000's hectares)	
Nigeria	840	2,000
Senegal	187	180
Somalia	85	87
Sudan	1,700	3,300
Totals		
Arid and semi-arid zones	3,284	8,788
All sub-Saharan Africa	5,293	33,641

Small-scale traditional irrigators number about 2.5 million families. In large, public schemes, approximately 850,000 small-scale irrigators operate 60% of the surfaces (FAO, 1985b).

FAO estimates that irrigated grain production represents only 10% of consumption in semi-arid Africa. In 1982, 1.5 million tons of coarse grains (sorghum, etc.) were produced under traditional irrigation, and 3.7 million tons of rice were produced, of which 1.0 million tons were produced in Madagascar. Only 1/6 of the region's total rice production came out of modern irrigation projects.

The costs of developing surface water irrigation systems range from $3,000/hectare for 10-to 50-hectare village-level schemes in Mauritania, to $8,400/hectare for large, public developments in Niger requiring land leveling. In the arid and semi-arid sub-region, low yields and high production costs have undermined the economic benefits of large-scale schemes.

Irrigation development utilizing groundwater is prohibitively expensive except when used for the highest-value crops. In Mali, for example, development of a well yielding between 7 and 14 cubic meters of water per hour, a small reservoir (100 cubic meters), and related fields would entail the following costs, varying according to the power source (FAO, 1985a, Appendix I):

Table 3.3 COSTS OF IRRIGATION UTILIZING GROUNDWATER IN MALI

Energy source for pumping	US$ per hectare
Diesel	15,400
Animal	19,200
Solar	34,500

Traditional irrigation from shallow wells is inexpensive but very labor-intensive. In Chad, for instance, 1/4 hectare of

irrigated wheat or corn requires that a farmer pump a total of 50 to 60 days, seven hours a day, using the counter-weighted chaduf (a water lifting device). This effort is only possible if the water table is shallow, i.e., 3.5 meters or less (ORT, 1986). PVO's and donor organizations are active in assisting small, traditional irrigators to find ways to pump more water and increase production (better pumps, seeds, fertilizers, credit, etc.); however, management of water consumption, water quality, and pesticide usage remain troublesome technical aspects of these small, "low-technology" schemes.

LAKE RESOURCES AND THEIR MANAGEMENT

Man-made lakes are not included in this discussion. Presently, A.I.D. is not participating in dam construction or man-made lake management in Africa. Most man-made lakes are ten or more years old and have developed fisheries management programs with assistance from FAO.

Africa's lakes are important for their fish and other aquatic wildlife, as well as their water resources. Africa has many important saline lakes as well as freshwater lakes.

Saline lakes attract spectacular birds, as at the Nakuru and Arusha National Parks. There are approximately 50 such lakes, mostly in East Africa. Lake Nakuru is receiving a steady inflow of industrial and agricultural pollutants, but their impacts are not yet known (Symoens,et al, 1981). Shallow lakes in Zimbabwe are also experiencing pollution. These lakes are more sensitive to eutrophication than are deep lakes, and also more sensitive to development such as canalization, because of their shallow morphology.

Numerous shallow lakes, such as Lake Chad, have formed within closed drainage basins. These lakes are characterized by marked seasonal or long-term changes in water level and salinity. This characteristic jeopardized a World Bank polder project in the Lake Chad basin, whose works were almost irreparably damaged by unexpectedly high lake levels in 1984. The salinity levels and high turbidity in these closed lakes have one very positive effect: they curtail the incidence of schistosomiasis, whose snail hosts and free-swimming cercariae cannot tolerate these conditions.

Shallow lakes can be productive fisheries, although they are susceptible to lake level changes. In Lake Chad, fisheries harvests ranged around 100,000 tons/year between 1974 and 1980, which contributed importantly to the protein requirements of the populace (average of 22 kg/person/year) (Symoens, et al, 1981). Spirulina, an edible alga, is also gathered from the lake's shallow waters.

Deep lakes are also concentrated in East Africa in the Great Rift valley, e.g., Lakes Tanganyika (over 900 meters deep), Kivu, Malawi, Victoria, Turkana and Edward. Water temperatures and related characteristics of these lakes display a stable gradient, or stratification. Absence of oxygen at depths results in the production of methane (from anaerobic decomposition of organic matter), which is tapped in some places, e.g., Rwanda.

Africa's deep lakes are showing the effects of over-fishing, i.e., a reduction in fish size, especially since the introduction of the nylon gill net in the 1950's. Fishing is a traditional practice that is not easily controlled. The dangers of exotic introductions are exemplified by Lake Victoria. The carnivorous Nile perch (*Lates nilotica*) was introduced in 1960 and has virtually eliminated the once-productive cichlid fisheries of the lake. *Tilapia* have partially compensated for this loss.

Pollution is also affecting deep lakes whose shores have long been settled; pollution from pesticides is of greatest concern. In Lake Tanganyika, DDT metabolites have been found at concentrations of 0.45 to 2.3 mg/kg in sun-dried fish. Lakeshore cotton fields (10,000 hectares) were receiving 45 tons per year of DDT in aerial spraying (Symoens et al, 1981). DDT metabolites have also turned up in dried fish flour from fish caught in Burundi.

Metabolites of chemicals used to control insect vectors of river blindness and sleeping sickness have been found in fish and birds such as kingfishers in the Lake Chad and Lake Victoria basins. In general, however, deep lake pollution is not being well researched or monitored, because the sophisticated analytical and sampling techniques that are necessary are only now being acquired.

3.3 ISSUES IN WATER DEVELOPMENT: SUDAN AS A CASE STUDY

Sudan's dams and irrigation projects have suffered virtually every environmental, social and related economic problem that can be associated with water development in Africa. Siltation of reservoirs and irrigation canals is a major concern for irrigation projects in Sudan, whose rivers arise in the rapidly eroding Ethiopian highlands (El Badri Ali, 1983). Rivers elsewhere in Africa carry less sediment. Silt has shortened the useful life of reservoirs (usually measured in centuries for successful projects) and has clogged irrigation canals. This has led to increased weeds, which further slow water flow. Weeds also provide habitat for mosquitos and snails, which are vectors of malaria and schistosomiasis, respectively.

The Khashm el Qirba reservoir on the Atbara River (near the Ethiopian border) had lost one half of its capacity by 1982, only six years after completion. The Roseires Dam on the Blue Nile had lost almost one third of its capacity by 1981, equivalent to 40 per cent of the production potential of the irrigated project that it supplies (El Badri Ali, 1983). There are no simple engineering solutions to dam siltation problems when rivers (such as those flowing into Sudan from Ethiopia) carry such high loads of sediments. Additional siltation in existing reservoirs might be reduced by flushing, but silt already deposited in the reservoirs cannot be economically removed. Sudan has considered upstream dams whose sole function would be to act as sediment traps; however these dams would also eventually fill up.

Clearly, the only solution is the reduction of sediment loads through soil and water conservation measures in the Ethiopian river tributary catchments that feed into Sudan's dams. These conservation measures would serve the purpose of rendering both Ethiopian hillside agriculture and Sudan's irrigated agriculture more sustainable. Such work will involve international cooperation on a level that is difficult to envision at present, but that must someday be achieved.

Sudan's vast Gezira scheme, which began in 1920, has encountered virtually every possible difficulty and problem besetting state-owned projects. Weed infestation of the canals feeding the 900,000-hectare Gezira have contributed to recent declines in water supply and productivity. Twenty-three species of weeds have been recorded in the canal system (El Badri Ali, 1983).

Malaria infection rates are also high in Sudan's irrigation projects. What was once a seasonal problem in a few places has become the primary killer of humans in Sudan. Mosquito vector control has been complicated by increasing resistance of the mosquito (A. arabensis) to DDT and malathion insecticides. The insecticide fenitrothion (BNH) was used in the early 1980's to control the mosquito (Abu Ahmed, 1983). Agricultural pesticides have further complicated malaria control by exposing the vectors to a range of chemicals to which they become tolerant or resistant.

Sudan has set up an emergency schistosomiasis treatment, research and surveillance program, the Blue Nile Health Project, to combat water-related disease epidemics. A.I.D. is supporting the project with a ten-year (1981-91), $8.48-million effort in schistosomiasis surveillance and control. The tenant farmers have faired poorly under this scheme, from both health and income standpoints. The Rahad extension of the Gezira project was found by A.I.D. to have left the "beneficiary

populations" worse off than they were before the project began (Harrison, 1986).

3.4 DEVELOPMENT ASSISTANCE RESPONSES

Assistance by A.I.D. and other international donor organizations in resolving the great range of management problems of African water resources has taken many forms. In general, water resources development per se has been hampered by lack of fundamental knowledge of the resources, too narrowly defined policies, and fledgling or ineffective water and land development institutions. Consequently, considerable development assistance effort has focused on data collection and development of government services and water and river basin development authorities.

Indirectly, the current drought has fostered small-scale garden irrigation, which has been supported through the emergency development of groundwater for community water supplies (well deepening and development). Such water supplies have proven in many cases to be an essential ingredient in successful, small-scale nurseries and dry-season gardens. In fact, drought rehabilitation, as well as emergency work at the community level, almost invariably begin with water-well development, first for people and domestic livestock, and then for nurseries and dry-season gardens.

A.I.D.

A.I.D. has focused in recent years almost exclusively on the water development needs of drought-stricken nations, as described below. In general, A.I.D. missions have not tackled water pollution as a development problem, unless it is related to rural potable water supplies; however, an isolated but successful attempt to attack deep lake pollution in Kenya was recently supported by a regional project (Environmental Training and Management in Africa, or ETMA).

In Kenya, the Lake Basin Development Authority at Kisumu, on Lake Victoria, was assisted by ETMA to construct and equip a water quality laboratory, by means of a 3-year (1983-1986) series of consultancies and baseline studies of lake ecology and water quality. This assistance was in response to the growing threat to Winan Gulf and its fisheries resources from industrial, agricultural and urban wastes.

A Bureau for Science and Technology project, Water Management Synthesis, has been set up to help improve irrigation water management and is now in its second stage. Very little work has been carried out in Africa to date, however. The extension of this project, scheduled for design in 1988, will focus on

Africa and Latin America, since the Asia and Near East Bureau will not be included. Niger, Rwanda and Zimbabwe will be visited by multi-disciplinary teams in order to reconnoiter water resources development. Specific sites will be pre-selected by missions and host-country institutions.

A.I.D.'s attempts to assist international river basin development institutions have been rife with setbacks and frustrations; however, small technical advances are being made. In April, 1985, A.I.D. sponsored a workshop on river basin development in Africa during which experiences, issues, and problems were brought out (Clark University and Institute for Development Anthropology, 1985). These are summarized later in this section.

In the Senegal River Basin, A.I.D. funded a $3.0-million environmental assessment of the UNDP Master Plan for the Basin in the late 1970's. Subsequently, in 1981, A.I.D./Senegal began planning for a $60-million package of institution-building and irrigation development, with related research and health and water quality monitoring to be carried out through the multinational Senegal Basin Development Authority, the OMVS. Disagreement among the riparian states (Mali, Mauritania and Senegal), design problems, and changing priorities in A.I.D./Washington have delayed the approval of this ambitious project.

Presently, this "integrated" project initiative has been reduced to three separate projects, having little connectedness: (1) a long-term institutional planning assistance effort to the OMVS, funded at a level of $6.0 million over a five-year period (1986-91), (2) a $4.6-million, 6-year project to establish a groundwater monitoring system in the Senegal River Basin to investigate concerns that damming and water use will affect groundwater (this project could cost $3.0 million more than originally budgeted), and (3) a 6-year project to support agricultural research in each of three riparian nations until 1990, with each nation receiving approximately $1.0 million over the life of the project.

A.I.D. also sought to strengthen the multi-state Niger Basin Authority with an $11.7-million, institution-building project during 1982-86 (Niger River Basin Planning, #625-0944). A later addition was a $1.0-million project undertaken by the U.S. Army Corps of Engineers that was to accomplish detailed morphological and sedimentological investigations of the Niger River, construct and computerize a model of the river's sedimentation patterns, and develop this as a planning tool. The effort is being terminated early, however, for lack of a contribution of funding and personnel by the riparian states, a required condition for the project's implementation.

A.I.D. recently commissioned a review of irrigation in Africa through the above-mentioned Water Management Synthesis project (Moris and Thom, 1985),

> "to examine whether wider adoption of irrigation could relieve existing food production constraints, either by stabilizing food supplies in the drought affected zone or by permitting other farmers to use fertilizers and higher yielding varieties."

Traditional, small-scale projects, but not large-scale modern systems, were found to hold potential for increasing food production. Some other findings related to future actions are listed in the following section (3.5, Agenda of Possible Actions).

Groundwater development experience by A.I.D. has not been reviewed except in the context of individual projects. Lack of expertise in hydrology and geohydrology, in particular, indicates a long-term training need.

A.I.D. is not financing major groundwater development for agriculture at present; however, numerous PVO's supported by A.I.D. are assisting villages across Sahelian Africa to develop or rehabilitate wells for potable water and stock water. There is essentially no management component in this work. For instance, use of chadufs (a traditional water-lifting device) in Chad and Sudan to irrigate dry-season crops is being supported indirectly by A.I.D. and others. Salinization problems are perhaps inevitable in these small projects, however, since the amounts of water available are inadequate to flush out salts.

Training is virtually an automatic add-on to A.I.D. water development projects, but its impacts aren't routinely evaluated, nor do the long-term students "graduate" in time to participate in the projects that financed their scholarships. In addition to training linked to development projects, which responds to a lack of trained personnel, larger institutional manpower development needs should be addressed. Training needs for water resources development and management should be assessed from the standpoint of long-term trends, master plans for water development, and related institutional and survey needs.

Support for fisheries and other biological aspects of inland waters has been very modest, particularly when compared to the strategic role in nutrition that is played by fish throughout Africa. A.I.D. has in recent years supported aquaculture, rather than natural fisheries development. Much of this work has been carried out by Peace Corps volunteers and through the

Bureau of Science and Technology's Collaborative Research Support Project in Pond Dynamics.

OTHER DONORS

The building of hydrological data networks has been largely supported by UNDP; however, a multidonor effort in the Sahel is sponsoring the regional AGRHYMET (agrometeorological and hydrological) network. A.I.D. is contributing $7.0 million to this effort during 1982-87.

UNDP and bilateral donors alike have financed the preparation of national master plans for water development, as well as national-level groundwater surveys.

The EDF was financing a new survey of groundwater resources in West Africa in 1986.

In June, 1986, the World Bank began preparation of a proposal to upgrade hydrological and meteorological forecasting services throughout Africa. This proposal involved use of NOAA satellites, improvement of data collection, and employment of extension services. Funding through UNDP was planned.

With regard to river basin development assistance, the multi-donor funding arrangements typical of these schemes add to their complexity. Additional, and unfortunate, obstacles to international river basin development that have emerged in the recent past have been civil strife (Chad, Sudan, Ethiopia, Uganda) and the long drought.

Among international donors, disenchantment with large-scale water development is widespread, even though African states see such development as the one sure way to satisfy expanding urban food needs and to safeguard food production against drought. To date, however, large schemes have been devoted to cotton for export, or sugar and rice for urban consumers, even during the prolonged drought that began in the Sahel in 1968. Also, the costs of producing rice on a large scale are high. On SAED lands in Senegal, the cost of rice was higher than the market price of broken rice imported from Thailand.

FAO's recent assessment of irrigation in Africa agrees with the A.I.D. overview study of this topic: the greatest potential for assistance lies in the improvement of small-scale, traditional irrigation. This is an important change in emphasis from earlier, large-scale schemes.

Most international support for fisheries developments has focused on offshore fisheries or those in man-made lakes. UNDP support for Zaire's freshwater fisheries is an exception.

3.5 AN AGENDA OF POSSIBLE ACTIONS

The shift towards working at the small scale, with low-input resources, and in direct assistance to traditional farmers, is a reaction to the ineffectiveness of large, semi-autonomous development authorities and ministerial services. As in the case of soils and vegetative resources, however, water surveys and, where needed, research must be done to lay down the basis for reasoned actions that will sustain development, and not undercut its resource base. Assistance to institutions and people in Africa that can manage the complex variety of water resource problems should be a long-range assistance objective.

IRRIGATION MANAGEMENT

An A.I.D.-commissioned study of irrigation prospects and needs in Africa in 1985 made the following observations regarding future A.I.D. support in irrigation (Moris and Thom, 1985):

* Institutionalization and rehabilitation of existing irrigation systems are more important than new irrigation. A joint World Bank/A.I.D. effort was suggested. Research on the reasons for poor maintenance should precede financing of rehabilitation.

* Farming systems research projects should include irrigation.

* Modest support for strengthening river basin development authorities is justified. They are the only authorities capable of planning and executing irrigation development. (Specific ideas are listed below, originating in a separate conference.)

* There is a need to foster exchanges of technical information related to irrigation, especially with respect to soil fertility maintenance, pests, and weeds.

PVO-MANAGED WATER DEVELOPMENT

In some cases, missions support small-scale, improved traditional schemes through PVO's, rather than larger-scale schemes through governmental organizations. Under these circumstances, management of water-related diseases, salinization, weed problems, etc., could be neglected. A special technical assistance and management capacity seems necessary for dealing with these environmental and related social problems.

RIVER BASIN AND WATERSHED MANAGEMENT

An A.I.D.-supported conference on river basin planning (Clark

University and the Institute for Applied Anthropology, 1985) identified the following possibilities for A.I.D. support with respect to land and water development at the river basin level:

* Conduct institutional capacity studies regarding identification of appropriate institutions to plan and implement African river basin development. Stress should be placed on identifying existing local institutions in order to avoid exclusive assistance to the "increasingly ineffective" parastatal river basin development authorities.

* Increase efforts to improve the research, information dissemination and planning capabilities of existing agencies.

* Support irrigation administration, which aims to decentralize management responsibilities within large projects (down to water-user associations). Also, articulate small projects within a regional context so as to increase such potential multiplier effects as non-farm employment.

* Support the integration of production systems from bottom to top (i.e., from local production systems to regional credit and marketing organization, to national policies and institutions), rather than from top to bottom, which experience has shown is deleterious to local producers in and downstream from projects.

* Foster increased local participation in management of soils and water as well as forests, range, and wildlife. Devote more attention to maintenance of habitats, and, secondly, to institutionalizing appropriate local organizations for protective, managerial and extractive purposes.

FISHERIES MANAGEMENT

Support for training, research and field surveys would be especially useful. A modest level of support aimed at long-term needs would yield strategically important results.

A long-term effort is needed to understand and monitor the functioning of running- and still-water aquatic ecosystems, and their living resources, i.e., the biological perspective on water resources. Without research and surveys, opportunities will be foregone and actions will be taken in ignorance.

A.I.D. could consider supporting:

Bachelor's-level and graduate-degree scholarships in limnology.

Joint U.S./African research projects similar to the

collaborative environmental research of the late 1970's, undertaken with the U.S. Man and the Biosphere program, which teamed U.S. and Third World scientists.

Selected limnological and fisheries field surveys and research. These could be carried out on a demand basis, through an arrangement such as the Environmental Planning and Management Cooperative Agreement with IIED.

A number of the following existing or planned projects could become vehicles for A.I.D. activities related to water and fisheries resources management:

OMVG and OMVS river basin planning and development

OMVS Agricultural Research II (1984-90) #625-0957

Strengthening African Agricultural Research #698-0435

Sahel Manpower Development I (1983-89) #625-0960

Sahel Manpower Development II (1986-90) #625-0972

Semi-arid Food Grains Research and Development II (1986-90) #698 0542

Environmental Planning and Management Cooperative Agreement between S&T/FENR and the International Institute for Environment and Development

Extension to the Water Management Synthesis Project

Research in Pond Dynamics, a Collaborative Research Support Project, managed by the A.I.D. Bureau for Science and Technology

The current World Bank initiative to upgrade hydrological and meteorological services in Africa could be another vehicle by which to provide A.I.D. support for data management and institutional strengthening throughout Africa, with minimal design and management effort.

4.0 COASTAL RESOURCE DEGRADATION

CONTENTS

4.1 Fisheries and other coastal values
4.2 The role of mangroves and reefs
4.3 Degradation of coastal resources
4.4 Management problems
4.5 Development responses
4.6 Agenda of possible actions

Coastal resources are in the zone of transition between the ocean environment and the terrestrial or inland environment. There is considerable latitude in the definition of the coastal zone, both to the seaward and the landward extremes, depending upon the research, survey or management objectives in question (Sorensen, et al, 1984).

In this document, coastal resources are defined as those found on the seashore and in adjacent shallow waters of the continental shelf or surrounding islands, and in estuaries. Included are beaches, lagoons, tidal flats, mangroves, sea grass beds, and coral reefs, and the fish and other life found in these diverse environments. African coastal peoples have exploited these resources for millenia.

The degradation of various coastal zone environments and the loss of their resources were the concerns that prompted their inclusion in this review.

UNEP (1982) has done a systematic review of the coastal resource issues of East Africa, discussing both the concerns and possible means by which to address them. Sorensen and others (1984) have reviewed the coastal resource concerns of Africa as part of a general global issues index.

4.1 FISHERIES AND OTHER COASTAL RESOURCE VALUES

The annual fishery potential of African waters, both marine and inland, is substantial. Approximately 15% of the current world fishing catch (estimated at 11 million tons) is taken from the African continent. In the marine sector, most of the potential fishing area is located in northwest and southwest Africa, where coastal states have low population densities. In the more densely populated coasts around the Gulf of Guinea and in East Africa, the offshore fishery potentials are not as great. Traditional fisherfolk are numerous in East Africa as well as West Africa and their contribution to the local economies and diets are important.

The fish caught in African coastal waters are a particularly important component of the diet in several countries (Ghana, Ivory Coast, Sierra Leone, Senegal, Togo). Approximately 40 percent of the total human intake of animal protein is fish in these countries. In the Central African Republic, Angola and Mauritius, fish constitute 30 to 47 percent of the intake of animal protein (WRI, 1985). Per-capita fish consumption in the Comoros, Madagascar, Mauritius and the Seychelles is three to ten times that of neighboring East African mainland countries (UNEP, 1982).

As the impacts of drought in West Africa persist, the coastal

and marine fisheries resource has become even more important to coastal West African states. Fish are now viewed as a principal renewable protein resource, as well as a source of foreign earnings through export of flatfish (flounder, etc.) and crustaceans (e.g., shrimp, lobsters, prawns).

Coastal resources are also important tourist attractions. Several of the East African island nations are heavily dependent on the tourist industry for foreign exchange earnings. It is the mainstay of the domestic economy of the Seychelles, and the second greatest foreign exchange earner for Mauritius; 100,000 tourists are attracted to its beaches annually (UNEP, 1982b).

In addition to the above, coastal resources are important to other aspects of the local economies. Mangrove forests provide food, fuelwood, building materials, and other products. Mangroves are also used locally and exported as firewood and building materials and for tannin extracts. The mangrove swamps of Madagascar and Mozambique support very profitable prawn fisheries. Coastal reefs and beaches are also mined for their sand and rock materials, which are used in construction. These various activities can, of course, be over-exploitative, causing damage to the resource and the coastal environment.

The value of the coastal environment is not limited to the various products it yields. Its ecological values are manifold, as described by the World Resources Institute (WRI, 1986): "Although near-shore coastal waters are a very small part of oceans, they are often sheltered areas of high localized productivity, based primarily on the concentration and cycling of nutrients from adjacent land masses. Among their most important characteristics are the intimate links between neighboring communities, which render the whole complex more diverse and productive than any of its constituent parts."

Coastal ecosystems and adjacent oceanic production are interconnected in terms of energy flow and subsidies, nutrient and mineral cycling, the movement of water and organisms, and the requirements for species of economic and/or ecological importance in one system to complete portions of their life cycles in other systems. Coastal ecosystems play a major role in the life cycles of economically important finfish and shellfish species by providing feeding, breeding and nursery habitat. Additional functions of coastal ecosystems include moderating coastal erosion and buffering large salinity changes. Coral reefs, for example, act as barriers dissipating wave and current energy. Mangroves, by occluding and absorbing terrestrial freshwater runoff, buffer salinity changes in coastal waters.

4.2 THE ROLE AND VALUE OF MANGROVES AND CORAL REEFS

MANGROVES

The mangroves of East, Southern and West Africa provide habitat for over 2,000 species of fish, invertebrates and plants. In the Niger delta there are 700,000 hectares of mangroves (WRI, 1986; Maltby, 1986). Mangrove stands in East African estuaries cover an estimated 125,000 hectares, including major stands in Kenya and Tanzania (UNEP 1982b). Mangrove poles have been traditionally exported from these countries to the Middle East, and each continues to export a million poles a year.

As has been observed elsewhere in the world, mangroves in Africa serve as spawning and breeding habitats for estuarine species such as shrimp, as well as some marine species. Mangrove leaves that have fallen into the water are the major source of food for aquatic organisms in the mangrove swamp. Their leaves are the first link in the food chain, which includes shrimp, prawns and fish at various life stages. In Gambia, for example, fish associated with mangroves account for 40% of the total catch in the Gambia River estuary.

The effect of the deterioration of mangrove forests can be sweeping insofar as it affects local fisheries and the lives of the people who are dependent on the estuarine environment.

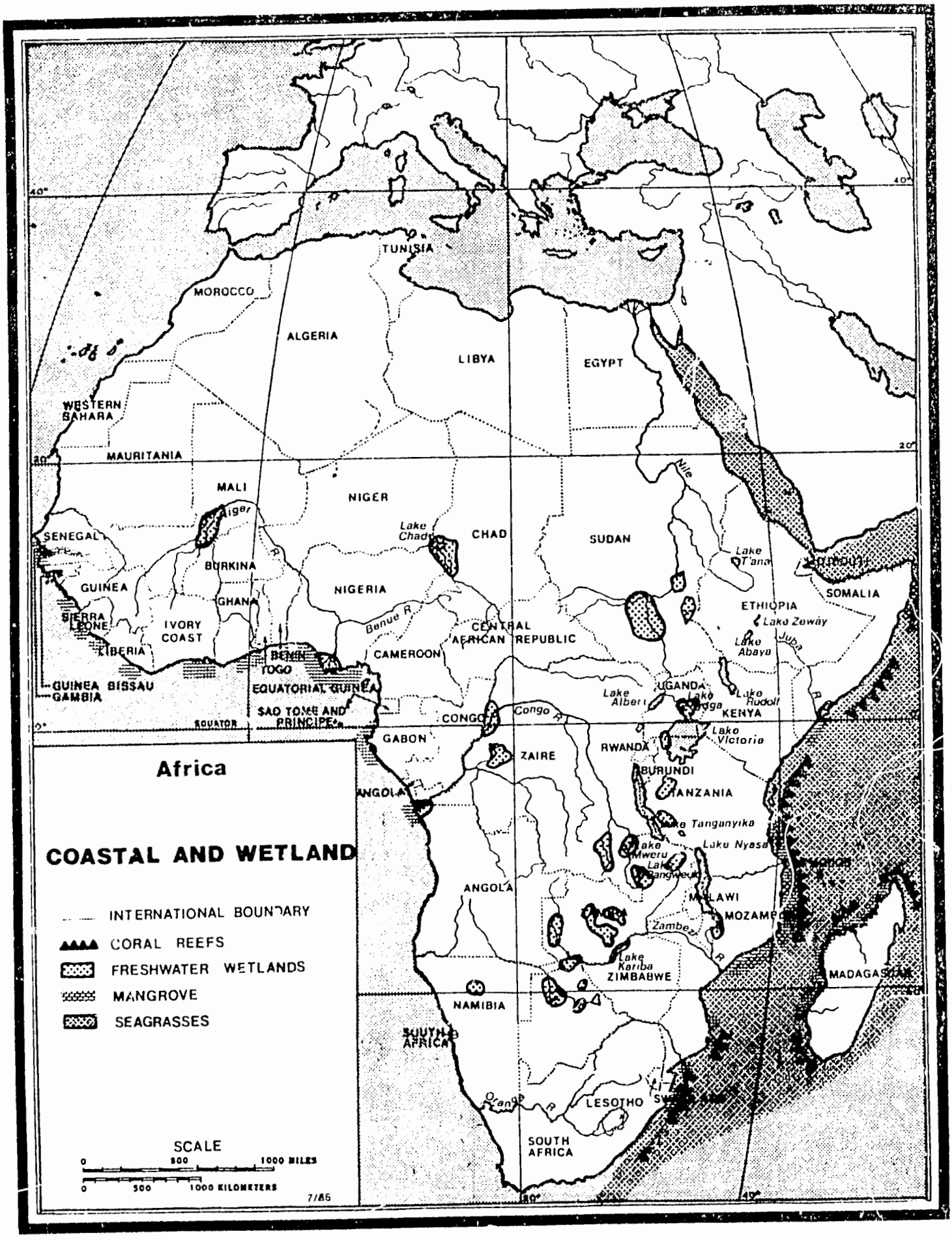
CORAL REEFS

Coral reefs are important in East Africa and the Indian Ocean; however, none or very few are found off the West African coast, because the water is too cold. Reef deposits play a major role in Indian Ocean island formation; for example, forty-seven percent of the total area of the Seychelles has resulted from coral reef deposits (WRI, 1986).

Coral reefs rank among the most biologically productive and diverse of all natural ecosystems. They support a high density of marine life including food fish and commercially important species such as spiny lobsters and ornamental (aquarium) fish.

Coral reefs are fished in Kenya and Tanzania. Even in Somalia, where fishing is not traditional, there are over 22 cooperative fishing societies.

In Kenya, sandy beaches complement the coral reefs to create an important coastal tourist resource. Over 100,000 tourists visit Kenya's beaches annually. Kenya has established marine parks to protect coral reefs as a tourist focus.


Africa
COASTAL AND WETLAND
INTERNATIONAL BOUNDARY
CORAL REEFS
FRESHWATER WETLANDS
MANGROVE
SEAGRASSES
SCALE
0 500 1000 MILES
0 500 1000 KILOMETERS
7/86
TUNISIA
MOROCCO
ALGERIA
LIBYA
EGYPT
WESTERN SAHARA
MAURITANIA
MALI
NIGER
CHAD
SUDAN
SENEGAL
GUINEA
BURKINA
GHANA
NIGERIA
SIERRA LEONE
IVORY COAST
LIBERIA
BENIN
TOGO
CAMEROON
CENTRAL AFRICAN REPUBLIC
GUINEA BISSAU
GAMBIA
EQUATORIAL GUINEA
SAO TOME AND PRINCIPE
EQUATOR
CONGO
GABON
ZAIRE
ANGOLA
UGANDA
KENYA
RWANDA
BURUNDI
TANZANIA
ETHIOPIA
SOMALIA
DJIBOUTI
MALAWI
MOZAMBIQUE
ZIMBABWE
NAMIBIA
SOUTH AFRICA
LESOTHO
SWAZILAND
MADAGASCAR
COMOROS
Lake Chad
Lake T'ana
Lake Zeway
Lake Abaya
Lake Albert
Lake Rudolf
Lake Victoria
Lake Tanganyika
Lake Nyasa
Lake Mweru
Lake Kariba
Niger R.
Benue R.
Congo R.
Nile
Juba R.
Zambezi R.
Orange R.
40°
20°
0°
20°
40°

4.3 DEGRADATION OF COASTAL RESOURCES

Although the degradation of Africa's coastal resources is very poorly documented, scattered reports from individual countries in East and West Africa point to a number of key problems: over-exploitation of fisheries, degradation of estuaries, mangrove decline, damage to coral reefs, coastal and estuarine pollution by urban wastes and oil, and lack of management (UNEP, 1982a). Estuaries and near-shore coastal fisheries are, in addition, threatened by dams, irrigation withdrawals, and various forms of agricultural and urban pollution.

OVER-EXPLOITATION OF FISHERIES

Africa's commercial fisheries are mostly found in deep waters off West Africa, which are enriched by up-welling. These deep waters are not directly affected by coastal degradation; however, the marine fisheries are reported to be over-exploited. Heavy fishing of these deep waters during the last decade has altered the composition of fish stocks and the sustainability of these fisheries (RDA, 1985).

The deep-sea fisheries are harvested by foreign as well as national fleets. Foreign trawlers sometimes fish illegally, and licensed fleets are difficult to regulate.

Although marine fisheries are not of immediate concern to this review, catch statistics group into one category both marine and near-shore fisheries. Thus, near-shore coastal fisheries may also be subject to over-fishing, but quantitative analysis is impossible.

DEGRADATION OF ESTUARIES AND LOSS OF MANGROVE FORESTS

The degradation of estuaries has been reported often in West Africa. This degradation is directly related to a reduction in freshwater flows, which is in turn the result of the long drought. Planned dams, tidal barriers, and irrigation developments, however, threaten to aggravate or prolong the stress of reduced freshwater inflows (Maltby, 1986).

Mangroves occur only in estuaries, since they are dependent upon the silt and freshwater carried by rivers to the sea. Mangroves have been subjected to clear-cutting, conversion to areas suitable for rice production, and, in drier zones, conversion to salt ponds. There are indications that considerable illegal harvesting of mangrove occurs in the more inaccessible areas (UNEP, 1982a).

In arid and semi-arid Africa, the planning and construction of various water development schemes, especially salt water

barriers at the mouths of rivers, has accelerated as a result of the drought. These works pose threats to coastal environments, since they disrupt or interrupt the silt and freshwater inputs to estuaries.

Top die-off and mortality of certain kinds of mangroves (e.g., tall Rhizophora trees), probably caused by salinity stress, have created barren flats and communities of scrubby halophytes that are adapted to high salinity. This effect has been documented in the Casamance and Sine Saloum areas in Senegal, as well as in the Gambia River estuary (IUCN, 1985).

Reduction in freshwater runoff affects estuarine and marine animal species that are dependent upon recurring temporal and spatial patterns of reduced salinity, and dams can exacerbate this effect (Berry, 1986). The Diama Dam has recently been completed in the mouth of the Senegal River mouth in order to block the tide. Another salt water dam proposed for the Gambia River, if built, could reduce the existing mangrove area by 70%, and fish and fish culture by 30% (Maltby, 1986).

Rice cultivation is impacting the mangrove areas of Guinea Bissau; however, the consequences are not yet known.

DESTRUCTION OF DAMAGE TO CORAL REEFS IN EAST AFRICA

Exploitation of coral reef ecosystems appears to be increasing. The effects of over-fishing, blast-fishing with dynamite, and coral- and shell-collecting have been reported from sites over the length of the reefs (UNEP 1982b). Heavy fishing pressure on reefs has occurred near Tanga and Dar es Salaam in Tanzania.

Die-off of fish and coral due to high sediment loads and pollution has been recorded at Malindi, Kenya, and Dar es Salaam, Tanzania. Heavy sediment loads carried from river mouths to the reefs are almost certainly damaging them (Salm and Clark, 1984; UNEP, 1982a).

4.4 MANAGEMENT PROBLEMS

Coastal zones and their resources are inherently difficult to manage. They are affected by land-based activities as well as the ocean environment. In Africa, moreover, there is a paucity of objective data on the nature and uses of coastal resources. Notwithstanding the existence of traditional management systems of great antiquity, coastal resources are poorly known and understood scientifically. In East Africa, for example, where coral reefs play a major role in tourism, there are no quantitative data on their abundance or extent. On the other hand, management plans that have been drawn up (for mangroves,

for instance) have not been executed because of a lack of national or international support. The Management of fisheries in various coastal environments is hampered by the lack of hard data on their stocks and composition.

The complexity of the management problem deters effective responses, particularly with respect to the cumulative effects of activities which cross national and international boundaries. In addition, the effects of certain activities may be felt several hundred miles away. Dam construction in Zambia, for example, is likely to affect prawn production in Mozambique by causing changes in freshwater flows. Other examples are noted in the previous section.

Institutional jurisdiction over coastal resources is often unclear, falling in an undefined area between marine and inland waters management. In Senegal, for example, coastal resources are neither under the jurisdiction of the division (Eaux et Forets) dealing with forests and inland waters, nor under that of the marine fisheries sector.

Concern for coastal resources management among African nations is increasing. Three countries in West Africa (Mali, Mauritania and Senegal) currently belong to the 1971 Convention on Wetlands of International Importance, known also as the Ramsar Convention. Guinea is currently collaborating with the IUCN to develop a coastal resources conservation strategy.

4.5 DEVELOPMENT RESPONSES

Governments and donor groups have tended to focus development efforts on the exploitation of coastal and marine resources, through improved fishing, fish processing and marketing; establishment of tourist centers, hotels, etc.; and, in a few instances, creation of tourist-related coastal parks and protected areas.

Various donors, including UNEP, IUCN and the East-West Center, and France, the Netherlands, and Australia, have financed status reports and management guidelines for mangrove forests. Coastal and mangrove forest plans exist, e.g., for Kenya, Tanzania and Nigeria. Other nations such as Mozambique are seeking international support for coastal plan development. There has generally been a lack of follow-through by donor agencies to coastal plans, however (Snedaker, pers. communication).

France's overseas research arm, ORSTOM, has undertaken coastal zone research, and modeling and monitoring efforts in francophone West Africa. Various United Nations organizations, most notably UNEP (Regional Seas program), have undertaken a

series of workshops and studies to come to grips with this complex environment. Several sets of recommendations and action plans have resulted (UNEP 1982a, 1982b, 1983). It is too early to determine the degree to which they have been implemented, however.

A.I.D. ACTIVITIES

Almost every coastal West African nation has requested U.S. assistance in marine fisheries management, and A.I.D. has provided some support. A.I.D. has not undertaken any activities in the coastal zone as defined here, however, except for studies or assessments that have included the coastal zone. In African governments, jurisdictional confusion over coastal zone resources has no doubt impeded the definition of development assistance needs and requests for assistance.

A.I.D. is currently supporting the secretariat costs of the regional fisheries commission for West Africa, CECAF, and in southern Africa, A.I.D.'s regional office in Harare is supporting the development of fisheries information and training systems.

A worldwide Bureau for Science and Technology project to assist nations in coastal zone management has focused exclusively on Latin America and Asia; however, A.I.D. is currently working with the U.S. Park Service's International Office on a review of the state of knowledge of the coastal zone of West Africa. Overall management of the coastal zone has eluded development, however.

With respect to the management of African coastal resources for long-term production, A.I.D. has indirectly contributed through support for international publications, conferences and training sessions dealing with coastal management. This has included a review of several international coastal studies which may have application to African needs (Clark, 1985).

4.5 AGENDA OF POSSIBLE ACTIONS

There is a considerable need for specific actions. A.I.D. is gaining competence in addressing coastal resource management and development needs in Asia and Latin America, and many U.S. institutions are capable of supplying effective management and qualified personnel.

TRAINING AND EDUCATION

* There is a need for bachelor's-and graduate-level training at U.S. universities with strengths in coastal zone

environments and their management.

* Workshops and seminars in West and East Africa on critical management needs would be very helpful.

STUDIES AND RESEARCH

* Studies of the economic and social values of various coastal resources and environment could serve as a basis for policies and management effort.

* There is a need for surveys and research on indigenous management systems and technologies related to coastal resources, especially fisheries.

* Improvement of the inventory and data base for coastal resources of the African coastal areas, starting with the arid/semi-arid West African coastal countries and extending to Guinea Bissau, is critical. Their coastal areas are facing the most immediate risks.

PLANNING SUPPORT

* Assessment of development impacts on the coastal zone and its resources is needed.

* Planning should be done in order to develop operating rules of dams so as to ensure simulated flood regimes that can maintain ecological processes in estuaries.

* Development of guidelines for coastal shrimp culture is required.

* There is a need for work with national and international political bodies to define and develop coastal resource conservation strategies for West African coastal areas beginning with the delta areas, of the Senegal, Gambia and, in East Africa, the Zambezi rivers.

INSTITUTIONAL STRENGTHENING

* Institutional capabilities, policies, laws, and technical skills in coastal resource management should be analyzed, particularly in the semi-arid/arid and Madagascar/Indian Ocean Islands sub-regions.

* The management of protected coastal areas should be supported, particularly within Ramsar convention member countries and for areas of international significance (World Heritage sites, etc.). The U.S. has a great deal of expertise in this field.

PRIORITIES

Table 4.1 lists sub-regional and country priorities based on coastal resource issues and management needs facing the sub-regions and countries. The table displays the various categories of intervention (policy dialogue, institutional development, etc.) and at what point in the planning period programs need to be undertaken (immediate-, medium- and long-term). Those sub-regions and countries which have immediate needs should be the primary focus of A.I.D./other donor programs and activities.

Table 4.1 Coastal Resources: Priority, Subregions, Countries and Categories Where AID Technical and Financial Support Would Be Most Effective

*** = Immediate
** = Medium Term
* = Long Term

Priority	Subregion	Key Country(s)	Pol. Dial.	Institution/ Training	Research/ Data Centers/Inventories	Coastal Prot. Area Management Est/Mangrv.	Coastal Prot. Area Management C.R.	Wld. H.Needs	NGO/PVO	Reg. Strat.	I.D. Plan.
1	Arid/Semi-Arid Coastal West Africa	Mauritania	*	**	**	***	N/A	*	**	***	***
		Gambia	*	**	**	**	N/A	*	*	***	***
		Senegal	*	**	**	***	N/A	*	*	***	***
		Guinea Bissau	**	***	**	***	N/A	**	**	*	***
2	Mad./ I.O. Is.	Madagascar	*	**	**	**	*	**	*	N/A	***
		Comoros	***	**	**	?	***	**	**	N/A	***
3	S.H.T. Uplands	Mozambique	**	***	***	**	N/A	*	*	***	**

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5.0 DECLINE IN BIOLOGICAL DIVERSITY AND ECOLOGICAL RESILIENCE

CONTENTS

5.1 Background
5.2 Status of biological diversity
5.3 Management problems
5.4 Development support
5.5 A.I.D. response
5.6 Action agenda

The scope of concern for biological diversity ranges from complete ecosystems to progressively lesser elements (OTA, 1986). There are three broad categories of biological diversity:

* Ecosystem diversity (many different ecosystems within a geographic region)

* Species diversity (measured by the number of different endemic species within a given ecosystem)

* Genetic diversity (exemplified by the totality of wild and domesticated varieties or genotypes of a species)

5.1 BACKGROUND

In 1983, heightened concern for the conservation of biological diversity prompted the U.S. Congress to mandate A.I.D. to include additional assistance in its programs (Section 119 of the Foreign Assistance Act), and to earmark funds for this purpose in 1987 foreign-aid appropriations. Conservation of biological diversity is thus the most recent natural resource-management issue that A.I.D. has addressed.

The rural African's long co-evolution with the diverse environments of the continent has resulted in landscapes whose diverse ecosystems and species represent a useful diversity that is essential to survival and well-being. Thus, biological diversity is a matter of day-to-day living. For those only minimally engaged in the monetized economy, livelihood needs are met by diverse wild and cultivated species. For instance, wild animals and plants are utilized for both food and medicine by Africans. A survey of edible wild and semi-wild woody plants in Nigerian forests found 150 such species, many of which yield nuts or fruits widely consumed by rural people (Okafor, 1982). Wild game, and even insects such as grasshoppers, are important food sources and can supply as much as 44% of the total animal protein intake (Prescott-Allen, 1982). International recognition of Africa's biological diversity can be measured economically by the hundreds of thousands of tourists who yearly visit wild game parks. These tourists contribute importantly to local and national economies.

The agricultural value of genetic diversity is exemplified by Ethiopia's wild relatives of arabica coffee, which are resistant to rust, and a recently discovered caffeine-free coffee variety in Madagascar, now being researched by the General Foods Corporation (Prance, personal communication). There are at least twelve African countries where uncollected grains can contribute important genetic materials to crops such as sorghum and millet (Hawkes, 1985).

The need to develop low-input technologies for soil fertility maintenance has stimulated the search for plants and fungi that can serve this purpose. In West Africa, ORSTOM researchers discovered a unique annual legume, Sesbania rostrata, in which nitrogen-fixing bacteria form nodules on the stem, and consequently greatly increase nitrogen-fixation and the value of this plant as green manure. The plant is now being tested on other continents.

The contribution of plant life to medicine can be important. Thanks to a drug derived from the Madagascar periwinkle (Catharanthus roseus), children suffering from leukemia now have an 80% chance of survival instead of the previous 20% chance (OTA, 1986).

The role and value of biological diversity in ecological processes has recently been revealed. Birds and mammals are key agents in the regeneration of tropical forests, for example. In the Ivory Coast, forest bats were found to be responsible for 98% of all seeds left on re-colonized sites along the edge of the gallery forest. The current lack of knowledge of effective humid forest management in the tropics lends special significance to such interactions.

5.2 STATUS OF BIOLOGICAL DIVERSITY

Current knowledge related to the status of ecosystems and genetic diversity in sub-Saharan Africa is rather poor. A continent-wide vegetation map under preparation by the FAO was unfinished as of January, 1987. Collections of plants are still being made. FAO efforts to monitor deforestation using satellite images have yielded very small scale images that capture only gross trends in ecosystem diversity. Declines in species diversity, however, are being monitored by the International Union for the Conservation of Nature and Natural Resources. The so-called Red Data Book lists plant and animal species that are threatened with extinction (IUCN, 1984).

5.3 MANAGEMENT PROBLEMS

Expansion of agriculture, commercial logging, illegal hunting, and burning all contribute to the changes that threaten ecosystems and species diversity in sub-Saharan Africa. The high rate of human population growth in Africa is an essential factor whose numerous effects include a severe threat to various facets of diversity.

Only a few actions are currently being taken to conserve biological diversity: gene banks (or in vitro conservation, e.g., seed collections) and the establishment of biological

preserves. Seven of the ten countries in the world that have more than 10% of their land under protected status (parks, etc.) are in Africa: Benin, Botswana, the Central African Republic, Rwanda, Senegal, Tanzania and Zimbabwe. Of particular interest has been the conservation of large animals and their habitats, as well as ecosystems with primates.

Many important ecosystems (or portions of ecosystems), especially those without notable wildlife, are not protected, despite efforts by UNESCO to promote a series of Biosphere Reserves. Of special concern are the humid coastal forests of West Africa, montane forests in East and West Africa, and all natural vegetation in Madagascar. Also, the management of ecosystems and species diversity in settled areas presents special problems (outlined below) that are not being resolved.

The aforementioned problems and situations are described very briefly below, and in greater detail in the corresponding sub-regional descriptions, Part III.

PROTECTED AREA MANAGEMENT

Key management problems are illegal hunting, unlawful removal of plant products (sometimes a continuation of the traditional use of natural resources), and gaps in botanical and ecological knowledge.

Illegal hunting or harvesting in protected areas is often done by local people for purposes of survival or supplementary income. It is well-recognized now that people dwelling in the environs of protected areas must somehow be involved to their benefit in the park or preserve, e.g., as guardians, guides, research assistants, etc. Without such involvement, protection is difficult or impossible.

One of the more intractable management problems has been the prevention of poaching of species for which there is an international market, specifically tusk ivory (for carving) and rhino horn (the powder of which is sold in the Orient as an aphrodisiac or for dagger handles). To stop trade in such products, the Convention on International Trade in Endangered Species (CITES) was developed. Eighteen sub-Saharan African nations are signatories; however, enforcement of CITES has proven difficult when highly-valued products such as ivory are involved.

In war-torn nations, slaughter of wildlife with military weapons has been a recent phenomenon that has added to the pressures from poaching. Rural poverty also exacerbates the enforcement problem.

At present in Africa, the lack of operational funds to manage parks is a serious problem. Wildlife and park management capability exists, and has been steadily built up since the founding of wildlife management schools in East and West Africa (Mweka and Garoua, respectively). Over 1000 graduates of these schools now staff parks throughout Africa. Budget cutbacks, however, have severely impeded the ability of park authorities and wildlife management offices to prevent poaching and illegal trade (IUCN, 1981). Support for CITES activities in Africa now comes largely from private sources.

A more fundamental management problem is posed by the lack of baseline data with which to manage habitats and control permissible harvesting of game.

On the positive side, there now exist thousands of wildlife clubs in east Africa, over 1,000 each in Zambia and Kenya alone. The founding and expansion of many of these clubs has been supported by the World Wildlife Fund, which plans to increase support for education activities in Zambia, Kenya and Tanzania (Kemf, 1986; "Conservation Briefs" Development Forum, 1986).

GENETIC PRESERVATION

Worldwide efforts to collect and preserve seeds of food crops have included Africa and are carried out under the aegis of the International Board for Plant Genetic Resources. Collections are not complete, however, especially those of grains such as millet and sorghum (Hawkes, 1985). An agroforestry workshop held in January, 1986, by the International Union of Forestry Research Organizations also identified the need to complete collections of browse and tree species that are useful in livestock and forestry.

Developing and diffusing higher-yielding varieties of food and tree crops can be a threat to genetic diversity. In the arid and semi-arid sub-region, domesticated and wild grains have still not been completely collected (Hawkes, 1985); however, in 1985, higher-yielding, shorter-cycle sorghums bred with genetic material from South Africa were being introduced into Sudan and elsewhere. Some of West Africa's indigenous rice varieties may have been lost even before new varieties were introduced from Asia. On the other hand, many of Africa's food staples have been introduced from other continents, e.g., maize, potatoes, sweet potatoes, and cassava.

The recently recognized incapability of certain exotic trees, notably eucalyptus, to take the place of indigenous multi-purpose trees, especially in the semi-arid zone underlines the importance of preserving native tree diversity

in collections or in representative plant formations. Some limited progress has been made in this regard through the Biosphere Reserve program promoted by UNESCO.

An apparent obstacle to better management of species diversity is the bias against species that are not of direct value as food crops (OTA, 1986). Collections have emphasized these at the expense of other plants.

Like domesticated native grains, domesticated cattle display very great diversity; however, there are no organized efforts underway to conserve this centuries-old genetic heritage (K. Rennie, IUCN, personal communication).

DIVERSITY IN SETTLED AREAS

Little or no effort is being expended to manage or assess the nature and significance of diversity in settled areas. In fact, population growth and development have been synonymous with loss of species diversity, during which a few selected species of plants, trees and animals displace the more diverse natural flora and fauna.

Ecosystem diversity is diminishing in settled areas as wetlands are drained, steeplands are cleared, and marginally-productive rangelands are brought under cultivation. Human and animal population increases can only result in less diversity and, ultimately, decreased resilience and regenerative capacity of the agro-ecosystem.

How much diversity is needed in settled areas? The question is almost unanswerable. Desirable levels of diversity in rural environments of Africa will probably be defined in the process of searching for sustainable forms of agriculture.

Production-enhancing biological technologies (e.g., nitrogen-fixing organisms, mycorrhizae, agroforestry species) may depend on previously unmanaged species in the ecosystem. Perhaps one measure of the degree of needed biological diversity would be that amount that must be retained and managed in order to sustain the natural resource base and supply rural livelihood needs for food, fuel, medicinals, construction materials, forage, etc.

The recent emphasis in development assistance on low-input agricultural technologies compels an explicit consideration of the use of diverse biological resources and processes, for traditional as well as innovative purposes, and the corresponding need to manage them.

5.4 DEVELOPMENT SUPPORT RESPONSES

Support from governmental and non-governmental organizations has been forthcoming since independence in many nations, but has focused principally on Africa's more spectacular wild animals and their habitats. More recently, however, attention has broadened to all aspects of biological diversity.

The IUCN, the World Wildlife Fund and the African Wildlife Foundation have provided initiative, funding and technical support for the protection and management of animals, plants and wildlands for many years.

The IUCN has developed an ecosystem conservation strategy for broadly representative bio-geographical regions in Africa (and elsewhere in the world). It has also promoted and helped to carry out the preparation of National Conservation Strategies (NCS's) in Madagascar, Zambia and Zimbabwe, while others are under preparation in Botswana, Guinea Bissau, Ivory Coast, Senegal, Sierra Leone, Togo, Uganda and Zaire.

Also, IUCN has supported surveys, research, conferences, workshops and publications (guidelines, legislative models, educational materials, etc.). IUCN's Conservation Monitoring Center in Cambridge maintains and updates a data bank on rare and endangered species, now accessible at the International Affairs Office of the U.S. Park Service, Washington D.C.

UNESCO has promoted the establishment of "biosphere reserves" in various sites throughout Africa, but they have proven to be difficult to manage.

In recent years, international organizations have begun to better define the problem of biological diversity and to propose specific steps for its conservation and management. International funding to protect biological diversity in sub-Saharan Africa has been very modest, however, representing less than 3% of support by major donor and non-governmental organizations. Several initiatives could lead to greater support, however.

The World Resources Institute is now helping four African nations (Botswana, Cameroon, Zaire and Madagascar) to conserve critical ecosystems through assistance in project planning and environmental assessments.

The World Wildlife Fund is developing a variety of small scale projects in Africa, with partial funding from A.I.D., to integrate conservation with local development needs, thereby easing pressures on critical parks and protected areas. WWF has also supported extensive wildlife conservation programs in

eastern and southern Africa, and is planning to increase support for rainforest conservation by working with governments as well as local wildlife organizations.

The UNEP Regional Seas Programme reports and studies have focused attention on the biological resources of the coastal zone.

The World Health Organization (WHO) is funding a worldwide program on traditional medicine, which involves several African institutions, including the University of Ife. The program will systematically study the use of traditional products in primary health care and in research for medicine.

5.5 A.I.D. RESPONSE

As of January, 1986, A.I.D. had prepared an Action Plan on Conserving Biological Diversity in Developing Countries, in response to a preceding inter-agency effort to outline a strategy on biological diversity that acts upon Section 119. (Please see introduction of this chapter.) No specific funding had been budgeted by A.I.D. for actions, however, partly owing to overall budget constraints. About one-half the 67 recommendations in the forerunner strategy were assigned to A.I.D. Actions in support of conservation of biological diversity have not been direct; however, rural development which stabilizes land uses can be interpreted as supportive.

A.I.D. has helped the World Wildlife Fund's project on Wildlands for Human Needs, with matching funds. A number of small activities were being planned in Africa.

A.I.D.'s environmental assessment procedure can avert or lessen the impact of development projects on native biological communities. For example, USAID has recently undertaken an environmental assessment of the impact of a port improvement project on, among other things, aquatic communities.

Several missions in Africa have supported biological systems conservation in the broader context of natural resource management, particularly watershed management. In Burundi, the mission has funded the protection of the Bururi forest. The Madagascar mission has proposed collaborative efforts with the World Wildlife Fund.

To date, however, mission actions in this area are exceptional. This category of assistance is unfamiliar to A.I.D. and does not fit in well with ongoing strategies and portfolios.

5.6 AGENDA OF POSSIBLE ACTIONS

Priority sub-regions for support in conserving and managing

biological diversity appear to be:

1) Madagascar and other islands in the Indian Ocean, owing to the highest rate of endemism and second-highest risk of loss.

2) African Highlands (East and West), due to the second highest rate of endemism and third highest risk of loss.

3) Humid Coastal Lowlands, because of the imminent loss of the sub-region's tropical forest ecosystems.

4) Arid/Semi-Arid sub-region, by virtue of the potential loss of its crop genetic diversity and the national and international importance of the freshwater and coastal ecosystems of the sub-region.

Possible actions that could be supported are:

* assessment of biological resource conservation needs in planning and strategy statements.

* allocation of specific funds to appropriate entities for collection of crop, grass, browse and tree varieties according to needs defined by IBPGR and collaborating members.

* assessment of the needs of local seed banks for adequacy of storage and data management.

* technical support for increasing host country capabilities in biological diversity management through short courses, workshops, field tours, etc., as well as distribution of publications and educational materials.

* technical support to missions to perform, commission and review environmental analyses of projects, so as to better account for biological diversity. Among other means, links should be established with IUCN's Conservation Monitoring Centre data bank, in order to review the possible impacts of projects on endangered species.

* the establishment of a regional project to support local, non-governmental groups and university research centers or scholars who are working on different aspects of biological diversity or its conservation.

* a dialogue that would seek concensus among donor groups and NGO/PVO organizations as to priorities and responsibilities in conserving genetic and biological diversity. The value would be similar to that of recent initiatives by FAO and the World Resources Institute to broadly define the priority needs

in the tropical forestry sector.

* close work with countries within priority sub-regions to establish positive links between conservation and development. Actions could include inter-sectoral analyses, planning studies, and strengthening of educational institutions with experience in biological or resource planning.

6.0 STRESSES ON NATURAL RESOURCES AND THE ENVIRONMENT COINCIDENT WITH DROUGHT

CONTENTS

6.1 Introduction
6.2 Drought-related stresses on the environment
6.3 Dryland farming regions
6.4 Rangelands
6.5 Stresses on irrigation
6.6 Development assistance responses
6.7 Agenda of possible actions

6.1 INTRODUCTION

The prolonged period of below-normal rainfall (*) that began in 1968 in Sahelian Africa is the worst drought of this century in more respects than its duration. It has taxed the institutional capacities of newly-independent nations. It has coincided with an economic crisis driven by high oil prices in the 1970's, high interest rates, low commodity prices, and, in some nations, civil strife (e.g., Chad, Ethiopia, Sudan, and Mozambique). The stresses brought to bear by drought alone are not readily distinguished from the total impact of these converging events. To the extent that below-normal rainfall is an expected and historically recurring phenomenon, however, rural Africans are perhaps better prepared for this than for calamities of a more modern nature.

In much of semi-arid Africa, the flora and fauna, as well as traditional agrarian and pastoral peoples display amazing resilience with respect to drought. Nevertheless, that resilience has been stretched to its limits by the severity of the recent drought.

An expert committee convened by the WMO, chaired by the Canadian climatologist Dr. Kenneth Hare, summed up knowledge about the African drought in 1983 as follows (WMO, 1983):

* Drought is a common occurrence in many parts of Africa, but the conditions necessary for both the onset and cessation of the African drought are not yet fully understood. Casual mechanisms are being actively researched and should be explained in the next several years.

* No periodicities or trends exist upon which drought can be predicted.

* No known method exists to reliably predict the continuation, cessation, or reoccurrence of drought in Africa.

* Reliable and continuous weather data do not exist in many parts of Africa, and drought warning is therefore handicapped.

(*) "Below-normal" and "average" are poor descriptors of rainfall. More accurate would be the use of standard deviation, or variance, which can be up to 40% or more in semi-arid Africa. Thus, a drought year would be one with rainfall below the lower level of variance.

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* All African nations should establish plans to detect drought and alleviate its effects on agricultural production (e.g., renovation of deteriorated data-gathering networks, analyses of rainfall data to determine probabilities of particular rainfall amounts and their timing, early warning systems to detect meteorological drought and to analyze likelihood of agricultural drought, etc.).

It should be noted that systems to monitor the deterioration of soils and vegetation and to detect thresholds of irreversible damage do not yet exist.

6.2 DROUGHT-RELATED STRESSES ON THE ENVIRONMENT

There is wide agreement that drought exacerbates, but does not cause, environmental degradation and desertification. Rather, the stress comes from the unrelenting pressure exerted by people and their livestock on the soils, groundwater and vegetative resources during a period when these resources become temporarily non-renewable because of lack of rain.

Over 50% of sub-Saharan Africa is within the arid and semi-arid climatic zone, which is subject to periodic and long-term drought. It is estimated that ninety million people reside in this zone, and these people depend mainly on rainfed farming for food (GTZ, 1986). In addition, the highlands of Ethiopia, Kenya and even normally-moist Rwanda are subject to drought. During the most recent drought episode (1981-85), crop failures extended into neighboring sub-humid zones. A total of 130 million people were judged to be at risk at one point when the drought had spread to the highlands and the humid areas.

The peoples in this region have evolved various cultural and technical responses to the high variability of rainfall in the region: pastoral nomadism, food stores, sharing of surplus, etc. By such means, a number of poor harvests can be tolerated; however, the occurrence of several low-rainfall years cannot be distinguished from the onset of a long drought. Only when food stores have been exhausted and fodder sources are too scarce to support herds does the impact of drought seriously threaten people and livestock.

Before this occurs, however, the vegetation, soils and groundwater reserves will have already been stressed during several years of poor rains. These stresses include:

* over-pruning and over-browsing of bushes for fodder and fuelwood

* destruction of natural regeneration of various woody tree or browse species

* reduction of crowns of larger trees (People climb them and prune the branches for use as fodder and fuelwood. This damage is irreparable in most species.)

* lowering of water tables

* loss of organic matter in soils, a consequence that is really the exacerbation of a long term trend affecting the farmlands of semi-arid Africa

Ironically, some kinds of emergency food aid actually assist the process of environmental degradation by allowing people (and their resident livestock) to remain in their villages. Thus, people may be sustained by emergency food and by deeper wells, but trees (and other woody vegetative cover) suffer doubly: from not growing (in response to water stress), and from the burden of providing daily firewood and animal fodder (there being little or no crop residues or annual grasses).

The habitability and ecological resilience of arid and semi-arid tropical Africa are first and foremost a function of the presence of trees and other deep-rooted woody species. This type of vegetation taps deeper soil horizons for moisture and nutrients, and acts as fuel and fodder reserves during below-normal rainfall years and the long dry season. Recognition of this vegetation resource is central to understanding the environmental stresses coincident with drought.

Habitability of the semi-arid zone is also a function of the shallow groundwater resources of the zone, and, of course, its food-producing potential. Food, however, may be the least important determinant of habitability during droughts, as long as outside food aid is provided.

6.3 STRESSES IN DRYLAND FARMING REGIONS

Dryland farming regions are located in the semi-arid tropics which have a 75- to 180-day growing season and an annual rainfall of between 275 millimeters and 800 millimeters.

In dryland farming regions, droughts temporarily reduce the capacity of the environment to sustain people and livestock; yet, sedentary agrarian Africans are loath to leave their villages and lands until they have become desperate (as was the case during the famine that killed 300,000 in Ethiopia in 1984/85). They will continue to graze or browse their animals, cut firewood and draw water, while drawing down their food stores. Neither the vegetation nor the water table is being renewed by rain. Both dwindle under the daily pressure, and essentially become non-renewable resources for the duration of the drought.

Tree crowns are steadily pruned for their forage, lesser bushes are browsed to the ground, and crop residues (if any) are burned or eaten by animals rather than plowed back into the soil. Also, trees and annuals that are less tolerant of drought wither and die. This process, which ultimately results in a reduction of biological productivity, is desertification. It is going on in arid and semi-arid Africa even without the drought, but droughts greatly accelerate desertification.

The various uses made of trees and other woody vegetation have been described. Their ecological role in providing resilience to this dry environment is equally important. Evenly-spaced trees, whether on agricultural or natural landscapes, interrupt and buffer the energy of wind erosion. They shade the ground and reduce soil temperatures, thereby reducing evaporation and rendering the soil more habitable to micro-organisms, which feed upon dead leaves, twigs and other litter. The action of termites is illustrative.

Dr. Robert Chase of Texas A and M University discovered in land treatment experiments for A.I.D. in Niger that dead twigs and branches laid upon bare soil attracted termites who colonized the underlying soil. Their actions rendered it more porous and able to accept rainfall, thereby increasing its productivity as rangeland (in this instance). Fallen, dead branches and twigs are not to be seen within walking distance of villages, however, especially during droughts. All have been collected for cookstoves.

Thus, in a general sense, the resilience of the semi-arid regions to drought becomes weakened as trees and other perennials are cut back and disappear. When the current drought cycle ends, the regions will be more vulnerable to aridity than before. Also, they will be more vulnerable to water erosion from strong rains because of lack of vegetative cover.

Another ecological thread unravels more rapidly during droughts: the one connecting crop residues, manure and soil fertility as measured by organic matter. As fuelwood and forage from trees become scarce, crop residues are diverted to the cook stove or fed to animals. (Crop failure, i.e., zero growth, is rare even during major droughts, and stalks and vines will grow even though harvests are slim.)

Manure may also be burned. Normally, it is left on fields surrounding villages, where it is deposited by herds corralled at night after watering. These are often the most productive fields, reserved for continuous cultivation of grains.

A reduction in livestock numbers during droughts also results

in less manuring. The recent drought only exacerbated a trend towards fewer cattle in dryland cropping zones. This trend resulted from reduction in areas of fallow which formerly served as wet-season grazing reserves.

The productivity of cropland diminishes as it is deprived of sources of organic matter, e.g., crop residues, manure, or even roots. Plants may be uprooted instead of cut off, so as to get the maximum amount of vegetative matter for fuel or fodder.

The arid and semi-arid sub-region's sandy soils, in particular, need organic matter. Its loss and the associated loss of humus (decomposed organic matter) reduce the capacity of soils to hold water (field capacity) and nutrients (cation exchange capacity). Even if nutrients were supplied through chemical fertilizers, they could not be retained. Humus is especially important for imparting cation exchange capacity to sandy soils, since they lack clay.

Urban demands for fuelwood in Africa aggravate the ecological consequences of loss or degradation of vegetative cover (World Bank, 1985). Moreover, as in the case of food staples, government-imposed price ceilings on fuelwood or charcoal (set at low levels to favor the urban poor) can act as deterrents to resource conservation. Low charcoal prices discourage efficiency of fuelwood cutting and charcoal production and use.

6.4 STRESSES ON RANGELANDS

All the drought stresses on African rangelands are, in effect, exaggerations of longer-term stresses caused by decreasing range resources and growing herds.

Stresses on rangelands coincident with drought are, on the surface, subtle but self-evident (i.e., reduction in the amount of growth of annual grasses and a shift to dominance of species that are more tolerant of arid conditions). In general, however, rangelands in Africa are quite resilient (NAS, 1983). Further, over-exploitation of range is limited to zones with dry-season watering points. Thus, most of the arid zone range is untouched by livestock, a circumstance that has generated various schemes for establishing temporary water supplies.

Where deep water has been tapped, however, the surrounding landscape becomes seriously over-grazed and over-browsed to the point of becoming desertified. Often, water for cattle is a day's walk from browsing areas. (Cattle can survive two days without water.)

African pastoralists have evolved herd management to cope with the erratic nature of arid zone rainfall and resulting variable

range productivity (GTZ, 1986). They are highly mobile and nomadic, and are opportunists. They "stock" as many animals as possible on the range resource and then move on. They do not manage the range resource per se; rather, they manage their herds. Their primary goal is subsistence, not maximum gain per animal, especially during droughts. Nomadic herders will relocate to more humid zones during severe droughts.

The stress of drought on arid range is a natural one within the context of the evolutionary history of the region. Far more stress is caused in minimal-rainfall years that are not dry enough to actually be considered drought years. During such years, herders continue to migrate through their customary ranges. Woody browse species in particular are likely to suffer during these periods.

Social stress resulting from conflicts between herders and resident farmers at the borders between rangelands and more humid soils is probably the key stress associated with the recent drought. Conflicts in Sudan are especially serious. In fact, all across the arid and semi-arid region, the period of above-average rainfall years in the 1950's and early 1960's had encouraged farmers to move into the former domain of nomads and occupy lands that were formerly dry-season grazing reserves.

An increase in numbers of sheep and goats during droughts may occur. This often has detrimental effects on low-growing browse species. Small ruminants survive and rebuild their numbers more readily than do cattle. Pastoralists will therefore trade sheep and goats for cattle. The overall effect of these animals on browse resources can be deduced, but it has not yet been documented.

The sinking of boreholes to offset a lack of water, and the subsequent lack of range management in their environs, has probably caused as much stress as any other factor on arid rangelands.

The East African arid range has a double rainy season and significant potential for the growth of perennial grasses. These grasses are often over-grazed to the point of disappearance, however. Taken together, the various processes that are triggered by drought undercut the ecological mechanisms that lend resilience and stability to the agricultural and pastoral landscapes in this difficult environment. The extreme result is total loss of biological productivity, or desertification. Ironically, this is more of a problem in the relatively moist inhabited zones than at the margins of the true desert, where human and livestock pressures are minimal or absent during droughts (World Bank, 1985).

6.5 STRESSES ON IRRIGATION

The recent drought has jeopardized traditional and modern irrigation works alike and, combined with the declining economic health of the countries in the zone, has delayed or set back water development. In the Senegal River's lower valley, for example, intrusion of saline water from the sea has made it impossible to pump river water into several large-scale irrigation projects. Estuarine rice farming in Senegal and Gambia has also suffered for lack of freshwater inflow. Low barrages (to bar tidal movement) are being built to counter this effect.

6.6 DEVELOPMENT ASSISTANCE RESPONSES

The U.N. Conference on Desertification in 1977 and the efforts of the Club du Sahel were effective in attracting attention and drawing development assistance resources. The "first generation" of projects, launched through the Club du Sahel and its Africa partners (CILSS), did recognize the importance of fuelwood demands and their relationship to deforestation, and the need to understand and monitor desertification. Nevertheless, most efforts by various donors focused on developing new or improved sources of potable and irrigation water, restoring herds decimated by the drought, and increasing food production.

Only since the early 1980's has a comprehensive development response to the systemic problem of environmental degradation been set forth, namely the IUCN's strategy for environmental rehabilitation of the Sahel, contained in the IUCN Sahel Report. This strategy is keyed to village-level development actions (eco-development) that would be carried out by partner NGO's and host governments. The IUCN strategy recognizes that development cannot proceed without environmental rehabilitation, and that environmental rehabilitation cannot succeed without a development impetus.

Contingency planning for drought has nevertheless focused on the problem of famine rather than environmental stresses. FAO has established an early-warning system to detect the likelihood of crop failure in a given rainy season, and A.I.D. has also recently contracted for the development of a Famine Early Warning System that seeks to detect early signs of malnutrition, and related socio-economic factors.

Dramatic successes in stabilizing the sand dunes that threatened oases and villages were achieved during the post-1968 drought period. The idea of establishing a greenbelt of trees across the Sahel has been seriously proposed time and again; however, while drifting sands can indeed threaten much

of the millet-and peanut-growing belt across the Sahel, sand drift represents a rather advanced stage of environmental deterioration. We must replace our concern for sand dunes with one for the earlier stages of the insidious and difficult-to-reverse unraveling of the agro-ecosystems of this region, as trees and lesser woody plants disappear from fields and grazing reserves, and soils are rendered unproductive.

Over ten years of forestry development projects following the drought have shown that (Taylor and Soumare, 1984; A.I.D., 1984):

(1) Trees alone do not stop sand dunes and the spread of desert sands. Initially, palisades (grass or brush windbreaks) must be erected to stop sand drift, followed by establishment of transplanted bushes or trees, as well as spontaneously-regenerating grasses and herbaceous vegetation. A combination of trees and ground cover is the best protection.

(2) Fuelwood plantations alone cannot solve the fuelwood crisis of the region. (Good land is scarce; fuelwood growth is too slow.)

(3) Exotic, "fast-growing" eucalyptus cannot outperform indigenous trees (or Prosopis) at rainfall levels below 800 millimeters annually.

Research and development have addressed individual facets of the semi-arid agro-ecosystem, e.g., determination of range and woodland productivity, fuelwood planting, manipulation of soil micro-organisms, development of more efficient woodstoves and charcoal kilns, crop residue management, soil moisture management, and agroforestry. These have been scattered efforts, lacking an overall research or development hypothesis that could serve to integrate efforts.

Initially, combatting desertification in the form of encroaching sand dunes was an effective banner under which to organize emergency responses to drought. Now, however, "reversing Africa's decline" may more aptly apply to drought-stricken regions in the process of economic and environmental rehabilitation. Certainly, the restoration of trees and other perennial woody species will require years of commitment, and innovative and experimental efforts, as well as ordinary protection and conservation on a tree-by-tree basis in many instances.

A unique challenge is posed to agricultural development. It must be designed to be supportive and contributory to environmental rehabilitation, while also maintaining the goal of increasing food production. In fact, the two are mutually

dependent, and in practice must be combined into a single action by the farmer and unified supporting actions by development agencies.

With regard to a development response to the problem of stressed rangeland resources, there has been a singular lack of progress on the practical plane. Some promising research is underway, however.

Ongoing and planned development assistance responses to this situation are surveyed in greater detail in Part III.

6.7 POSSIBLE ACTIONS

Assuming that the worst of the drought which began in 1968 is over, the task at hand is to restore ecological resiliency to the Sahel and other drought-stressed regions. The resulting crises with respect to dry-season forage and fuelwood will exist for a number of years. Long-term rehabilitation actions on these two issues are priority needs. (Please see recommendations in the sub-regional treatment of the arid and semi-arid sub-region.)

Donors should encourage drought-prone nations to prepare drought contingency plans, dealing not only with food, livestock and seeds, but also with fuelwood and forage needs, which, as was shown above, can make fatal demands on vegetation in drought years. Drought-prone nations should also have in place contingency public works plans to occupy rural peoples affected by drought.

Similarly, A.I.D. should have in place a contingency plan for employing PL-480 funds in concert with funding by African governments to finance public works, such as watershed terracing, during drought years. Numerous examples, including some in Cape Verde, indicate how effectively such plans can be employed.

A.I.D.'s new Famine Early Warning System monitoring project could be expanded to interpret not only indicators of nutritional and food situations but also environmental and geophysical indicators of impending drought periods.

Continuing support for WMO and other research on predicting long-term climatic cycles is also recommended.

Lastly, A.I.D. should collaborate with initiatives in the Sahel, such as the IUCN and CILSS plans, which seek to combine developmental and environmental rehabilitation responses.

III. SUB-REGIONAL OVERVIEW

The natural resource management problems described in the previous sections vary greatly from one place to another, as a result of the great diversity of environments in sub-Saharan Africa. Within different sub-regions with distinctive environments, their gravity and nature vary, principally as a function of ecological conditions and population pressures. Thus, in the semi-arid and arid zones, desertification is a threat, whereas in Madagascar, loss of unique species is the most serious of several problems.

In this section, the various issues presented briefly here are reviewed in greater detail with respect to the specific ecological circumstances of the various sub-regions. The sub-regions were selected for their environmental and demographic homogeneity.

Each sub-region is described, development responses or activities are noted, and apparent constraints on or gaps in assistance efforts are mentioned if these are identifiable. Possible additional solutions are listed, and in Section, IV, which follows, an agenda of possible actions for each sub-region is presented.

A. IDENTIFICATION OF SUB-REGIONS

For the present study, seven homogeneous sub-regions were identified, principally on the basis of agro-climatological criteria, but also taking into account population densities and species endemism, or uniqueness. Agro-ecological Zones Project were used to establish sub-regional boundaries on the African continent. The resulting sub-regions are defined in the following paragraphs. Population totals for the sub-regions are 1975 figures computed by FAO in its study of potential population-supporting capacities of lands in the developing world (FAO, 1983). More recent population statistics for the agro-ecological zones have not been compiled, however.

An attempt was made to employ the sub-regional classification used in the 1985 "Plan for Supporting Agricultural Research and

Faculties in Africa." It did not, however, prove to be sufficiently precise for the sub-regionalization of natural resource management problems. In that plan, sub-regional country groupings correspond to a general matching of countries with groups of major food crops to be researched. The "ecological" boundaries are not entirely accurate, since they follow political frontiers (*). This is perhaps of little consequence for the research plan, but it hinders the identification of resource management problems corresponding to particular ecological zones.

1.0 ARID AND SEMI-ARID TROPICS

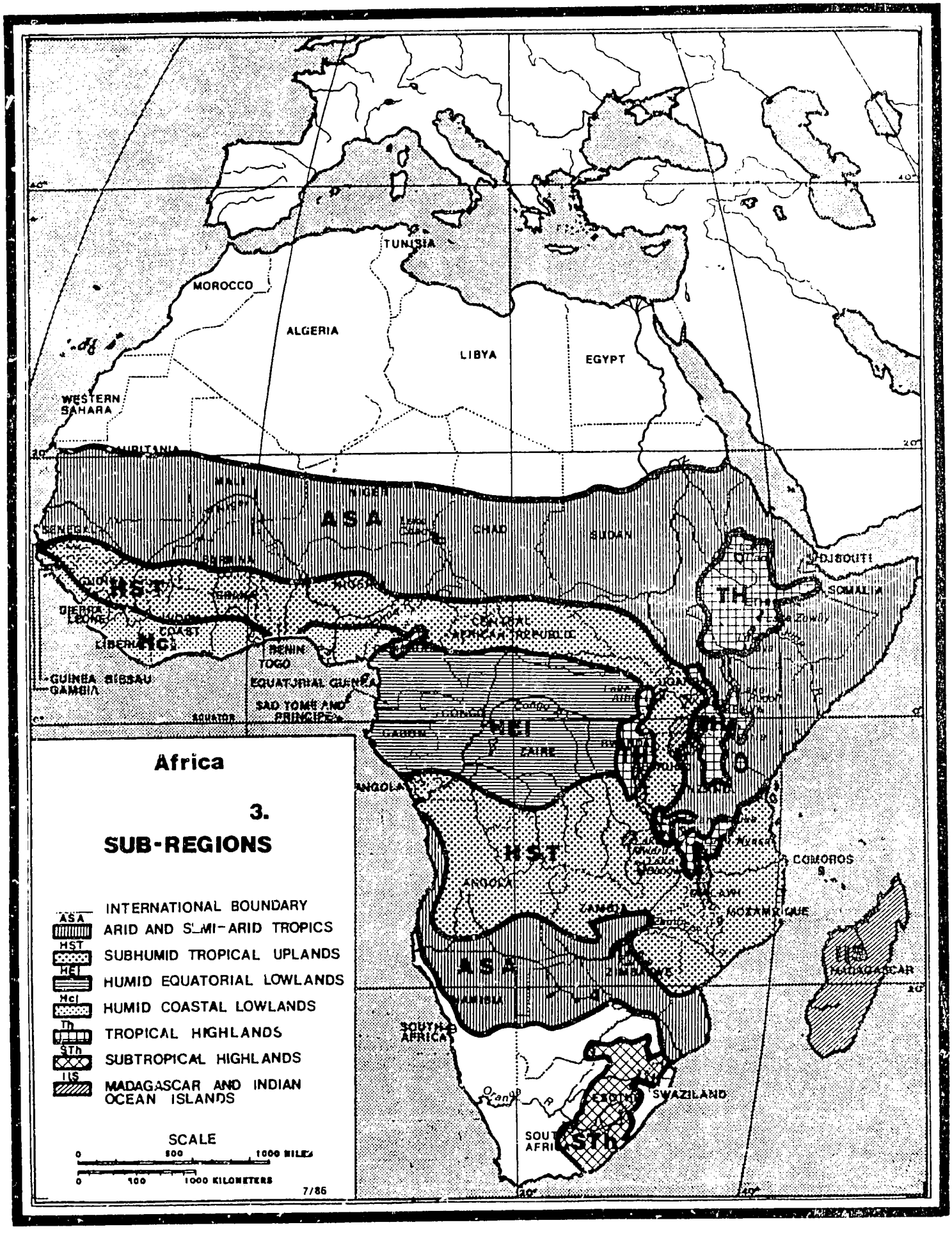
The length of growing season is 0 to 180 days. Rainfall in the arid zone supports some vegetation, but rainfed cropping in this sub-region does not take place at annual rainfalls of less than about 350 millimeters, which corresponds to a growing season of about 75 days. A growing-season ranging of from 75 days to 180 days is considered to be the semi-arid zone in this classification. In West Africa, the 75- to 180-day growing-season range corresponds to the Sahelo-Sudanian and Sudanian zones, while the climatic Sahel occurs north of the 350-millimeter rainfall line and grades into the Sahara. 1975 population: 82 million.

2.0 SUB-HUMID TROPICAL UPLANDS

The length of growing season is 180 tO 270 days. The sub-region generally embraces the upper portions of river basins, whose elevations above sea level do not exceed 1000 meters and more usually are 100 to 300 meters. 1975 population: 104 million.

A more rigorous climatic definition of this expansive sub-region generally embraces the higher lands south of the Equator (e.g., the Zambesi Plateau) where higher elevations result in slightly lower temperatures. For simplicity's sake however, the suh-tropical designation follows the latitude-determined "sub-tropics" used by FAO, which refers only to sea-level climate.

(*) For instance, Lesotho and Swaziland are identified as modified tropical highlands; in fact, they are well within the sub-tropical latitudes. Botswana is identified as sub-humid tropical, which is true in part; however, most of Botswana is the semi-arid to arid Kalahari desert, whose southern portion extends into the sub-tropics. Somalia is identified as semi-arid tropics, when in fact it is arid to hyper-arid over most of its territory.


Africa
3.
SUB-REGIONS
INTERNATIONAL BOUNDARY
ASA ARID AND SEMI-ARID TROPICS
HST SUBHUMID TROPICAL UPLANDS
HEI HUMID EQUATORIAL LOWLANDS
HCl HUMID COASTAL LOWLANDS
Th TROPICAL HIGHLANDS
STh SUBTROPICAL HIGHLANDS
IIS MADAGASCAR AND INDIAN OCEAN ISLANDS
SCALE
0 500 1000 MILES
0 100 1000 KILOMETERS
7/86
TUNISIA
MOROCCO
ALGERIA
LIBYA
EGYPT
WESTERN SAHARA
MAURITANIA
MALI
NIGER
CHAD
SUDAN
SENEGAL
GUINEA
SIERRA LEONE
LIBERIA
IVORY COAST
BENIN
TOGO
GUINEA BISSAU
GAMBIA
EQUATORIAL GUINEA
SAO TOME AND PRINCIPE
EQUATOR
CENTRAL AFRICAN REPUBLIC
GABON
ZAIRE
ANGOLA
ZAMBIA
SOUTH AFRICA
SWAZILAND
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3.0 AFRICAN HIGHLANDS

(a) TROPICAL HIGHLANDS

The length of the growing season is variable, and cool temperatures as a function of altitude are the distinguishing characteristic. Generally, elevations are above 1500 meters are average temperatures are less than 20 degrees during the growing season. There are two rainy seasons. Steep, mountainous terrain predominates. Some highlands are heavily populated, e.g., Rwanda's volcanic highlands with 600 people per square kilometer.

(b) SUB-TROPICAL HIGHLANDS

Elevations to 1500 meters or more predominate. Terrain is mountainous or consists of rolling, high-elevation plateaus. Lesotho and Swaziland are the only A.I.D. assistance recipients within the sub-region.

4.0 HUMID COASTAL LOWLANDS

The length of the growing season is 270 to 365 days. Populations are dense, and the sub-region includes a number of large cities: Lagos, Accra, and Abidjan.

5.0 HUMID EQUATORIAL LOWLANDS

The length of growing season is 270 to 365 days. Population densities are generally low.

6.0 MADAGASCAR AND INDIAN OCEAN ISLANDS

Islands in this sub-region include the Comoros, Mauritius, and the Seychelles, as well as Madagascar, the largest of the Indian Ocean Islands.

During a period of continental drift, Madagascar separated from the present African continent, resulting in a unique and rich flora and fauna which are unparalleled elsewhere in the world. Madagascar's inhabitants are culturally distinctive. The island's diverse climates mirror all the climates found on the African mainland. Typhoons are major weather events for these islands.

B. THE SUB-REGIONS

The following sub-regional descriptions treat the distinguishing characteristics of the various sub-regions, their resource management problems, development experiences in resource management, and ongoing assistance. A listing of possible development assistance actions for all the sub-regions is then presented in Section C. As noted in Part II, coastal zone resources were found to be best treated on the basis of an East Africa/West Africa separation. Consequently, with the exception of the Indian Ocean Islands and Madagascar, coastal zone management questions are not described. They are treated in Part II, Section B.4.

A separate treatment of the sub-tropical highlands is not given, since it is understood that the problems of that region are similar in nature, if not in gravity, to those of the tropical highlands. The greater cold in the sub-tropical highlands, however, presents a special situation for soils and vegetation management.

The treatment of the arid and semi-arid sub-region is longer than the others because of its importance and the amount of work and number of ongoing activities that were reviewed.

1.0 ARID AND SEMI-ARID TROPICS

CONTENTS

1.1 Description
1.2 Natural Resource Management Issues
1 3 Development Assistance in the Sub-Region

1.1 DESCRIPTION

The arid and semi-arid climatic belts were combined into a single sub-region because of the continuity of land uses and the long history of inter-dependency of the pastoral, agro-pastoral and agricultural groups that populate these zones.

This is presently the most critical sub-region in sub-Saharan Africa, because of the many and severe natural resource management problems that it faces and that must be resolved as a prerequisite to sustainable development. The principal problems are: scarcities of fuelwood, accessible range, and arable soils; degradation of soil and vegetation; and erratic food production.

Its vast area (939 million hectares or 1/2 of sub-Saharan Africa), the numbers of people and livestock in this sub-region (at present, approximately 90 million and 77 million, respectively), the variability of its productivity, and the decline in productivity because of desertification, are additional features of this sub-region.

Environmental degradation affects virtually the entire sub-region. Out of 19 countries in the sub-region, only thinly-populated Guinea and Guinea-Bissau report stable conditions. Only portions of the two extend into the sub-region. Of the rest, eight countries report some increase, and nine report a significant increase, in desertification (WRI, 1986). Development banks, development agencies, and private voluntary relief organizations all realize now that reversal of the environmental decline in this sub-region is a key requisite for sustainable improvements.

POPULATION

The sub-region is in places densely populated (up to 60 to 100 people per square kilometer, e.g., in Senegal's groundnut basin or Burkina Faso's Yatenga Plateau) and can be very productive. Also, population growth has continued unabated even through the long, drought-dominated period between 1968 and 1985. Except for Senegal, where 1 in 6 persons lives in a city, the sub-region's people are mostly rural dwellers. They comprise a very diverse cross-section of humanity which includes hundreds of culturally-distinctive agro-pastoral societies, deriving subsistence livelihoods from this erratic environment. The drought caused a major migration of people from the drier, northern regions to cities or the more humid, southern regions.

Virtually the entire sub-region is considered by FAO to be over-populated with respect to sustainable, rainfed food production at low levels of inputs, i.e., traditional farming.

CLIMATE

Annual rainfall in the sub-region ranges between 0 and 1000 millimeters. The length of the growing season ranges from 0 to 180 days per year. The semi-arid tropics are usually defined as having a 75- to 180-day growing season (ICRISAT, 1984).

The shortest growing period (75 to 90 days per year) in the African tropics occurs in areas that receive annual rainfall ranging from 275 to 350 millimeters. Extreme rainfall variability at the arid margins of cultivation results in an indistinct transitional zone into the true rangeland, which is marked by the the last vestiges of rainfed millet cultivation. During the recent period of long-term, below-normal rainfall, the boundary for rainfed cultivation shifted southward about 200 kilometers (Rijks, 1986).

According to UNESCO's 1979 world classification of desert regions, the climate of this sub-region is characterized by a single summer rainy season (except in Ethiopia and Somalia). The area north of the equator within this sub-region is the hottest inhabited area in the world.

Those parts of the sub-region that are south of the Equator have a cooler winter season, with temperatures between 10 and 20 degrees C. Summers are not quite as hot as north of the Equator, even on the Kalahari Desert, where mean temperatures in the warmest month rarely exceed 30 degrees C. As a result, aridity is somewhat less than it is north of the Equator. The Cape Verde Islands and southwest Madagascar are also arid to very arid.

Average values for rainfall have little meaning in this zone because of the characteristic high variability of rainfall from year to year. Expected departures from mean values are from 25% to 60%. On the arid side of the zone, rainfall occurs as spotty, local showers rather than as frontal storms. The latter shed rain more uniformly over large areas, and only occur in the humid extremes of this sub-region.

Aridity, a function of both temperature and rainfall, is a more precise descriptive factor than is rainfall alone, since in Kenya portions of this sub-region are located at elevations of up to 1,500 meters. At these altitudes, cooler temperatures prevail and rainfall is more effective than at lower elevations, but arid conditions are found, nevertheless.

Evapotranspiration potential in this sub-region is 33 times the amount of rainfall on the arid extreme, and only twice the amount of rainfall on the humid boundary. Within the rainy season, however, precipitation will often exceed

evapotranspiration potential, and the surplus either percolates into the soil horizon or runs off.

In this way, a soil which has lost porosity becomes more arid than a neighboring soil that has retained porosity and can therefore store more water and support a more abundant vegetative cover. Also, deep rooted plants in sandy soils have an obvious advantage over those whose roots are in surface horizons, where evaporation removes water, e.g., generally the first meter of most soils. Deeper roots can tap stored groundwater during long, dry periods. Therein lies the value of trees, no matter how small in size, in the desert.

VEGETATION AND WILDLIFE

Vegetation in the sub-region ranges from ephemeral grasses (in the true deserts of the Sahara and the Kalahari) to the semi-deciduous, wooded savannah of the humid boundaries. Perennial grasses occur in areas with both an annual rainfall in excess of 800 millimeters and a single rainy season. In the northernmost portion of this sub-region, perennial grasses are limited to clay-filled interdunal depressions and permanently-wet valley bottoms or swales (has fonds), where they supply important sources of forage for migrating cattle.

The wet pastures of various inland deltas (e.g., those of the Niger and Nile rivers) and shallow lakes are also strategically important dry-season reserves. These same wetlands are over-wintering habitats for European waterfowl, but in the future could be the target of major irrigation schemes. Traditional irrigators and farmers have already occupied the better soils.

The sub-region contains wetlands of major national and international significance. The Diawling-Djoudy reserves of Mauritania and Senegal and the Delta du Saloum reserves of Gambia and Senegal are internationally important waterfowl habitats. The largest swamp in the world, the Sudd, is located in the Sudan. According to the IUCN and WWF, the two most important freshwater wetlands in West Africa are the Niger delta in Mali, and Lake Chad, which borders on Chad, Niger and Nigeria. Mauritania's Bane d'Arguin wetland alone supports approximately thirty percent of Africa's Atlantic coast shorebird migrants. The Niger inner-river delta is an important migratory habitat for pintail ducks and garganey geese. The Okawango delta in Botswana supports over 400 bird species. The WWF views the East African (Kenya, Somalia and Tanzania) migratory bird route and associated wetlands as important resources which need protection.

In the double-rainfall regimes of the East African portion of

this sub-region, where permanent grasses can survive at lower annual rainfall than in the Sahel, year-round grazing is possible.

Wood growth in natural formations ranges from less than 0.5 cubic meters to 20 cubic meters per hectare per year at the margin with the sub-humid uplands. Although there are relatively few endemic species of plants and animals in the arid and semi-arid zones, some are of critical importance to the future of agriculture, forestry and grazing: domesticated and wild sorghums and millets, browse species, and certain trees with agroforestry values. Collection of these species are proceeding, but are incomplete (Hawkes, 1985).

The sub-region supports several endangered species including the addax, the scimitar horned oryx and the Dama gazelle in the Air/Tenere region of Niger. Other important wildlife in the sub-region include elephants and rhinos, such as those found in the Kaokolandare region of Namibia, and migratory wildlife, such as that found in the Etosha Pan region of Botswana. There are also isolated, elevated, high-rainfall areas within the aforementioned regions which support endemic plant populations.

1.2. NATURAL RESOURCE MANAGEMENT ISSUES

SOIL EROSION AND DECLINES IN PRODUCTIVITY

Soils present complex management problems for dryland farming, and they are not yet well-mapped in the sub-region. Small-scale (1:1,000,000 to 1:250,000) soil surveys are gradually being carried out in this region north of the Equator: Senegal (1:250,000), Mauritania (1:250,000), and Mali (1:500,000) are examples. All were financed by A.I.D. and utilized satellite as well as aerial photographic imagery, in addition to field surveys and previous maps. The French have undertaken soils mapping at various scales through Fonds d'Aide et Cooperation as well as ORSTROM, France's overseas research program.

FAO has mapped degradation and desertification hazards at the 1:5,000,000 scale. These small scales are suitable for national or regional planning, but not for farm or multiple-field-level work.

Soils of this sub-region are very diverse, but have in common a low content of phosphorus and organic matter. Low content of organic matter seems to be a problem that has developed during the last 25 years, while phosphorus deficiencies are an innate characteristic.

In a 1982 monograph on Africa's dryland soils prepared for

A.I.D., H.E. Dregne summed up the major characteristics of the sub-regions's agricultural soils:

* Low inherent fertility is the most significant and pervasive problem.

It arises from the sandy and acidic character of soils in the northern portion of this sub-region and from the low nutrient-holding and phosophorus-fixation capacities of the ferruginous soils in the more humid southern portion of the sub-region.

Nitrogen and phosphorus are limiting nutrients. Sulfur can be deficient for some crops in the more humid margins; micro-nutrients can also be deficient and can limit plant growth.

* Soil surface crusting is a problem everywhere. It is not easily solved; organic matter can reduce crusting but it's virtually impossible to maintain. Post-harvest plowing could help, but on dry soils, plow penetration is a problem.

* Hardening (not just crusting) of the top layers is especially serious in southern Africa.

* Drainage is poor on the clay plains of Sudan and Chad, and along the Angola-Zambia border.

* Vertisols (black cracking clays) are poorly drained in Sudan, but have good crop potential.

(Australian experience in mechanized cultivation of vertisols is being adapted to conditions in Somalia with good results in a World Bank project (McPherson, 1986)).

* Low content of organic matter is a fundamental fertility constraint, which, among other effects, limits the value of mineral fertilizers. Crop rotations and better management of crop residues and other sources of organic matter are solutions.

* Unlike some other arid regions of the world, there are practically no salt problems in the dryland soils of Africa.

LOSS OF VEGETATIVE COVER AND PRODUCTIVITY

The scant vegetative resources in the sub-region support both people and livestock. Continuous harvesting of perennial species for fuel, lopping of branches for fodder in the dry season, and occasional cutting of poles and grasses or palm fronds for construction (supplementing the customary use of

sorghum stalks for shelter walls) are principal means of exploitation. Current rates of fuelwood harvesting are not sustainable (World Bank, 1985).

During the long dry season, livestock browse perennial grasses or woody browse species, or crop residues if the animals are herded to farming regions. The slow disappearance of desirable browse species has been observed in one of the few surveys which have monitored this resource.

Burning is a problem in the zone. Nomadic herders burn dry grasses at the end of the growing season to promote a flush of fresh shoots that tap residual groundwater. Hunters also employ fire, and these fires often get out of control. Dry-season browsing and grazing reserves are often in or near forest reserves. For these reasons, "bush fire" control has become a major concern of forest services, especially in the more humid portions of this sub-region.

The ecological results of burning are destruction of tender re-growth (including seedlings of woody plants which have germinated during the short rainy season), destruction of organic matter, and baking of the top centimeter of soil surface, with a consequent destruction of microbial life. Progressive dessication of the site can take place, i.e., local edaphic and micro-climatic aridity in excess of what overall climatic conditions indicate.

RANGE MANAGEMENT

This sub-region is the principal livestock-raising environment of Africa. It is free of tsetse flies, except in the more humid margins and where a combination of perennial streams and riverine vegetation is found, e.g., the Lower Juba River, Somalia.

North of the Equator, the sub-region presents the greatest potential for adapting the traditional association of livestock and farming (which could be described as an antagonistic, yet symbiotic, association between nomads and sedentary farmers) in order to intensify agriculture. Scientific improvements in traditional agroforestry systems have potential for intensifying agriculture in this sub-region. A complex but promising research need exists: the integration of trees, livestock and cropping systems. Nowhere are these three elements of traditional livelihood systems being researched in combination.

In the arid portion of this sub-region, where agriculture is not possible, research, surveys and monitoring of range ecology and livestock projects over the past 10 to 15 years have not

yet been accomplished. Our knowledge of this region, however, has increased significantly (e.g., works by G. Boudet in Niger (1977), UNESCO in the IPAL project in Kenya (1985), and Breman and de Wit in Mali (1983).

Studies in Mali in different humidity provinces of this sub-region have shed new light on range productivity, as well as possibilities for the integration of farming and transhumant herding (Breman and deWit, 1983). Water is the major limiting factor, but only until rainfall levels approach 300 millimeters. Above 300 millimeters of rainfall, phosphorus and nitrogen, not water, limit greater production of annual grasses. Water-limited range in this sub-region is nevertheless of good quality since protein content is greater than in grasses of more humid range.

These research findings support the logic of transhumant herding between the northern portion of this sub-region during the short rainy season and regions to the south during the dry season. Also, the findings point to the benefits that could be derived from using phosphorus and nitrogen to improve the fertility of farmlands in the semi-arid portions. Their use increases not only crop yields, but also the amount and quality (and thus, value) of crop by-products available for feeding the transient herds.

In Senegal, several livestock development schemes funded by A.I.D. were based on the idea of using crop residues, especially cowpea and peanut vines, to fatten animals raised in the arid Ferlo and Bakel regions. Small farmers in the groundnut-growing regions near the urban market were to stall-feed heifers and then later sell them to the Dakar market. For many reasons, these projects had very limited success; however, the stall-feeding aspect of the project (even though small in scale) worked out well.

Sheep and goats are not only more numerous than cattle in the sub-region, but are economically as important. Further, their fecundity makes them especially valuable in recovering losses in cattle herds decimated by drought. The importance of sheep and goats in pastoral and agro-pastoral systems has not been reflected in development assistance, which has focused almost exclusively on cattle. (See Section 1.3, below.)

In eastern and southern Africa, rangelands have greater potential, especially where the existence of two rainy seasons and/or cooler temperatures support perennial grasses. In general, however, over-stocking and over-grazing are the rule. For example, in Zambia, where livestock numbers are 10 times the carrying capacity of the available rangelands, the range is rapidly deteriorating. Large areas of Zimbabwe's rangelands

are also overgrazed or bare, including 4 million hectares of former trust lands (WRI, 1986).

WATER RESOURCES

Greater use and better management of water resources in this sub-region will be a key element in efforts to achieve a measure of food self-sufficiency.

Surface Water: Various traditional means of using water for subsistence crops have evolved over the centuries; some are in conflict with modern development. An example of such a conflict is flood recession farming, which is widely practiced in the Senegal and Niger River Basins as well as in lesser rivers.

Four of Africa's major rivers flow through the sub-region: the Senegal, the Niger, and the Blue and White Niles. They have supported fishing, farming and grazing livelihoods throughout human history. Since independence and the subsequent onset of drought in this sub-region, large integrated development schemes have been proposed and initiated for these four rivers.

These development schemes were encouraged during a period of surplus "petro-dollars" and financial assistance from Middle Eastern oil producers for dam construction, e.g., the Manantali and Diama dams on the Senegal river. They had been the subject of general planning studies in previous years, however.

Irrigation and potential irrigation in countries of the Arid and Semi-Arid sub-region
(Source: FAO, 1985b)

Country	Irrigated in 1982	Irrigation potential
	(000's hectares)	
Botswana	12	100
Burkina Faso	29	350
Chad	46	1,200
Kenya	49	350
Mali*	150	340
Mauritania*	23	39
Niger	24	100
Senegal*	187	180
Somalia	85	87
Sudan	1,700	3,300

* A.I.D. estimated the Senegal River valley's potentially irrigable lands at 360,000 hectares for all three riparian states (Senegal, Mauritania, and Mali).

FAO concludes that all of the above countries, except Sudan, will have to count on irrigated food crop production as a major element in future food strategies, in the short and medium term.

Cooperative river basin projects in recent years have often been delayed by economic crises and political differences among the countries in this sub-region. Also, construction of a canal through the Sudd in southern Sudan has been interrupted as a result of civil strife.

The construction of dams in the Senegal River has proceeded, but parallel planning and development of irrigated agriculture has been delayed. There have been disagreements among the riparian states, as well as a re-thinking on the part of A.I.D. and other donor organizations, regarding the appropriate size of irrigation projects: large-scale projects (i.e., over 500 hectares) in the Senegal River valley, as opposed to smaller-scale development aimed at village groups.

Health problems, notably from water-borne or water-related diseases such as malaria and schistosomiasis, are important complications of irrigation projects in this region, as well as in the adjacent sub-humid uplands. The incidence of schistosomiasis in Sudan's 1,700-hectare Gezira scheme increased from 9% to 50% between 1940 and 1985.

Regarding the scale of irrigation development, the 1985 FAO study concluded that:

* Entirely new, large-scale schemes may seldom be economically justified in these countries, but there is latitude for cheaper rehabilitation, and in some cases, expansion of existing perimeters.

* Simple improvements in traditional swamp and recession irrigation, although yielding smaller gains, could, in aggregate, also make an appreciable contribution to food supply.

A.I.D. is supporting specific projects in the Senegal River Basin aimed at strengthening the OMVS, as well as the development of irrigated agriculture in the Lower Juba Valley, Somalia. This latter development is presently being planned with the pledge of World Bank financing of a major dam. The A.I.D. Juba Valley project study includes an environmental assessment of the impacts of land and water development.

<u>Watershed management</u>: The importance of upper catchment areas to the quantity and quality of water flowing into the sub-region's major rivers raises the need for international cooperation, since these rivers have their headwaters in other

nation-states. The Nile arises in the East African Highlands, as does the Juba River, flowing from Ethiopia into Somalia. The Gambia and Senegal Rivers have their origins in Guinea's sub-humid Fouta Djallon highlands; the Niger River also arises in Guinea, slightly further south. These catchments are in sub-humid uplands with markedly seasonal rainfall, resulting in sharply seasonal river flows.

These watersheds should be wisely managed. The upstream catchment states should ideally maintain land cover and land uses that supply clean, regulated run-off which would benefit downstream users. In addition, if the uplands of Guinea and Ethiopia are to remain productive for agriculture and forestry, land-use practices must be followed that will conserve soil and water. These same practices regulate run-off, as well. Uncontrolled logging and steepland cultivation in remote upper catchments present management problems that are not easily solved.

Groundwater management: Groundwater resources in the zone include shallow aquifers (which are renewed by rainfall) as well as deep aquifers in rock strata. Most rural inhabitants depend upon the seasonally renewed shallow aquifers. Their levels, however, have dropped during the drought, and wells have had to be deepened. Deep aquifers have been tapped in recent years for livestock watering in this sub-region.

Knowledge of Africa's groundwater resources is rather scant. The groundwater resources of West Africa were mapped by the Centre Inter-Africain d'Etudes Hydrauliques (Burkina Faso) in the early 1970's, using rainfall averages of the preceding period to estimate groundwater potential. The long drought has necessitated a reassessment of potential, now underway with assistance from the European Economic Community.

Groundwater is generally too scarce or deep for use in irrigation. According to FAO (1985), groundwater yields in the sedimentary basins of Chad and Senegal are intermediate, and in Somalia and Sudan aquifers are too deep (over 100 meters) for use in economically viable irrigation.

Many villages, however, are beginning to irrigate small tree nurseries with shallow well water formerly used only for drinking and livestock. Vegetables are often raised on a small scale by village women in conjunction with nurseries. Numerous PVO's in the region have been especially active in promoting such small gardens. A local management problem, however, has not yet been addressed: the rate of water withdrawal that the local water tables can withstand in small-scale water development projects. It could be exceeded to the detriment of the local potable water supply in a given season.

DECLINE IN BIOLOGICAL DIVERSITY

Wildlife poaching and economic and social problems within the sub-region have led to widespread deterioration of its parks and reserves. Both Niger and Senegal have important park networks which are jeopardized by a shortage of funds and staff (IUCN, 1986). Many of these parks and reserves serve as important genetic repositories for plant species which could be used to re-vegetate deteriorated lands within the sub-region.

The wetlands are complex ecosystems and are valuable reserves of biological diversity (IUCN, 1986). At this point, the sub-region has not been adequately surveyed for wild varieties of plants which could be utilized to produce higher agricultural yields under drought conditions. It appears possible that such varieties may become extinct even before they are identified.

The major problem facing coastal and freshwater biological systems is the continued alteration of these habitats. The Sahel wetlands contain fertile alluvial soils which have the potential to support irrigated agriculture. Exploitation of these resources has been limited in the past by low-intensity traditional agriculture. In the future, however, these wetlands will likely be subjected to much more intensive use.

Current water and agricultural development assistance projects have the potential to cause large-scale loss or disruption of wetlands and river biological communities. The cumulative impact of trans-national projects on riverine systems (such as that of the Senegal River) can be very great.

DESERTIFICATION

Stresses on natural resources and the environment related to drought are treated in Part II.B.6. As opposed to drought, which is a climatic event, desertification is a long-term trend in the sub-region impelled by human and livestock pressures on the environment, which are degrading soils and vegetation. Drought, however, tends to intensify the factors causing desertification.

This section more specifically treats the long-term problem of land degradation leading to desertification in this climate.

As defined by the U.N. Conference on Desertification (Mabbutt, 1984):

> "Desertification is the diminution or destruction of the land, ultimately leading to desert-like conditions"

A desert surface may be in the form of bare sand or desert pavement (pebbly surface). Since the process is essentially caused by over-use or abusive use of natural resources in semi-arid and arid zones, the degradation of farming and pastoral livelihoods proceeds in parallel with the degradation of the land and vegetation.

The 1:25,000,000 map of desertification hazards ("Desertification Map of the World", FAO and UNESCO, 1977) clearly shows the various desertification processes to which different parts of the sub-region are subjected. Virtually the entire northern portion of this sub-region is subject to sand drift, as is most of Botswana and portions of southwestern Zimbabwe. Run-off erosion endangers lands in many places in the higher rainfall portions of the sub-region. Most serious, because of its irreversibility, is the threat of extreme erosion leading to the formation of stony pavements and hard pan. Extreme erosion is especially serious in Ethiopian Ogaden and Somalia, much of Western Sudan, East Chad, the Ferlo of Senegal, and a portion of Mauritania.

How far desertification has gone and how reversible it is are poorly known, because the different stages of desertification have not been monitored. UNEP attempted to assess the status of desertification in Africa and the rest of the world by questionnaire during 1981-83 (Mabbutt, 1984). The level of response was relatively high, but the information provided was "patchy." Countries had not undertaken actual assessments of desertification. The results of the survey were therefore largely qualitative, even though the information is presented quantitatively, i.e., as percent of rangelands or croplands moderately or severely desertified.

For Africa, the responses indicated that the production potential of between 80% and 90% of the sub-region's range and farmland had been reduced by 25%, affecting the livelihoods of 11 million pastoralists and 70 million agriculturalists. Farmlands are experiencing moderate desertification as defined in the UNEP survey.

Notably, some stages of desertification are not readily monitored (e.g., a shift in dominance to more drought-tolerant range species, the reduction in low brushy growth, and the early stages of wind and soil erosion). Trends in amounts of seasonal biomass, which have been monitored by NOAA for A.I.D. since 1981, are acting as beginnings of a baseline that, if continued and enriched with ground observations, could serve as a tool to remotely-sense some indicators of desertification. Presently, however, the thrust of this interpretive work is prediction of crop yields.

1.3 DEVELOPMENT ASSISTANCE IN THE SUB-REGION

Responses to the recent drought crisis are noted in the discussion under II.B.6 (Stresses on natural resources and the environment coincident with the drought). Reviewed here are long-term development actions that go beyond the amelioration of drought-caused stresses.

Drought and desertification have been, however, inseparably linked in Africa since 1968. This has caused the two problems to be addressed together in development assistance responses; however, the drought has masked or obscured the effects of long-term land and vegetative degradation associated with rising livestock and human populations.

Development responses to overcome the effects of the drought initially focused on restoring production, including cattle numbers, to pre-drought levels, without regard for the fact that use intensities with traditional technologies are no longer environmentally sustainable.

All countries in the sub-region now have programs to combat desertification. These programs are key elements in the national economic and social plans of the CILSS nations. They have been developed with the support of the UN Sahelian Office, as well as through the CILSS/Club du Sahel mechanism. As the drought continues, the programs to combat desertification have served as umbrellas to garner international support for a great diversity of development assistance.

REVERSING LAND DEGRADATION

The arresting of erosion and of declines in soil productivity in this sub-region is being accomplished in places, although not to the extent of our knowledge or enough to meet current needs.

Some notable experiences include:

* Regeneration of soil water holding capacity and productivity in an experimental project at the Guesselbodi forest near Niamey, Niger, through the conservation of litter on the ground. Resulting termite activity increased soil porosity and, as a consequence, rainfall percolation.

* Soil erosion and run-off control with stone and trash lines in an OXFAM project in Burkina Faso. A simple leveling technique which employs a clear plastic hose was introduced by an OXFAM field worker. Villagers have now mastered this way of finding the contour, and on their own are continuing the work, which has produced visible gains in yields (Wright, 1985).

* *Acacia albida* regeneration in Chad, Niger and Senegal, with the multiple objectives of maintaining soil organic matter (from leaf fall), providing dry season forage (leaves and pods) and buffering sun and wind effects during the dry season, and rainfall splash erosion during the first rains (McGauhey, 1986).

* Dune stabilization in numerous places (Senegal, Mauritania, Niger, Sudan, Somalia) using palisades and plantings.

The economic benefits of land regeneration are an important consideration. GTZ has calculated the benefits of simple low barriers to erosion. Even at low productivity of dryland millet cropping, i.e., 400 kilograms/hectare, GTZ computed that an increase of from 24 to 77 kilograms per hectare would compensate for the labor cost of berm construction. Preliminary experiments pointed to increases of 30% to 50% by this method alone (GTZ, 1986). Similar assessments of the benefits to subsistence food production of conservation works are needed in other environments of Africa.

The costs of other needed actions have inhibited their initiation. For instance development assistance has not managed to find ways to finance fertilizers to redress low phosphorus levels or acidity.

LIVESTOCK AND RANGE MANAGEMENT

Livestock projects have come under particular criticism within A.I.D., as indicated by in-house evaluations (see below), as well as in other donor agencies. All experience and reviews point to the need to enlarge the scope of projects so as to include all relevant factors.

In 1986, USAID was supporting the following projects related to range management and livestock:

Gambia : range ecology and management (U. of Colorado)

Lesotho: range development, as a sub-project of a land conservation and range development project (1980-87)

Mali : livestock production but no range management

Niger : range regeneration and management (Forestry and Land Use Project, to be ended in 1987)

Somalia: rangeland development project, part of a multi-donor effort for development of the central rangelands (The A.I.D. contribution is $19.2

million during 1979-1986. A.I.D. also joined the Kuwait Fund for Arab Economic Development in the development of rangelands in northern Somalia through reserve establishment, well drilling, and fodder production.)

The problems of African rangelands and the results of various development experiences in range management and livestock have been recently reviewed by the NAS (1983) and the West German aid agency, GTZ (1986). Also, in 1985 A.I.D.'s Bureau for Science and Technology reviewed a number of A.I.D. projects concerned with livestock and range in Africa (various unpublished reports).

The GTZ review examined a wide range of range and livestock project interventions:

Breeding programs

Veterinary care

Marketing and processing

Stratification of livestock production

Water development

Range management (~~through~~ privatization), including technologies such as: grazing blocks, grazing reserves, group ranching, re-seeding, forage cultivation, animal traction, and Settlement projects.

Problems and setbacks were found in every one of these approaches. The review concluded that "on the whole, negative experiences in livestock development projects prevail" (GTZ, 1986). The reasons for this include insufficient knowledge of tropical biology and ecosystems, insufficient knowledge of existing production systems, inappropriate or inadequate organization, poor communication and staff incompetence.

The GTZ report recommended greater emphasis on the development of smallholder "traditional" systems and less on the introduction of large-scale modern systems. Also, it recommended the use of the systems approach to obtain a more methodical procedure for inter-disciplinary work in understanding, diagnosing and designing, as well as testing and extension.

The review is generally in agreement with the A.I.D. in-house evaluations noted next.

A.I.D. REVIEWS OF RANGE AND LIVESTOCK PROJECTS:

In recent years, A.I.D. has undertaken or commissioned a number of reviews and evaluations of A.I.D.-supported livestock and range projects. These have been undertaken independently of similar reviews for forestry projects, notwithstanding the widely recognized importance of permanent woody vegetation as browse resources in semi-arid and arid range.

In June, 1980, the Institute for Development Anthropology reported on the conclusions of an A.I.D. Workshop on African Pastoralism and African Livestock Development:

* Quantitative data on pastoral systems are inadequate.

* Management of livestock development should be small-scale and based on existing cultural-ecological systems.

* Pastoralists' mobility helps them to survive in drought crises as well as to effectively exploit the range over the long term.

* Subsistence, rather than commercial, pastoralism should be supported during droughts.

A 1982 "Livestock Development Assistance Strategy" paper developed in the Africa Bureau lacks any mention of the above workshop or of range management, except for the recommendation to open up unused range resources through the provision of temporary water points. The strategy addresses integration of livestock production with cropping systems.

Continued difficulties with livestock projects spurred the convening by A.I.D.'s Bureau for Science and Technology of an expert panel in Washington, D.C., in September, 1985, to deliberate the question:

> "Should A.I.D. try to promote development of sustainable extensive livestock production systems in Africa?"

("Extensive production" refers to range-fed livestock only, as distinguished from those that are herded into adjacent farming regions to eat crop residues during the dry season. In the Sahel, only camels and goats are not herded into farmlands to the south. Extensive ranching does exist in east and southern Africa, however.)

The panel cautiously answered the question in the affirmative. The strongest recommendation concerned training in order to build a stronger in-country cadre of technical and scientific people. Training in range ecology and management, animal

sciences (including wildlife), range and livestock economics, and anthropology and sociology were specified.

Also recommended were drought planning, a broader systems view of livestock/range development, and a long-term view. The panel noted the important role played by livestock in sustainable agricultural systems in Africa; however, no related recommendations were made.

In 1986, a systems view of livestock projects was being modeled in a project carried out by IIED for A.I.D.'s Bureau for Science and Technology. It could be used in the future for attaining more comprehensive, systematic attention to all aspects of livestock and range management in the African context. 500 to 600 data points in Africa have been developed.

In conclusion, A.I.D. still has not identified a clear policy and direction concerning range development and management in Africa; however, progress is being recorded in better understanding range development.

FORESTRY

A.I.D. is currently supporting a wide range of forestry and agroforestry projects and activities in the sub-region; however, there were few new starts in 1986, and many projects were coming to a close.

Evaluations and experience over the past ten years or more indicate that much more attention must be placed on research and management of natural woodlands and associated vegetation than has been accorded up to now. It is now generally recognized that in this sub-region, block plantations are not the answer to "deforestation," much less "desertification" (World Bank, 1985; A.I.D., 1984; GTZ, 1986). Also, agroforestry is seen as a key element to sustainability of agrarian livelihoods in the sub-region.

Block plantations may be needed to supply urban fuelwood or charcoal, but in rural areas, other solutions that are more ecologically and culturally appropriate are needed. In particular, intensification of research on and development of agroforestry species and systems is needed.

Lack of trained African foresters handicaps progress; as a result, it is usually identified in A.I.D. forestry projects both as a constraint, and as a justification for on-the-job training and long-term training in the USA or another country.

On-the-job training and training provided by project advisors

have frequently been accorded short shrift, typically because project management difficulties eclipse this input (Taylor and Samoure, 1985). The transformation of post-colonial forest services in Africa from law enforcers and forest preserve protectors to facilitators of rural development and promoters of agroforestry and village forestry is slowly taking place. Training for these tasks is not available except in the field, on the job. No university or school teaches the needed combination of skills and subject matter, except for the Dinderesso Forestry School in Burkina Faso (Bobo Diaoulasso).

Semi-arid zone agroforestry and forestry training can best be provided in Africa, by Africans or foreigners with great experience. Arid zone forestry training is weak in the forestry schools of the USA and Europe. It must eventually be developed in semi-arid Africa, along with basic and applied research, which are now being carried out on a very minimal level relative to current to needs.

CONSERVATION OF WILDLIFE AND GENETIC RESOURCES

Major international funding and development agencies have shown little interest in financing parks and management of natural areas in this sub-region. Assistance has been dominated by a combination of drought and economic stagnation. Nevertheless, countries such as Senegal and Tanzania devote a respectable proportion of their budgetary resources to conservation and natural area management.

Major non-governmental programs have concentrated in conservation activities in East Africa. West Africa is now receiving renewed attention, however, particularly by IUCN and the Africa Wildlife Foundation in the area of wetlands conservation.

Local, non-governmental organizations are rare. A notable exception is the Kalahari Conservation Society of Botswana.

REGIONAL WATER DEVELOPMENT

Great importance is attached to the development of international rivers in the arid and semi-arid regions, especially the Senegal, Niger and Gambia Rivers. The Chari River, flowing into Lake Chad from headwaters in the Central African Republic, is also a lifeline for Chadians and lakeshore dwellers on the Nigerian and Niger shores.

An awareness exists of the important role of upper catchments of these rivers. A UNDP watershed research project in the Fouta Djallon has been undertaken to establish the basis for a wider watershed management effort. For the most part, however,

donor assistance has focused on planning for and development of water and land resources in the valleys of these rivers, including support for multi-state bodies such as the Senegal Basin Development Authority (OMVS), the Niger Basin Authority, and the Lake Chad Basin Commission.

The multi-donor-sponsored AGRHYMET project executed by the World Meteorological Organization responds to the need in the Sahelian states for better agro-climatological, hydrological and meteorological data. This regional project is headquartered in Niamey, Niger. At present, A.I.D. is supporting AGRHYMET at a level of $1.4 million per year, during 1982-87.

Groundwater development and management are of crucial importance to most parts of the region. But almost everywhere, there is a dearth of information and lack of African hydrologists, geo-hydrologists and corresponding institutions. The UNDP has played a lead role in undertaking groundwater surveys, gathering data, training technicians and strengthening institutions.

2.0 SUB-HUMID TROPICAL UPLANDS

CONTENTS

2.1 Description
2.2 Natural Resources Management Issues
2.3 Development Assistance in the Sub-Region

2.1 DESCRIPTION

The prolonged African drought, which started in the arid and semi-arid sub-region, has revealed how important the adjacent sub-humid tropical uplands sub-region is to pastoralists. Many nomadic pastoralists moved from their usual dry-season ranges in the semi-arid regions into the sub-humid regions in search of green forage, crossing political as well as cultural boundaries.

Malawi and the Central African Republic are the only countries that are located entirely within the sub-region. This sub-region embraces most of Guinea and the Central African Republic, and much of Angola and Zambia, but less than one half of Sierra Leone, Ivory Coast, Ghana, Togo, Benin, Nigeria, Cameroon, Chad, Sudan, Kenya, Tanzania, Zaire, and Zimbabwe. This circumstance also renders difficult the use of secondary information sources for discerning resource management issues, since data are normally organized by nation states.

No major urban centers are found in this sub-region because of its geographic distribution in upland areas that span watersheds and national boundaries, far from the major river or coastal ports. Its rural population is dense, however, especially in East Africa and south of the Equator, where concentrations of over 100 people per square kilometer are not unusual. Exceptions are the rather sparsely populated Central African Republic, southern Sudan and southern Guinea.

There is a single rainy season of 6 to 9 months' duration. Yearly rainfall is generally between 1000 and 1800 millimeters. North of the Equator, temperatures are 24 to 28 degrees C. on average. The Harmattan wind adds heat and aridity to the dry season, prior to the summer rains, making fire control difficult. South of the Equator, the higher elevations lower average temperatures to around 20 degrees C. Elevations are not normally greater than 300 meters above sea level north of the Equator, but increase to between 900 and 1100 meters north of the Kalahari basin on the Zambesi Plateau.

The climate favors a diversity of food crops. Rainfall as well as temperature and length of growing season are optimal or nearly so for almost every food crop: sorghum, yam, maize, soybean, phaseoulus bean, and, at the drier margin, cotton. At the humid margin, cassava is well suited. In fact, were it not for sleeping sickness (trypanosomiasis) in cattle and humans, and river blindness (onchocerciasis), this sub-region would be the most habitable lower-elevation environment in Africa.

Both of the aforementioned diseases are transmitted by flies whose habitat is in and around water courses and their riparian

vegetation. A long-term, multi-donor project is underway to eradicate the Simulium fly vector of river blindness, but a single solution has not yet been found for trypanosomiasis. Onchocerciasis does not affect the southern extent of this sub-region, however.

The rate of species endemism within the sub-region is generally low in comparison with that of other sub-regions. The southern portions of the sub-region, including all of Zambia, Malawi and Zimbabwe (particularly the Lake Victoria area), support the highest levels of endemic plants and moderate levels of endemic birds (15%) (IUCN, 1986). This sub-region has an extremely rich array of flora and fauna which are commonly associated with Africa.

Within the sub-region, both wild game and plants play an important role in the diets of the people. In Zambia, game meat accounts for over 13% of total annual protein consumption (Prescott-Allen, 1982). In Zimbabwe, game ranching, including crocodile farms, has become an increasingly important form of land use. Here, there is special emphasis on returning both products (meat, hides, etc.) and revenue from wildlife resources to local rural communities.

The herbaceous swamps bordering the lakes of this sub-region are very productive ecological systems. These lakes include Lakes Victoria, Bangweulu (Zambia), Mwena (Zaire/Zambia), Naivasha (Kenya) and Chilwa (Malawi/Mozambique) (Maltby, 1986). Of the major seasonal floodplains within the sub-region, the Kafue Flats of Zambia are most important.

Many areas within this sub-region are under intense human pressure from overgrazing, agricultural expansion into marginal lands, deforestation, and excessive hunting. In addition, water management development assistance projects have disrupted biological systems, particularly on the Zambezi River (Maltby, 1986).

This sub-region has the greatest number of national parks and reserves in Africa. Some of the parks in Burkina Faso, Benin and Niger are multi-national efforts; however, many of these parks and reserves are inadequately staffed and equipped.

SOILS AND VEGETATION

The geology, geomorphology and, consequently, the soils of the sub-region, are varied. Soils have formed over Pleistocene clays, pre-Cambrian rocks, and, in places, sedimentary rocks. Almost every major soil group found in the African tropics is found in this sub-region. Alfisols and oxisols are most widespread. Alfisols are the more typical of sub-humid

climates, being coarse- to medium-textured on the surface, clayey at depth, and moderately fertile (over 50% base saturation). Their water-holding capacity is low, however.

The natural vegetation corresponding to the sub-region has been described by White (1983), and represents two distinct major groupings, the Zambezian and the Sudanian. Each has distinctive flora, although both are open woodlands. Also, a narrow strip of the Zanzibar Inhambane "regional mosaic" containing endemic flora occurs on the coastal lowlands of Tanzania and Mozambique.

The dominant natural vegetation in the southern arm of the sub-region is the Zambesian miombo woodland occurring on leached, acidic, shallow or stony soils, often with lateritic or gley horizons. The dominant trees do not exceed 20 meters in height and are characteristically flat-topped with short boles. There are few undisturbed remnants, however.

Shifting cultivation has everywhere altered this vegetative formation. North of the Equator, where there is a gradual transition to aridity (not complicated by major ranges of mountains), the vegetation of the sub-region is classified as Sudanian woodland. The UNESCO classification of Sudanian woodland extends into the agro-ecological growing zone of 150 days and less, i.e., well into agronomically defined semi-arid tropics.

In the Fouta Djallon highlands (Guinea), from which the Gambia and Senegal Rivers arise, mists are frequent and ferns and epiphytes are plentiful, especially at 800 to 1000 meters above sea level (White, 1983). Tree species are mostly the same as those found at lower elevations on the coast, and are dominated by Parinari sp. Only remnants of this vegetation in steep ravines have survived fires, however. Larger blocks have persisted in the wetter highlands, except where mining operations have destroyed them.

This sub-region contains genetic potential for improved varieties of sorghum and millet. IITA has targeted the Central African Republic, Mozambique and Zimbabwe for cowpea surveys to locate potentially valuable varieties (Hawkes, 1985).

2.2. NATURAL RESOURCE MANAGEMENT ISSUES

SOIL EROSION AND DECLINE IN PRODUCTIVITY

Fragile and easily eroded or degraded soils (for instance, with lateritic layers at depth) are a principal management problem in the sub-region. The dry season in this sub-region is sufficiently long to make moisture stress an effective control on weeds, with help from fires.

VEGETATIVE COVER AND PRODUCTIVITY

Brush fire and fuelwood scarcity are the principal resource management problems for the sub-region's vegetation resources. The vegetative cover in this sub-region becomes a potential danger in the dry season. Fires for clearing or for ridding rangeland of dry growth in order to encourage re-sprouting of new growth may often get out of control. Seasonal migrations of nomadic herders (from semi-arid regions of West Africa) during droughts can be a problem.

Fires not only prevent regeneration of trees, they also speed the process of soil degradation in farmed areas where fallowing is still practiced. Fires set by herders in Oyo State, Nigeria, south of Ibadan, for example, are considered to be a major factor in the reduction of organic matter, humus and phosphorus in fallowed soils. Moreover, a hard, pebble-strewn surface had evolved after repeated burnings. Consequently, 20-year-old fallows had poorer soils than 5- and 10-year-old fallows (Areola, 1980).

There is no threat of desertification in this sub-region, according to UNEP's Desertification Map of the World; yet, dense rural populations, a predominance of shifting cultivation of food crops, and generally rolling rather than flat topography combine to threaten the soils and vegetative resources of this sub-region. Only in the Central African Republic, Guinea Bissau and southern Sudan are fuelwood supplies in the sub-humid belt adequate for the forseeable future. Elsewhere, there is a growing crisis due to insufficient or dwindling supplies of fuelwood.

Fuelwood situation in the sub-humid tropical uplands.
(Source: FAO, 1981)

Presently over-cutting	Over-cutting by year 2000
Guinea	Mali
Nigeria	Ivory Coast
Cameroon	Ghana
W. Kenya	Togo
Angola	Benin
Zambia	Mozambique
Zaire	
Malawi	

Despite this situation, rainfall is sufficient to reward

efforts to plant and maintain woodlots, shelterbelts, and commercial plantations, as well as multiple-purpose agroforestry species.

WATER RESOURCES

The principal catchments of many West African rivers are located in the uplands and plateaus of this sub-region, e.g., the Gambia, Senegal and Niger Rivers in Guinea, the Bandama River in the Ivory Coast, the Volta River in Ghana, and the Chari River, which flows northward into Lake Chad. Their sharply seasonal flows, resulting from the seasonality of rainfall, could become an even greater management problem for downstream users if accentuated by vegetative degradation and erosion in the major catchment areas.

Present and future dam and irrigation developments on these rivers are dependent upon maximum regulation of the quantity and quality of flow from tributary streams in the upper catchments. In practice, this will mean that water- and soil-conserving agricultural, forestry and grazing land uses must be devised and applied in these catchments. Critical catchments (very steep and humid) should be conserved under natural vegetation.

2.3 DEVELOPMENT ASSISTANCE IN THE SUB-REGION

Only Malawi and the Central African Republic are entirely within this sub-region. In the Central African Republic, A.I.D. is supporting an inland fisheries program.

In Zimbabwe, A.I.D. has provided financial support for the national conservation strategy workshop, as well as mobile extension educational programs on natural resources management.

In Mozambique, A.I.D. supported a candidate to a recent international training activity for marine protected areas.

WWF-US is currently considering increasing its activities in Zambia and Malawi under its A.I.D.-financed Wildlands and Human Needs Program. This new program, partly funded by A.I.D.'s Bureau for Science and Technology, aims to harmonize the management of protected areas with development of the surrounding settled areas. The Luangwa Valley in Zambia is likely to be one of several program sites. Lake Malawi is likely to be another.

Elsewhere, in this sub-region the description of A.I.D. projects is not sufficiently precise to determine their precise locations within the sub-region.

OTHER DONORS

The region's magnificent wildlife attractions have generated considerable assistance.

* FAO/UNDP has actively worked for the in situ conservation of forest genetic resources in Zambia, assisting in the establishment of two botanical reserves.

* IUCN has been active in a number of countries both in dealing with national conservation strategies as in Zambia, and in species-specific action plans, as with elephants and rhinos in collaboration with WWF-US in the Luangwa Valley.

* WWF-US is active in park management and anti-poaching activity support, particularly in Zambia, Lake Malawi, the Central African Republic (one of the last major faunal reserves in Africa and under severe poaching pressure), and Tanzania.

* AWF is primarily involved with conservation education activities in Tanzania. Most notable of their efforts is their support for the College of African Wildlife Management at Mweka, Tanzania, whose initial years were partially funded by A.I.D.

* FAO/UNDP has funded several wildlife/protected area management projects within the sub-region including projects in Angola, southern Burkina Faso, the Central African Republic, Uganda, Mozambique and Zimbabwe. The various projects ranged from anti-poaching assistance (Uganda) to wildlife products marketing (Mozambique, Zimbabwe) (FAO, 1985; see also Appendix A).

3.0 AFRICAN HIGHLANDS

CONTENTS

3.1 Description
3.2 Critical natural resource issues
3.3 Development assistance in the sub-region

3.1 DESCRIPTION

The African Highlands sub-region includes all of the Ethiopian highlands and much of Rwanda, Burundi, Swaziland and Lesotho. There are also highlands in Cameroon, although they are lower in elevation and less extensive than the East African Highlands.

This is the most densely populated sub-region. As an illustration, Rwanda contains as many as 600 persons per square kilometer in its highlands. The FAO has indicated that all of the sub-region is over-populated at present levels of agricultural production technology. These highlands require an increased and sustained effort to arrest soil erosion and related productivity declines. Stable farming systems must be designed and implemented for the many discreet and unique ecological situations in the African Highlands sub-region.

As defined agro-ecologically, the tropical African Highlands lie above the 1500-meter topographic contour line; however, the highlands also encompass the uplifted areas of Africa which form the Great African Plateau. The Plateau commences at approximately the 900-meter contour line. It is bowl-shaped, with its rim higher than its interior.

In southern Africa, the edge of the Plateau is marked by the Great Escarpment, which rises to its highest point in the Darkenberg mountains. To the west, the Plateau is bordered by the Angolan mountains and the Aus highlands, which separate the coastal Namib desert from the Kalahari desert (MacKinnon 1986).

The African Highlands represent an exceptional agro-climatic zone; they are equatorial, yet temperate. The nearness of the highlands to the equator is counterbalanced by their elevation. This results in temperate conditions and cold, alpine weather at higher elevations. Average temperatures in the highlands vary between 16 and 20 degrees C.

Agricultural land use in this sub-region is diverse, varying with altitude and slope. Bananas, sorghum, and yams are cultivated at lower, warmer altitudes (1,400 to 2,000 meters), giving way to maize, potatoes, peas, and wheat at higher altitudes (2,000 to 3,000 meters). Coffee, tea and pyrethrum are important cash crops. Above 3000 meters, cold temperatures, steep terrain, shallow soils and, in places, extreme humidity have limited cultivation in the past. But lands at these elevations are increasingly being cleared, exposing shallow soils to severe erosion, as at the Zaire-Nile divide in Rwanda and Burundi.

Traditional farming systems and methods of pasture and tree management are ecologically diverse, and can display

considerable sophistication. New World crops, such as potatoes, yams and maize, have extended the upper limits of habitability and have been integrated into the older farming systems. Although traditional farming systems are unraveling because of population pressures, their best ecological features can be retained and blended with modern innovations.

Closed forests formerly covered wide areas of both the Ethiopian and the East African Highlands. They are a recognized center of endemic flora, including plants of economic importance,such as wheat, barley, and the wild Coffea arabica (White, 1983).

The higher elevations support distinct conifer and broad-leaved vegetation types, although mostly in a stressed condition. The main conifer species is Juniperus orocera and the main broad-leaved species is Podocarpus gracilior, associated with Pygium species, Olea species, Hagenia species, Cussonia species, Celtis species and Polyscias species (FAO, 1981).

The mountain steppes, at altitudes of 3500 to 4500 meters, are formed by a continuous grass blanket and scattered shrubs of Erica arborea and Lobelia sp. (FAO 1981a). Evergreen rain forests are found only on the seaward side of Mt. Cameroon, in West Africa, (4,000 millimeters of rainfall per year) and along a narrow equatorial belt (from 2,000 to 2,500 millimeters of rainfall per year).

The highlands ecosystems are free from diseases, such as malaria, that are endemic in the neighboring lowlands, and in places have moderately to highly fertile soils.

3.2 CRITICAL NATURAL RESOURCE ISSUES

Population pressures on land and vegetative resources define the principal resource management issue in this sub-region: over-exploitation of soils, pastures and forests, and clearing of lands too steep for farming. Population densities varying from 75 to 400 persons per square kilometer, and livestock numbers of 75 head per square kilometer are common (Jones and Egli, 1984).

The inaccessibility of many areas in the sub-region makes central governmental management difficult. In the Ethiopian highlands and the highlands of Rwanda, Burundi and parts of Zaire, poor communications with the outside world (partly the result of the ruggedness of the terrain) are one of the major bottlenecks in development. These areas are among the most far removed from the world markets, and high transport costs severely limit the sub-region's trade.

SOIL EROSION AND DECLINE IN PRODUCTIVITY

Within the past decade, cropping has been intensifying and agriculture has been encroaching into hitherto uncleared, steep land that was previously in forest or pasture. This is leading to soil erosion. Extremes of temperature and the occurrence of frost are the only determinants of the upper limits of cultivation. In some places there is little fallow or grazing land left, and farmers are therefore keeping small ruminants and stall-fed cattle instead of cattle grazing on common pastures.

Soil erosion by water is the greatest single threat to the agricultural landscape in this sub-region (e.g., 34 tons/hectare/year in Ethiopia) (FAO, 1984). The entire sub-region is highly erodable because of steep slopes and the widespread cultivation of clean tilled crops such as maize.

Colonial and post-colonial governments in East Africa have attempted to arrest soil erosion with varying degrees of success. Kenya appears to have had the greatest success, but much land remains to be managed (Harrison, 1986). Erosion control techniques, however, are in places inappropriate for soils and cropping systems.

MAINTENANCE OF VEGETATIVE COVER

Fuelwood and watershed protection are two key values of forest and other vegetative cover in the highlands. Households in the African highlands have high energy requirements for both cooking and heating. Average consumption of fuelwood is around 2 kilograms per person per day, twice the lowland consumption rate. All of the highlands in East Africa are experiencing or have experienced fuelwood shortages, locally or regionally. This has caused cutting at rates greater than wood growth rates. The situation in Ethiopia, whose highlands are drier than elsewhere, is particularly critical, and a solution to this problem is integral to the stabilization of the land base. In Rwanda and Burundi, on the other hand, small on-farm tree planting is reported to be meeting fuelwood and construction wood needs.

The highland forests provide watershed stability. The Parc des Volcans in Rwanda, for example, is a watershed for over one-half million acres of agricultural land as well as a reserve for gorillas. Thus, the park benefits both the biological systems within it and the local rural farmers.

Considering that the highlands are the headwaters of several major African river systems (e.g., the Nile, Congo and Niger Rivers), dual-purpose conservation and watershed protection

programs are needed. Recognition of the need for these programs varies from country to country. Rwanda is working hard to stem the loss of natural highland forests, while other nations (such as Uganda and Kenya) are finding it difficult to control continued deforestation. The complexity and status of the deforestation of tropical highlands has been addressed extensively by the IUCN (1986).

MANAGEMENT OF BIOLOGICAL DIVERSITY

As a result of this sub-region's unique biological richness, the likelihood that it was a Pleistocene refugia, and the severe and increasing human population pressures on it, the sub-region constitutes the second-greatest priority for biological and genetic diversity in Africa (after Madagascar). The sub-region has an extremely high rate of endemism (75% of plant and 65% of bird species) (IUCN, 1986). The highlands support many unique mammal species, the most famous being the mountain gorilla in Rwanda.

Of the very many isolated highland and montane forests scattered throughout eastern Africa, those of greatest importance in terms of biological diversity and endemism are in the western Rift Valley, the eastern arc mountains of Tanzania, and the Ethiopian highlands. Mount Mulanje in Malawi is also important for plants and birds.

Because of the scattered, island-like nature of the highlands, threats on biological and genetic diversity are disproportionately great. Because only 4.5% of the sub-region is in any type of protective status, relic communities are often too small to sustain endemic populations. The problem is compounded by the difficulty in implementing a cohesive program for such a diverse sub-region.

West African montane forests have recently been receiving increased recognition, especially on the neighboring peaks of Mt. Nimba on the Liberia-Ivory Coast-Guinea border, the Fouta Djallon in Guinea, and Mt. Loma in Sierra Leone (IUCN, 1979). In Nigeria, the Oban Hills and Obadu Plateau are important for plants, birds and primates. (These are somewhat lower in elevation than 1500 meters, and are therefore too small for depiction on the sub-regional map.)

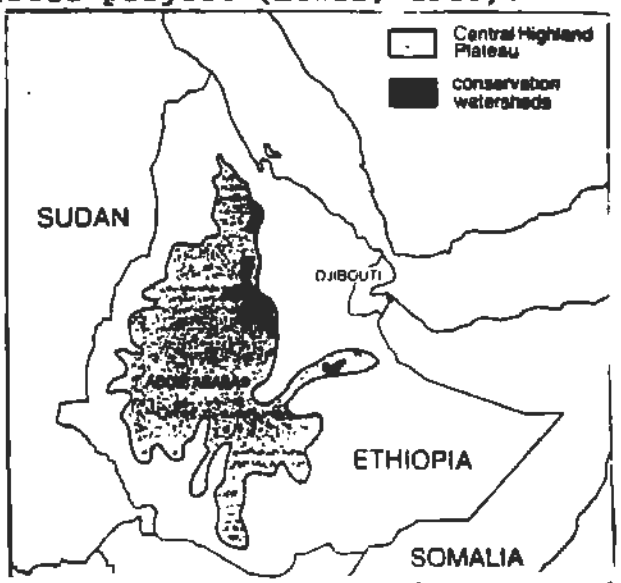
In Cameroon, Mt. Oku possesses the most biologically unique and heavily threatened mountain forests. A preserve was established on this mountain in 1986. Also in Cameroon, Mt. Cameroon, an important Pleistocene refugium, has an estimated 45 endemic plant species. It is also a major water catchment, with the lower southern slopes receiving the highest amount of rainfall in Africa. The mountain is unprotected at present,

and its forests are being destroyed by shifting cultivators.

3.3 DEVELOPMENT ASSISTANCE IN THIS SUB-REGION

Inaccessibility, the diversity of local environments, and the remoteness of these areas complicate donor assistance, which has been considerable and varied. Most generalizations that can be made about assistance are neither valid nor useful in the case of this sub-region. Assistance has been provided largely for agricultural production, although some has been targeted for soil conservation and watershed rehabilitation, and lesser amounts have been allowed for forestry and range rehabilitation and management. Non-governmental organizations, both national and international, are active in every aspect of development, and their scale of operation is well-suited to the needs of the sub-region.

Much attention has been focused on erosion in the densely populated East African highlands, from Ethiopia -- where the World Food Programme has undertaken the most massive watershed treatment efforts in Africa -- to the sub-tropical highlands of Lesotho and Swaziland in southern Africa. A special research effort to assess soil conservation efforts in Ethiopia is also underway, with collaboration and assistance from the United Nations University and the University of Berne, Switzerland (Brown and Wolfe, 1985). This type of assessment is much needed and has thus far been lacking. Actual measures of soil erosion formation rates are also lacking except on a few experimental plots. A.I.D. has sponsored some of the only recent field surveys of erosion rates, in Kenya and Rwanda, under a sub-project activity of the Environmental Training and Management in Africa project (Lewis, 1985).



WFP watershed conservation project area in Ethiopia

In Kenya soil conservation through terracing had resumed with Swedish aid, after independence in 1974, and considerable, steady progress has since been made (Harrison, 1986). The heavy-handed policy of enforced terracing instituted by the colonial administration in Kenya was such an irritant that rural people were biased against terracing for some years following independence.

The presidential-level Commission on Soil Conservation and Afforestation was set up in Kenya in 1980 to coordinate and stimulate efforts at local and higher levels; however, it is not an executive agency. Large areas still remain without erosion control treatment.

Kenyan non-governmental organizations, including women's groups, have been most effective in promoting and extending soil conservation, energy-conserving stoves, and agroforestry practices.

The colonial rule of Rwanda under the Belgians also pursued obligatory soil erosion control policies, namely the construction of infiltration ditches on cultivated hillsides, stabilized with plantings of a perennial grass, Pennisetum sp. The present government has continued this practice, setting quotas of so many kilometers per year of infiltration ditches in each prefecture.

The diversity of donor-assisted projects in Rwanda in 1986 is illustrative of specific actions:

* A "shelterbelt" plantation around the Gishwati National Forest was proposed by the World Bank.

* Belgians were undertaking 1:25,000-scale topographic mapping, and soils mapping.

* Switzerland was funding technical assistance in forestry and agroforestry.

* GTZ had recently ended a 7-year project to develop agroforestry systems in the highlands (Project Agro-pastoral Nyabishindu), which is now being evaluated.

* WWF supported research on mountain gorillas in the Parc des Volcans.

* CARE was supporting village reforestation and watershed forestation.

* A.I.D. was supporting agroforestry activities carried out as a part of the Energy Initiatives for Africa project, based in Nairobi, Kenya.

* A.I.D. was also supporting assessments of natural resources and environmental management problems in the environs of the Parc des Volcans, home of the mountain gorilla (remnant population: 250). The work was designed to relieve encroachment and poaching pressures on the park as well as to arrest environmental degradation.

The international non-governmental conservation community has been quite active in the sub-region. IUCN, WWF and AWF all consider the entire sub-region to be of immediate concern in biological conservation and wildlands management. Historically, the eastern African highland and montane forests have received the most attention. The most notable effort has been the Mountain Gorilla Project in Rwanda.

Official assistance agencies have been slow to address conservation and diversity issues; however, A.I.D. has financed efforts in Burundi and Rwanda (see above) to create stable buffer zones near important parks. Neither the FAO tropical forestry action plan (1985) nor the WRI (1985) companion document list any highland forests as priority areas, however. The World Bank (1986) does view the forest ecosystems of Ethiopia, Rwanda and Cameroon as being threatened nonetheless.

4.0 HUMID COASTAL LOWLANDS

CONTENTS

4.1 Description
4.2 Natural resource issues
4.3 Development assistance in the sub-region

4.1 DESCRIPTION

The nations which share this high-rainfall and densely populated sub-region are Guinea Bissau, Guinea, Sierra Leone, Liberia, Ivory Coast, Ghana and Nigeria.

The maximum width of this coastal belt is approximately 350 kilometers, and only Liberia is completely within the sub-region. Sierra Leone is almost entirely within the sub-region, but the other states extend northward into the contiguous sub-humid tropical uplands sub-region. Nigeria continues into the arid and semi-arid tropics.

The sub-region is one of growing cities (Lagos, Accra and Abidjan); this portion of West Africa is more urbanized than are interior states. The coastal cities have attracted migrants from landlocked countries in the drought-stricken Sahel as well as from the sub-region's own rural hinterlands.

Urbanization has resulted in growing demands for electricity, construction materials, and furniture-grade wood. The demand for wood is rapidly depleting the remaining forests. Electricity must be generated from rivers at sites in the contiguous sub-humid tropical uplands. The recent drought has proved how vulnerable these cities are to shortfalls in water for hydropower.

Percent Urban Population in Coastal West Africa

	1960	1985
Guinea Bissau	14	27
Sierra Leone	10	22
Liberia	19	40
Ivory Coast	19	42
Ghana	23	40
Togo	10	20
Nigeria	13	23

Source WRI, 1986, Table 3.1

CLIMATE

The maximum precipitation rates within this sub-region range from 4349 millimeters per year at Conakry, Guinea, to 3874 millimeters per year at Monrovia. Yearly values of around 2000 millimeters or less are more representative of the sub-region,

e.g., 2040 millimeters at Abidjan and 1834 millimeters at Lagos, near the low-rainfall, so-called "Dahomey Gap". There is usually a pronounced two-month dry season, although it is longer in some places (e.g., Guinea). Atmospheric humidity is high along the coasts, however.

This sub-region has a double rainfall regime with a growing period of 270 to 365 days. An exception to this is the Guinea Bissau coast from the point at which it "pinches off" at the southern border of Senegal, extending as far as the 180-day growing season boundary of the arid and semi-arid tropics. This drier portion of the sub-region was included because of its coastal lowlands character, the corresponding resource management problems related to estuaries and islands, and the onshore land uses that affect these areas.

SOILS

Soils of this sub-region are generally of moderate to low productivity. They are dominated by clay soils, which are fragile and easily degradable under cultivation of annual crops. Kaolinitic (white clay) soils or ultisols have developed on the highest-rainfall coastal portion, and coarser alfisols are found further inland. Alfisols are more fertile than ultisols, but are more susceptible to erosion.

Dominant Soils of the Humid Coastal Lowlands Sub-Region, by Classification System

	INRA (French)	FAO	USDA
Soils			
upland soils very acidic and leached	Ferralitic	Acrisols	Oxisols
coastal soils acidic, coarse-textured kaolinitic	same	same	Ultisols
slightly acidic, less leached soils derived from sandstone and basement complex rocks	Ferrugi-nous	Luvisols	Alfisols

VEGETATION

In general, the coastal forests are drier than the humid

equatorial forests. Few places receive more than 2000 millimeters of rainfall, but atmospheric humidity along the coast is very high.

On the dry peripheries of the sub-region, forests are deciduous and survive only in the deepest ravines, where they have escaped fires and logging. Grassy savannas occur in the zone; their presence reflects the limitations presented to forest growth by the soils (e.g., poor drainage or hardpan, the effects of burning).

Besides supplying valuable wood products, the unmanaged lands are major sources of animal and plant food products and medicines (Prescott-Allen, 1983). Within this sub-region, game meat provides an estimated 9-15% of the average per-capita animal protein intake. Among the rural poor, the percentage can be double or triple this figure. This traditional use and marketing of wildlife suggest that the sub-region has a potential for commercial game ranching and controlled harvest, particularly in Ghana, Liberia and Nigeria.

AGRICULTURAL LAND USE

A number of important export corps are grown in this sub-region, including rubber, oil palm, and cocoa. These crops are grown in block plantations, or by small landholders in traditional mixtures of tree and food crops. Food crops are primarily cassava, yams, maize and rice. Rice is indigenous to parts of the sub-region (e.g., Sierra Leone). It is grown in estuarine soils and upland sites, using both traditional and modern agricultural technologies.

The green leaves of many indigenous, cultivated plants are used in traditional recipes. Numerous wild forest species yield fruits; 150 species were found in a survey in Nigeria (Okafor, 1982).

Trypanosomiasis is endemic to this sub-region; therefore, livestock are pigs, small ruminants, or trypano-tolerant Ndama cattle, which are mostly kept as milk cows. Herds of cattle are brought into portions of the sub-region during the dry season in Nigeria, however.

4.2 NATURAL RESOURCE MANAGEMENT ISSUES

SOIL EROSION AND DECLINE IN PRODUCTIVITY

The soil management problems in the sub-region have been reviewed at length: rapid decline of fertility, low cation exchange capacity and pH; danger of laterization; and poor drainage and compaction (Greenland and Lal, 1977). Shortened

fallows resulting from land scarcity are leading to degradation (as they are elsewhere in traditional farming areas of Africa). Agroforestry solutions are gradually being developed to compensate for the decline of fallowing for fertility restoration.

Soil compaction and weeds are associated problems in clean tilled food crop cultivation. IITA has evolved no-till cultivation techniques for maize and cassava that avert both problems; however, herbicides are required to prepare fields for cultivation, and are simply unavailable to the majority of farmers. Also, no-till farming does not work on all soils.

It is apparent that for food crop farming in this sub-region, agroforestry supports the twin goals of soil conservation and food production. Sustainable agriculture must be the subject of crop-system-specific research in this sub-region.

LOSS OF VEGETATIVE COVER AND PRODUCTIVITY

Only about one tenth of the original forest remains. Forests in the sub-region are being rapidly logged and cleared. Forest loss within this sub-region is seven times the world average. Sierra Leone has only 18%, and the Ivory Coast 10%, of their original forest covers. At the present rate of deforestation, there will be complete disappearance of undisturbed tropical forests in the Ivory Coast by the year 2000 (WRI, 1986). This loss would be accompanied by the loss of many of the endemic plant and animal species.

Growing rural populations practicing shifting cultivation in the humid forested zones have converted original forests to secondary-succession brush in different stages of regeneration (usually not exceeding 5 meters in height). Periods of cultivation are becoming longer, and periods of fallow shorter (Okigbo, 1983). Over-cultivation leads to mixed grass and weeds, which are tolerant of impoverished soils. Grassy savannas also occur in the zone, which reflects soil limitations.

The region is not exempt from firewood scarcities, despite its high rainfall. Only in the most humid sections of coastal Liberia, Ivory Coast, and Nigeria did FAO find no foreseeable fuelwood supply problem (FAO, 1981). Elsewhere, however, a long history of settlement, present dense populations, and somewhat lower rainfall combine to create a situation of present and/or foreseeable fuelwood shortages.

MANAGEMENT OF BIOLOGICAL DIVERSITY

Of special biological value are the coastal evergreen

rainforests along the Atlantic coast from Sierra Leone to eastern Cameroon. Species diversity is lower than in comparable forests on other continents, but many species are unique to the sub-region. High plant and animal endemism is partly due to the sub-region's isolation from the more interior humid equatorial lowlands of Central Africa. (Estimates are that up to 59% of the plants and 32% of the ungulates and primate species are confined to this sub-region, mainly in the closed canopied tropical forests (IUCN, 1986a).) The natural forests have at least thirty-one tree and eleven other plant species of particular value to man. Forty-one bird, mammal and reptile species listed in the IUCN Red Data Book occur within this region.

The Ivory Coast and Liberia have been identified as priority countries for forest ecosystem conservation by the FAO (FAO, 1985), the World Resources Institute, and The World Bank (WRI, 1985). The IUCN (1979) has also included Sierra Leone and, in addition, recommended surveys of natural forests in Guinea and Guinea Bissau, where information is lacking.

The IUCN Action Plan for African Primate Conservation (IUCN, 1986) re-affirms the need for tropical forest management activities within the aforementioned countries. The Tai National Park in the Ivory Coast is by far the most important reserve of biological diversity in this sub-region, according to both IUCN and WRI. Other areas of concern are:

* Sapo National Park - Liberia
* Mt. Nimba Reserve - Liberia
* Loffa Mano/Gola Forests - Liberia/Sierra Leone
* Massif du Zeama - Guinea

Many parks and forest reserves within this sub-region need assistance in their natural resources management efforts. Even Ghana, with its successful system of parks and forest reserves, has great difficulty managing these resources.

Another concern within this sub-region is coastal wetlands management. For example, agricultural and water resources development projects on the coastal wetlands of Guinea Bissau are potentially damaging. Mangrove forests, intertidal mudflats and associated wildlife are increasingly threatened by ricefield developments. It is important to integrate wetlands conservation and agricultural development in order to maintain this coastal system.

4.3 DEVELOPMENT ASSISTANCE IN THIS SUB-REGION

The following countries in the sub-region receive U.S. development assistance:

Guinea-Bissau
Sierra Leone
Liberia
Ghana
Togo
Benin

USAID portfolios had no current or planned activities concerned with natural resources or the environment in these nations; however, A.I.D. supports research at the International Institute of Tropical Agriculture, in Ibadan, Nigeria, where important advances in agroforestry for the African humid tropics have been researched since 1976. The geographic scope of this work should be greatly expanded so as to speed the discovery and diffusion of adapted agroforestry solutions for intensified, sustainable agriculture in this environment. A.I.D.'s contribution to IITA has represented approximately 25% of the Institute's operating budget.

S&T's Forestry Support program, managed by the U.S. Forest Service, has funded a survey by ICRAF of agroforestry systems around the world. The survey, mainly of published material, was nearing completion in early 1986, and has been processed for computerized storage and retrieval. Agroforestry systems in this sub-region are included in the survey.

5.0 HUMID EQUATORIAL LOWLANDS

CONTENTS

5.1 Description
5.2 Natural resource management issues
5.3 Development assistance in the sub-region

5.1 DESCRIPTION

This sub-region is dominated by Zaire (2.3 million square kilometers). Other states are the Central African Republic, Gabon and Equatorial Guinea. The Congo River drains most of the lowlands. Human population densities are generally light in this sub-region.

Relative to the equatorial tropics of South America or Asia, the sub-region is somewhat dry. Annual rainfall in excess of 3000 millimeters occurs only on the coast of Cameroon (3948 millimeters per year at Douala). Only a small part of the Zaire basin receives more than 2000 millimeters per year, and rain in excess of 100 millimeters per month is seldom the case in the sub-region. Dry periods of several days can occur, even during the rainiest months. There are two rainfall peaks, typical of equatorial latitudes. Temperatures average 25 degrees C and show little seasonal variation. The length of the growing season is 270 to 365 days.

Three major categories of resource management opportunities emerge from this overview:

* Development of sustainable agricultural systems, especially food production systems.

* Development of sustainable forest exploitation systems and programs.

* Development of the bases for conservation of genetic resources and biological diversity.

The problems of rendering subsistence agriculture more productive in this sub-region are essentially the same as on the humid coastal lowlands. Low fertility and quickly-exhausted soils are common to both sub-regions. The difference lies in the lesser population pressure in this sub-region. In fact, FAO's study of population-supporting capacities in Africa projected no future problem of excess population relative to food production capacities, even at low levels of technology. Almost every other region in Africa will become over-populated by the 2000, some even at intermediate and high levels of farming technology.

In this sub-region, therefore, there is little cause to be concerned about a decline in the arable land resource due to population pressures as long as the land supply permits adequate fallows for shifting cultivation. Permanent degradation is a danger only where lateritic soil horizons are exposed; oxidization and hardening to rock take place if this happens.

Unlike the arid and semi-arid sub-region, there is greater latitude in research and development in this sub-region, given the lesser threat of irretrievable land degradation. A principal focus would be to render the present shifting agricultural systems more productive and sustainable. Agroforestry, improved varieties of food crops, and/or correction of deficiencies in soil micro-nutrients are important research topics.

VEGETATION AND SOILS

A mixed, moist, semi-evergreen forest is the most extensive type of vegetation in the sub-region. These forests are found on well-drained soils (except for the wettest and driest extremes) (White, 1983). The forests are floristically rich. Along major rivers and their delta swamps, forests flourish, with trees attaining heights of 45 meters.

This sub-region contains Africa's greatest reserve of forests. Its 148 million hectares of closed forest equal 60% of Africa's total closed forest resource. Almost one-half of Zaire is covered by closed forest, representing the largest surface of contiguous, closed forest in Africa, and the third largest in the world (after Brazil and Indonesia) (Guppy, 1984). Forests cover 76% of Gabon.

The most extensive soils are oxisols (termed ferralitic soils by French soils scientists). These are well-drained, deeply-weathered, reddish soils, some with large amounts of iron and aluminum oxides. Their intensive cultivation for food or cash crops requires constant, costly inputs of lime and multi-element fertilizers and pesticides, each bringing its own problems, especially when improperly used (Okigbo, 1983).

LAND USE

Agriculture is largely in the form of shifting cultivation of cassava, yams, maize and rice. Seven million hectares are cultivated in Zaire (3% of the land). An additional 2 million hectares are cultivated in the Central African Republic, Gabon, and Equatorial Guinea (WRI, 1986, Table 4.1).

Unlike parts of the West African coastal lowlands, this sub-region is short of neither agricultural land nor fuelwood resources. The exception is a portion of southern Zaire, east of Kinshasa, where there exists a critical shortage of firewood (FAO, 1981a).

FISHERIES

Freshwater fish are an important harvest in Zaire. The FAO

estimated an annual catch in 1983 of 100,000 metric tons, almost equal to the catch on Lake Chad.

5.2 NATURAL RESOURCE MANAGEMENT ISSUES

MANAGEMENT OF SOIL PRODUCTIVITY

Diverse farming techniques are used by shifting agriculturalists. Land preparation in one region of oxisols (in the Central African Republic) involves cutting green matter, mounding it up, covering it with layers of earth, and firing it. Raised beds formed in this manner are planted in manioc, vegetables, and tobacco. A farmer can work 0.2 to 0.5 hectares per year in this way. After three years, the land is fallowed.

This technique is termed ecobouage in French. Tractors or animal-drawn plows present no advantage or improvement, but green manuring and small additions of calcium could help. Also, newly researched techniques of alley-cropping may be applicable to these soils.

MANAGEMENT OF FOREST RESOURCES

The sub-region's forest resources are not being exploited as rapidly as are forests elsewhere in Africa. Each year an estimated 220,000 hectares of the sub-region's forests are lost, compared to 290,000 hectares per year in the Ivory Coast alone. In 1983, Zaire's wood exports were worth $18 million. In comparison, the Ivory Coast alone exported $334 million in wood.

Forests in the Humid Equatorial Lowlands

	Forests open	closed	Protected Forests
	(million hectares)		
Zaire	72.0	106.0	5.7
Congo	0	22.0	0.1
Equatorial Guinea	0	1.3	?
Gabon	-	20.0	?
Totals	72.0	148.0	5.8

Source: WRI, 1986, Table 6.1

The development of long-term management plans for this sub-region and its individual nations is needed. Past development assistance has often centered on improved techniques for forest exploitation. This has resulted in adverse consequences similar to those in West Africa. Several countries, particularly Zaire, are preparing to increase their forest harvests; however, there is a lack of institutional capacity to support forest management programs, thereby setting the stage for long-term problems.

MANAGEMENT OF BIOLOGICAL DIVERSITY

This sub-region shows a very high rate of endemism (80% for plants, 36% for birds and 45% for ungulates and diurnal primates). It also contains large areas of moist tropical forests. Zaire alone contains 39% of the world's total tropical forest lands (and 50% of Africa's). Only Brazil and Indonesia maintain more tropical forest lands. Unlike the rest of the African continent, this sub-region is not facing immediate pressure on its biological systems.

More information is needed regarding the sub-region's genetic resources. Because the moist forests of this sub-region hold nearly half of the continent's plant and animal species, systematic data collection and evaluation are needed in order to plan for long-term management. Priority areas are the forests of southern Cameroon, Gabon, Equatorial Guinea, the Central African Republic, the Angolan enclave of Cabinda, and the Mayome Forests of Zaire.

Illegal harvesting of wildlife resources is a management problem which affects biological and genetic diversity in this sub-region. Illegal hunting to satisfy export markets is the greatest danger. Most countries in this sub-region lack the institutional capability to deal with this growing problem, which is exacerbated in places by armed conflict.

The abundance of this region's flora and fauna presents an opportunity to manage its biological and genetic diversity before it is threatened. Projections of increasing resource pressures due to population increases and exploitation indicate that this opportunity must be seized now.

Even though Zaire has the highest floristic endemism in tropical Africa, there is often a perception that management of forest and biological resources in this sub-region is not urgent. Such a misconception could thwart the undertaking of necessary actions that would provide a basis for good management.

5.3 DEVELOPMENT ASSISTANCE

A.I.D.

A.I.D.'s program is very limited in this sub-region. A fisheries project was being planned for the Shaba region of Zaire in 1986. There was no A.I.D. activity in Gabon or Equatorial Guinea.

The Peace Corps has carried out some very successful aquaculture work in Zaire.

OTHER NATIONS AND ENTITIES

UNDP was supporting fisheries surveys or development in Zaire and Congo.

CIDA was to lead a multi-donor forestry sector review in Zaire in 1986.

6.0 MADAGASCAR AND INDIAN OCEAN ISLANDS

CONTENTS

6.1 Description
6.2 Critical natural resource issues
6.3 Development assistance

6.1 DESCRIPTION

This sub-region of island states is comprised of Madagascar, the Comoros Islands, the Seychelles, and Mauritius. It is distinctive for its insular character, and Madagascar is culturally very distinct from the African continent. A further distinction is Madagascar's unique flora and fauna, which evolved differently from those on the African continent, as a result of continental drift.

On islands, economic development and environmental management present unique problems. Islands, especially smaller ones, are much more fragile in all senses than are continents.

The very serious state of environmental degradation that has been reached on Madagascar confers special urgency on the conservation of biological and other natural resources on this largest island of the sub-region.

Although Madagascar's human population is not especially high (approximately 9 million people in an area of 58.7 million hectares --- about one and one-half times as large as California), the country is poor and its development is being undercut by environmental degradation.

Unlike the other sub-regions, a climatic homogeneity does not exist in this sub-region. Numerous climates occur on Madagascar as a result of elevation differences and the rain-shadow effect of a north-south-trending mountain range composed of granitic and volcanic rock. The climates range from a very humid coast (rainforests on the narrow northeast coast), to relatively cool, sub-humid uplands, to semi-arid and arid lowlands (on the southwestern tip), which includes a small area of desert. Rainfall varies accordingly, from over 3000 millimeters per year to less than 400 millimeters per year. Cooler temperatures at higher elevations are a limitation to cultivation.

The four volcanic islands of the Comoros archipelago, which is located between Madagascar and continental Africa, are humid, with annual rainfall averaging between 1500 and 3000 millimeters. Little original undisturbed vegetation remains.

The Seychelles archipelago consists of over 70 islands scattered over 390,000 square kilometers on a northeast-southwest axis 1000 kilometers long. There are granitic, coralline and sand-clay islands in the group.

6.2 CRITICAL NATURAL RESOURCE ISSUES

DECLINE IN BIOLOGICAL DIVERSITY AND ECOLOGICAL RESILIENCE

The environments of Madagascar and the Indian Ocean Islands are subject to intense pressure by human population. Nearly every major human activity, no matter where located, can affect the inland and marine environments (UNEP Regional Seas #6).

Madagascar has been ranked by the World Wildlife Fund as the single highest conservation priority area in the world. The flora of east and west Madagascar are so distinct from each other that the island has been divided into two centers of endemism. Madagascar's spectacular fauna and flora are unrelated to those of continental Africa, and possess what are probably the highest levels of species endemism of any country: 26% of lemur species, 80% of the flowering plants, 95% of the reptiles and 99% of the amphibians are unique to Madagascar. This endemism extends to the generic and even familia level in many cases.

As White (1983) notes in the UNESCO study of Africa's vegetation:

> "Malagasy [Madagascar] lowland rain forest is very rich in species, and varies greatly from place to place. One hundred individual plants growing side by side may belong to more than 50 species."

Indigenous palms, ferns and orchids are especially abundant and diverse. The moist montane forest, occurring at 800 to 1300 meters, is equally rich.

As a result of its climate, Madagascar also has a wide diversity of ecosystems: unique spiny deserts in the south, deciduous forests in the west, and moist tropical rainforests on the eastern escarpment. Each has its own fauna and flora, and each faces a wide variety of threats (WWF-US, 1986).

The drier West Malagasay flora is less rich, but nevertheless unique: 80% of the species and 20% of the genera are endemic. Dry, deciduous forest is typical of this side of the island; however, over 80% has been converted to secondary grassland or wooded grassland, which is burnt over every year.

Because of the great variety of species and ecosystems and the very limited extent of many forest formations on this mini-continent, the destruction of a few hundred hectares in Madagascar can have a much more devastating effect on species diversity than in most other parts of the world.

There is great concern in the conservation community, both in Madagascar and abroad, about the continuing destruction of the unique flora and fauna of Madagascar. The 1986 Madagascar Conference on Conservation of Natural Resources for Development focused international attention on this and other natural resource issues in Madagascar.

Conditions on other islands in this sub-region are equally precarious. Very little of Mauritius remains in natural forest, and the native plants and animals of the Comoros are increasingly threatened by destruction of the remaining patches of rainforest habitat (IUCN, 1986).

The Comoros also have a unique assemblage of wildlife, including the only populations of wild lemurs outside of Madagascar. Much of its flora is still unsurveyed for species endangerment. Mauritius also supports many endemic plant species (75% of its total plant taxa) and animal species, including nine species of threatened birds.

With the exception of the montane forests of Africa, there are no other areas in sub-Saharan Africa where the need for combined conservation and development strategies is more readily apparent.

SOIL EROSION

Soil erosion has reached "epidemic" proportions in Madagascar. A.I.D. reports that as a result of watershed erosion, 3,000 hectares of paddy rice are lost each year in the main rice-growing region, Lao Alaotra. The loss cancels out the development of new paddy areas.

Occasional cyclones accentuate the erosive power of torrential rains in Madagascar, and necessitate an additional measure of durability in erosion-control works. REDSO/East Africa reports an estimated annual loss of one million hectares of agriculturally productive land (Seyler, et al, 1986).

There are only 29 million hectares under cultivation in Madagascar, or 2.9 hectares per person on average (WRI, 1986, Table 4.1). In 14 years, the population will reach 15 million; clearly, then, the island can't afford to keep losing land at the rate of 1 million hectares per year. The man-to-arable-land ratio would fall to 1 hectare per person by the year 2000, at a time when population growth rates will have attained 2.93 percent annually (WRI, 1986, Table 2.1).

COASTAL RESOURCE MANAGEMENT PROBLEMS

Marine and coastal resources are key elements in the

productivity of the Indian Ocean island nations of Madagascar, the Comoros archipelago, Mauritius, and the Seychelles. Per-capita fish consumption within the island nations is three to ten times that of neighboring East African mainland countries (UNEP, 1982a).

The fisheries industries are generally small-scale subsistence and commercial industries. The only nation where exploitation may be exceeding production is Mauritius.

Management problems vary among the island nations, with the least pressures on the resource occurring on Mauritius, and some of the worst being on the Comoros archipelago (UNEP 1982a). In addition, coastal resources are important to other aspects of the inhabitants' livelihood. Mangrove forests provide food, building materials and other products. The mangrove swamps of Madagascar support very profitable prawn fisheries. Coastal reefs and beaches, in addition to their fisheries, provide important sources of building material.

Destruction of mangrove forests is a current problem in the Seychelles and is increasingly a problem in Madagascar and Mauritius because of the fact that building and fuelwood demands are out-stripping production. This could have a major impact on coastal industries such as prawn production. Destruction of coral reefs appears to have been controlled in the sub-region; however, in the Comoros, large areas of fringing coral and coral flats have been destroyed, and coastline erosion is occurring as a result.

Severe soil erosion on Madagascar, the Comoros and in some of the Seychelles may be damaging coastal systems in a manner similar to what has happened in Kenya; however, no documented information was available to link sediment accumulation and declines in coastal resource productivity.

Several of these island nations are heavily dependent on coastal-zone tourism for foreign exchange earnings. It is the mainstay of the domestic economy of the Seychelles, and the second greatest foreign exchange earner for Mauritius.

LOSS OF VEGETATIVE COVER AND PRODUCTIVITY

Much, if not most, destruction in Madagascar is the result of apparently habitual and uncontrolled burning, as well as cutting of forests for wood. Grasslands have replaced most of the forests that once covered the central highlands, or the Central Domain.

Of Madagascar's total land area, less than 10% remains in natural forest, and this figure is decreasing daily. The

eastern rainforests are the most diverse, and harbor the majority of Madagascar's endangered species. These and western deciduous forests, particularly the Ankarafantsiba Reserve, urgently need management and protection.

6.3 DEVELOPMENT ASSISTANCE IN THIS SUB-REGION

A.I.D. ASSISTANCE

A small mission of two full-time professionals administers the USAID program in Madagascar, with assistance from the REDSO staff in Nairobi.

A counterpart currency account in the Central Bank, holds proceeds from the sale of PL-480 food shipments. $37.0 million had accumulated by 1986, and an additional $10 million per year could be added. These funds can be used to underwrite the local costs of many activities, including environmental rehabilitation projects.

A modest but well-considered package of actions is proposed for the above-mentioned problems, included under the "agricultural production response" portion of A.I.D.'s strategy in Madagascar (A.I.D., 1986b):

* agroforestry training through ICRAF and IITA.

* use of counterpart funds to support local or other donor protects, e.g., Swiss projects for (1) demonstration and training in natural forest management, West Madagascar, and (2) farm agroforestry.

* a REDSO "pre-assessment" of the role of energy, forestry and natural resources in sustaining agriculture, followed by the testing of a few interventions.

* analyses of potentials for farm forestry/conservation projects, of the current training and support of extension staff dealing with forestry and soils.

* a workshop to discuss forestry/natural resource research issues.

The USAID program may finance a survey of soil erosion and vegetation that would be added to a natural resource inventory proposed for Madagascar by the World Bank, in its "Agricultural Institutions II" project.

As a follow-up to a recent conference on conservation in Madagascar, A.I.D./Madagascar is also working with the WWF to support biological inventory and mapping activities,

socio-economic research, and the development of conservation/ development strategies for two reserves in the southern portion of the country.

OTHER DONORS

International conservation activities have been carried out primarily through the IUCN, WWF-International and WWF-US. Their efforts have covered a broad spectrum ranging from park protection and biological inventories to training of conservation professionals and conservation education. A major program emphasis is to work within the context of an integrated regional conservation and development strategy, particularly in the southern portion of Madagascar.

IUCN helped launch the national conservation strategy exercise in Madagascar, which led to the 1986 conference on conservation noted in the introduction.

C. AGENDA OF POSSIBLE ACTIONS IN THE SUB-REGIONS

The following agenda of possible actions is extracted from the various sub-regional treatments. Each possible action pertains specifically to the sub-region in question, and is suggested as an example of what might be pursued at the Regional Economic Development Services Office (REDSO) level or the Africa Regional level. Possible actions at the level of the individual Mission are also included.

The bulk of the agenda applies to the arid and semi-arid sub-region, which was found to have the greatest number of natural resource management problems. With regard to the management of biological diversity, however, wetter portions of Africa are of more critical concern: the West and East African highlands and Madagascar.

Except for those pertaining to Madagascar and the other Indian Ocean Islands, coastal resource management actions are not addressed here. These have been consolidated in the agenda of actions included in the Coastal Resource Degradation Section of Part II.

1.0 ARID AND SEMI-ARID TROPICS

The following are possible actions concerning conservation of genetic resources and wildlife habitats, desertification, agroforestry, range and livestock projects, water projects, and the fuelwood crisis. The last item addresses village environmental regeneration and could strategically embrace most, if not all, of the other issues noted.

1.1 BIOLOGICAL RESOURCE CONSERVATION

Technical assistance and institutional strengthening are key points in the preservation of biological resources. Surveys, collection and characterization of fuelwood, browse and food crop species should be pursued, initially through the provision of support to the International Board for Plant Genetic Resources.

Also important is the search for means by which to bolster the management of existing parks and biospheric reserves, including the important waterfowl over-wintering habitats in the inland deltas and other riverine wetlands.

There is an immediate need to identify critical areas within the sub-region where protection is most needed and to provide logistical and technical support for continued protection through the activities of PVO/NGO organizations. National governments would ideally take the lead in protecting such

critical areas; both Niger and Senegal are likely candidates at this time.

1.2 UNDERSTANDING DESERTIFICATION

Basic and applied research on the ecological dynamics of desertification and its reversal is badly needed, and a modest research investment by A.I.D., perhaps as part of a multi-donor-supported research effort, should be of high priority.

Development of reliable indicators of degradation, including the population and land-use changes that create a context for it, has yet to be done for this sub-region. Ideal indicators would be those that can be observed remotely and measured with a minimum of ground checking. Various ecological thresholds in the degradation of vegetative formations and/or sites should be identified in different rainfall belts in the sub-region.

1.3 RANGE RESOURCES

Failures and ignorance have generally characterized assistance efforts in this area. It is apparent that greater knowledge is needed in order to more effectively approach existing development problems.

The dynamic systems model for range management that is being developed by IIED should be field-tested for conceptual appropriateness, as well as feasibility from the standpoint of data inputs. (In 1986, an application was being tested in collaboration with IUCN in Botswana).

A.I.D. could commission a survey of range and livestock project evaluations by other entities that would complement its rather limited and largely negative experiences in this area.

Currently supported research at ICRISAT Sahel should include livestock aspects of agro-pastoral systems in the reaearch agenda, with the aim of improving this component of farming and livelihoods in this sub-region.

1.4 AGROFORESTRY

Multiple-purpose agroforestry tree species, especially the Acacia albida, that exist in and around cropped areas are an important element in the sustainability of dryland agrarian systems in the sub-region.

Both research and applications of agroforestry techniques are needed. (A research agenda for agroforestry in the sub-region was discussed and prioritized at a workshop held in Nairobi,

Kenya, in January 1986, under the auspices of the International Union of Forestry Research Organizations.)

Public Law-480 accounts could be used for agroforestry promotion in as extensive a geographic area as possible. A.I.D. pledges to the World Food Program (WFP) could seek to stimulate the planting of agroforestry tree species.

1.5 FORESTRY

Training and research in arid zone forestry must be fostered, and a capability created in French-speaking and English-speaking portions of this sub-region.

Public Law-480 accounts could be used to support management of natural forests.

1.6 WATER RESOURCES

The need for effective water resource management at all levels in this sub-region can only increase as water-related development proceeds and the demand for water resources grows. Poor water management could have disastrous implications for human settlements and irrigation systems. Long-term, consistent support by A.I.D. with respect to certain facets of water management is recommended, especially in the areas of data collection, surveys, data management and communication, and training.

Support to AGRHYMET should continue for as many years as may be needed, perhaps into the 1990's.

The plan that is being designed by the World Bank to up-grade hydrological and meteorological services in Africa should be reviewed as a possible vehicle for A.I.D. support.

The means by which to monitor and manage shallow aquifers, which are seasonally recharged by rainfall, should be devised and instituted. They are the sources of rural potable water. Training needs in the areas of water resource development and management should be assessed from the standpoints of long-term trends, master plans for water development, and related institutional and survey needs.

1.7 RESOLUTION OF FUEL CRISIS

The resolution of the fuel crisis in this part of Africa must be viewed as one of several strategic goals in the reversal of agricultural land degradation. To date, the crisis has been assessed mainly in terms of the loss of vegetative cover. Of direct consequence to farming is the consequent loss of soil

organic matter in the form of wood, crop residues and manure, which go into cooking fires rather than back into the soils.

Tree planting is not an adequate response. Improved stoves have helped, but have not eliminated the deficit. New and alternative sources of energy and greater energy conservation are imperative.

The WRI/World Bank/UNDP Country Investment profiles, which are included in Tropical Forests: a Call for Action, address specific project suggestions on fuelwood production, substitutes, use efficiency, and conservation in every African country with acute scarcities or deficits of fuelwood. These should be reviewed for possible A.I.D. support.

1.8 VILLAGE-LEVEL REGENERATION ACTIONS

Actions at the village level in the sub-region are the key to the twin, mutually-interdependent goals of (1) arresting degradation and regenerating the land and vegetative resources, and (2) increasing food and fuel self-sufficiency.

At present, the strength of village social organizations and the tradition of group work stand in contrast to the weak or absent governmental rural development services concerned with resource management (although this relationship is slowly changing). A number of successful PVO projects have revealed that activities that consider the entire livelihood system at the village level can result in socially, economically and ecologically appropriate development interventions.

Given appropriate techniques and support, villages can mobilize the workers needed for reforestation and soil conservation, and, moreover, can undertake these on their own initiative (Harrison, 1986). More sophisticated work will eventually be needed, but simple starts set the stage for such future work.

Missions could support the mobilization of villages in self-help measures amend at arresting degradation and restoring productivity in the following ways:

* through grants to PVO's in the region.

* through special PL-480 village regeneration accounts.

* through specifically-earmarked accounts in WFP.

* by supporting IUCN's village eco-development initiative, which is a key element in the proposed long-term strategy for environmental rehabilitation of the Sahel. Support could be direct as well as by endorsement, which would encourage other OECD donors.

2.0 SUB-HUMID TROPICAL UPLANDS

2.1 AGRICULTURE RESEARCH

An expansion of the geographic scope of A.I.D. support for ICISAT/Sahel from the semi-arid topics to the adjacent sub-humid zone could be proposed. The crops of the two areas are much the same. Weeds in the sub-humid zone, however, present different management problems from those seen in the semi-arid sub-region; soil erosion in particular is a much greater problem. On the other hand, many more agroforestry possibilities exist in the sub-humid zone.

2.2 FORESTRY AND AGROFORESTRY

Both forestry and agroforestry have good potentials in this zone. Easily eroded lands would be best left in forest cover. Commercial plantations have good potential, if soils are adequate. Natural forest management in important watershed areas will require coordinated actions among donors as well as African nations. Fire control is a principal concern of forest and plantation management in this sub-region.

2.3 NATURAL RESOURCES INVENTORIES

Natural resources inventories and assessments are especially needed for this sub-region, prior to the implementation of major programs of use intensification or change. Control of the black fly vector of river blindness or of the tsetse fly, for example, could be a major force of change. The fragility of some of the sub-region's soils could lead to serious degradation under poor management by newly settled farmers who are unfamiliar with the soils' limitations.

2.4 BIOLOGICAL RESEARCH AND RELATED WILDLANDS MANAGEMENT

Support for biological diversity programs within the sub-region should focus on plant surveys and on integration of protected-area management with national and regional programs. Several countries within the sub-region have specifically requested support for park management activities. Park "W" in Niger, protected areas in Zambia, and areas in the Central African Republic are potential candidates for support.

The Mweka College, which specializes in training in wildlife management, could be supported so as to improve training with respect to a wider range of biological diversity management objectives. Support could be channeled through NGO/PVO organizational funding.

3.0 TROPICAL HIGHLANDS

Soil erosion control programs need to be merged with agricultural production projects and policies, in order to supply the incentive of increased marketable or consumable yields.

3.1 AGRICULTURAL RESEARCH AND DEVELOPMENT

Research and development should address total livelihood systems in which farms are too small for significant surplus, e.g., low-input technologies are needed for resource-poor farmers. Food, fuel, water and construction needs are paramount, and research must somehow integrate advances in crop improvement, crop and soil husbandry, animal improvement and husbandry, forestry, and agroforestry.

3.2 SOILS CONSERVATION, STUDIES AND RESEARCH

The following are needed:

- Soil surveys, including land-capability assessments at several levels of technology (e.g., traditional, modified-traditional, and high-input)

- Soil erosion surveys and monitoring, erosion-control research for different soils, cropping systems and socio-economic levels

- Assessment of the economics of soil erosion control

- Management of crops and other vegetation for erosion control

- Expansion of work done through the World Food Programme in the area of food shortages

- Multi-donor, regional watershed management needs assessments in the West African highlands

3.3 CONSERVATION OF WILDLANDS AND BIOLOGICAL RESOURCES

Management-oriented surveys and research on important preserves of biological diversity should be undertaken.

Indigenous institutions that are charged with protection and conservation should be strengthened.

4.0 HUMID COASTAL LOWLANDS

This sub-region presents environmental homogeneity, but there

are large differences in development from place to place. The development of intensified, sustainable food cropping systems is a need in all the countries of the sub-region; however, only Liberia and Sierra Leone must produce food exclusively in this humid environment.

4.1 RESEARCH

Activities at IITA that are worthy of consideration for A.I.D. support are:

A survey and dynamic description of traditional agroforestry systems and species. Field research grants could be awarded for interdisciplinary teams. Coordination with IITA and ICRAF would be imperative.

Support for additional basic and applied research on mixed tree and food cropping systems for all major soils of the sub-region, through IITA and national agricultural research institutes.

4.2 BIOLOGICAL RESOURCES MANAGEMENT

There is a need for the creation of herbaria (ex situ conservation) in the various countries of the region. Such herbaria would include useful trees and other plants, especially non-food plants.

Support is also needed for field research and surveys aimed at better defining potential biological preserves and/or addressing their management.

Guinea Bissau's coastal estuaries, islands and mangroves should be the object of a master management planning exercise, integral to, or as a follow-up to, current national conservation planning work.

5.0 HUMID EQUATORIAL LOWLANDS

Training, research, and field surveys to inventory and describe the wildland resources and soils of this sub-region are needed to lay the groundwork for future resource management.

Research on agricultural systems that sustain the agricultural land base should be pursued in this sub-region, as extensions of similar work at IITA in Nigeria.

A.I.D. might consider funding the translation of key IITA documents and research reports into French, in order to facilitate technology transfer with respect to soil-conserving or soil-enhancing practices.

6.0 MADAGASCAR AND INDIAN OCEAN ISLANDS

The gravity of the problems of soil erosion and associated habitual burning in Madagascar calls for more vigorous actions and initiatives; however, the small size of the A.I.D. mission in Madagascar -- and, in all likelihood, of other bilateral missions there -- presents a management constraint.

The answer could lie in a multi-donor program to attack the various facets of the soil erosion problem.

Suitably-scaled scientific and technical actions related to coastal environments (mangroves, reefs) and unique flora and fauna can be supported also, through various vehicles.

Improved management of natural forests for multiple-use objectives (including biological diversity) could help offset increasing pressures on parks and reserves.

World Wildlife Fund staff in Madagascar have identified the need for training to insure local capabilities to support biological resource management, as well as for the establishment of a data bank. A.I.D. will be making a small contribution in this respect.

There appears to be interest within the government of Mauritius to develop a coastal management program there. As the resource pressures appear to be less severe than in other areas of the sub-region, Mauritius presents an opportunity to work towards comprehensive management approaches so as to forestall future problems.

Comoros suffers from the most severe coastal resource pressures in the sub-region, and the possibility for assistance should be explored.

Assistance in the management of mangrove forests, including technological transfer of management schemes from Latin America or Asia, would be useful in both Madagascar and Mauritius.

Basic coastal resource inventories are needed. The degree to which baseline information has been developed should be assessed. The environmental profile process could possibly be used to synthesize existing information and to identify needs.

IV. ACRONYMS AND ABBREVIATIONS

AGRHYMET	Agroclimatological Hydrological and Meteorological Network
AID	Agency for International Development
AWF	African Wildlife Foundation
CAR	Central African Republic
CARE	Concerned Americans for Relief Everywhere
CDSS	Country Development Strategy Statement
CIDA	Canadian International Development Agency
CILSS	Inter-Governmental Committee for Combatting the Drought in the Sahel
CITES	(International) Convention on Trade in Endangered Species
DDT	Dichloro-Diphenyl-Trichloroethane (an insecticide)
EDF	Environmental Defense Fund
ETMA	Environmental Training and Management in Africa
FAO	(United Nations) Food and Agricultural Organization
FENR	(Office of) Forestry, Environment and Natural Resources (AID)
GEMS	Global Environmental Monitoring System
GTZ	Deutsche Gesellschaft fur Technische Zusammenarbeit
IBPGR	International Board for Plant Genetic Resources
ICRAF	International Council on Research in AgroForestry

ICRISAT	International Center for Research in Semi-Arid Tropics
IFAD	International Fund for Agricultural Development
IIED	International Institute for Environment and Development
IITA	International Institute for Tropical Agriculture
IUCN	International Union for the Conservation of Nature (and Natural Resources)
MAP	Man and the Biosphere (Programme)
NAS	National Academy of Sciences
NGO	Non-Governmental Organization
NOAA	National Oceanic and Atmoshperic Administration
OMVS	Senegal River Basin Development Authority
ORT	Organization for Rehabilitation through Training
OSTROM	Overseas Scientific and Technical Research Organization (of France)
OTA	(U.S. Congress) Office of Technology Assessment
PL-480	Public Law 480 - Food for Peace
PVO	Private Voluntary Organization
RDA	Rural Development Authority
REDSO	Regional Economic Development Services Offices
SIDA	Swedish International Development Authority
S&T	(Bureau for) Science and Technology (AID)
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNESCO	United Nations Educational, Scientific, and Cultural Organization
USDA	United States Department of Agriculture

WMO	World Meteorological Organization
WRI	World Resources Institute
WWF	World Wildlife Fund

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VI. APPENDICES

Appendix A
First Draft Reviewers

Outside reviewers and attendees of the review workshops at IIED, August 19, 20, and 21, 1986.

Session No. 1: Resource Management of Fresh Water and Coastal Systems

Sam Snedaker
7549 58th Avenue S.W.
Miami, FL 33143

Evelyn Wilcox
6723 Whittier Avenue
Suite 206
McLean, VA 22101

Christopher Shiyan
College of Environmental Science and Forestry
State University of New York
University Station
Syracuse, NY 13210

Val Mezainis
Director
International Training
USDA/OICD
Washington, DC 20520-4300

Mark Flora
Department of Forestry
Colorado State University
Ft. Collins, CO 80523

John Clark
International Park Service
National Park Service, USDI
Washington, DC 20240

Bert Brun
U.S. Fish and Wildlife Service
Annapolis, MD 21401

Lynn Hale
Coastal Resources Center
University of Rhode Island
Narragansett, RI 02882-1197

Session No. 2: Resource Management for Agroecosystems Productivity

Robbie Kieber
World Resources Institute
1735 New York Avenue, NW
Suite 450
Washington, DC 20006

Douglas Lathwell
Bradfield Hall, Room 803
Cornell University
Ithaca, NY 14853-0144

Charles Tapp
Care-NY
660 1st Avenue
New York, NY

Harold Dregne
ICASALS
Texas Tech
Box 4620
Lubbock, TX 790409

Michael McGahuey
Chemonics
2000 M Street, NW
Washington, DC 20036

Bonnie Ram
1815 17th Street NW
No. 808
Washington, DC 20009

Fred Weber
5797 Bogart
Boise, Idaho 83703

Henry Kernan
South Worcester, NY

Tim Resch
Forestry Support Program
Washington, DC 20013

Bobby Birdwell
C/O Director Soil Survey
Soil Conservation Service
Box 2890
Washington, DC 20013

<u>Session No. 3: Resource Management for Vegetative and Biological Productivity</u>

Antoine Cloutier
Head of Planning and Parks
3 Buade Street
Box 6060
Hauteville, Quebec
Canada, GIR 4V7

Susan Shen
OTA
Congress of the United States
Washington, DC 20510

Alain Dufresne
Planning and Parks
3 Buade Street
Box 6060
Hauteville, Quebec
Canada, GIR 4V7

Francis Putz
Department of Botany
University of Florida
Gainesville, FL 32611

Dr. Elliott Norris
Ecological Society of America
730 11th Street, SW
Suite 400
Washington, DC 20001-4584

Diana McMeekin
African Wildlife Foundation
1717 Massachusetts Avenue, NW
Suite 602
Washington, DC 20036

Bill Burley
World Resources Institute
1735 New York Avenue, NW
Suite 450
Washington, DC 20006

Ghillian Prance
New York Botanical Garden
Bronx, NY 10458

Dennis Child
Winrock International
Morrilton, AK 72110-9537

Russell A. Mittermeier
World Wildlife Fund
1255 23rd Street, NW
Suite 200
Washington, DC 20037

Outside Reviewers who did not attend the review workshops:

Patrick Dugan
International Union for the
Conservation of Nature and
Natural Resources
Avenue du Mont-Blanc
AH-1196 Gland-Swisse
Switzerland

M.J. Cockerwell
International Union for the
Conservation of Nature and
Natural Resources
Avenue du Mont-Blanc
AH-1196 Gland-Swisse
Switzerland

APPENDIX B

International Assistance in Natural Resources Management in Africa

Inventory of AID and Other Donor Projects by Country (July, 1986)

A. INTRODUCTION

Recent (since 1980), ongoing and planned projects were surveyed, and multi-lateral and bilateral assistance efforts were reviewed.

The inventory is presented country by country, in alphabetical order.

Projects aimed directly at renewable natural resources and their use and management are included. Related agricultural development and research projects are included where there is an explicit focus on natural resources (soils, water, agroforestry, range). Assistance in marine fisheries and oceanography is not included.

The inventory is based on a number of documents, referenced below.

The inventory includes:

- Ongoing A.I.D. projects;
- Forestry projects by all donors (lacking financial data in some cases); and
- UNDP projects (which encompass most FAO work).

The contents of a recently-released, detailed compilation of energy, forestry, and natural resource projects in the Africa Region, supported by A.I.D., have been incorporated into the current version of this appendix.

Coverage is thin or lacking for planned actions or programs of bilateral donors, and only fair for international donors. NGO (PVO) activities are described only for the Sahelian countries, and coverage is thin.

Interaction, a PVO coordinating body for North America, has surveyed its constituents' projects in Africa, and in July, 1986, prepared a special report on "Environmental projects" in the data base that was submitted to the Africa Bureau ("Survey of U.S. PVOs Working in Africa; Projects with a Forestry or environmental Component"). Its contents are not repeated in

the present document. A total of 154 projects were listed; these projects are currently carried out or have been recently completed by 33 different PVOs.

Much of A.I.D.'s work in forestation is accomplished through collaborative agreements with the Peace Corps. The inventory does not specify the Peace Corps component in every case. The involvement of PCV's in African forestry work will be increasing. Sixty new volunteers are being trained to work with various NGOs supported by A.I.D. in forestry activities.

Several references are cited in Appendix A. Complete citations can be found in the preceding list of references.

Source Documentation

A.I.D. 1986. Listing of A.I.D. projects in sub-Saharan Africa. Center for Development Information and Evaluation, Development Information Division (Computer print-out), pp.

Arawak Consulting Corporation. 1986. Energy, forestry and natural resources activities in the Africa region. Washington, D.C., Bureau for Africa, A.I.D., pp.

FAO. 1986. Tropical forestry action plan. Rome: Food and Agricultural Organization of the United Nations, 211 pp.

UNDP. 1986. Listing of UNDP projects in sub-Saharan Africa. New York: Documentation and Statistics Office, Bureau for Program Policy and Evaluation, UNDP. (Computer print-out), pp.

Active UNDP projects in the following categories (used by UNDP) were reviewed: natural resources (water and minerals, agriculture, forestry and fisheries, science and technology).

UNEP. 1985. Desertification control in Africa; actions and directory of institutions. Nairobi: United Nations Environment Program, Desertification Control Program Activity Centre, 126 pp.

Reports on 1982/1983 surveys of anti-desertification work, successes and failures, pilot projects, and available information and experience on desertification control technology. Includes (in Vol 2) a directory of institutions and their missions, staff and projects.

B. PROJECT INVENTORY

BENIN

Benin (formerly Dahomey) shares the West African coast with more humid nations, but is located in a low-rainfall zone, coined the "Dahomey gap." It is, therefore, entirely within the sub-humid tropical uplands sub-region. Its border with Upper Volta is also at the transition with the semi-arid zone.

The northern zone suffers pressures on grazing resources as well as bush fire dangers from migrating pastoral groups seeking range during drought years.

Anti-desertification control efforts in the north of the country have been discontinuous and lacking in long-term commitment from donor countries.

In 1986 USAID was supporting:

- development of safe water supplies in the north, including work in sanitation and hygiene education ($6.7 million).

UNDP was supporting:

- agricultural soil surveys (agro-pedologie) ($1.3 million);
- preparation of a master plan for water resources ($158,000);
- artisanal fisheries ($586,000);
- multiple-purpose forest plantations ($825,000);
- watershed management and brush fires prevention in north Benin ($224,000).

BOTSWANA

Botswana is almost entirely within the arid and semi-arid tropics sub-region, and the southernmost portion, comprising the Kalahari desert, extends into the climatic subtropics. Only 5 percent of Botswana is cultivable, and traditional as well as commercial cattle-raising is the dominant activity. Rainfall has been below normal during 1975-85.

Human and livestock populations have grown rapidly despite the drought. Cultivation is encroaching onto better grazing areas, and herding is threatening a rich wildlife population, for which several parks have been set up.

Botswana's system of monitoring rainfall, crop production and nutrition at 500 centers around the country averted malnutrition and starvation during the 1984/85 drought.

Great investments of effort and money have been directed at modernizing and commercializing traditional livestock raising in Botswana. UNEP reported that, in 1982, "... the development of a market oriented livestock economy has placed high value on cattle and has encouraged water prospecting and borehole drilling to enable cattle ranching to push further west into the Kalahari sandveld. Consequently, there has been extensive, in places severe, degradation of rangeland due to over-stocking, over-grazing, trampling, and uncontrolled fires, characterized by accelerated wind, sheet and gully erosion. The quality and quantity of forage available to stock have been reduced due to encroachment by annuals and unpalatable perennial species." (UNEP, 1985).

This situation prevailed throughout eastern Botswana, despite government efforts to arrest range degradation. In fact, some efforts have apparently aggravated rather than ameliorated the situation. Meanwhile, commercial livestock development projects are being pursued in the Kalahari Desert, in parallel with efforts to conserve and manage its wildlife and to map range and water resources.

Projects:

In 1986, the World Bank was planning an extension of the "second livestock development project," which had already received $7.3 million of support, and in which UNEP reported that "little progress had been achieved in respect to the control features of the project," namely, to protect rangelands by controlling over-stocking and over-grazing.

In 1986, USAID was supporting:

- a $11.8-million, 8-year rural sector grant, running to 1988,

and financing the development of land-use planning capacities, rural agroforestry and forestation, horticulture, and wildlife utilization and management as a source of income. Six Peace Corps volunteers are involved;

- development of rural renewable energy ($3.3 million).

UNDP was financing:

- soil mapping assistance ($1.1 million);
- assistance to the wildlife training center ($490,000);
- range management ($630,000);
- pasture and fodder crop seed production ($40,000);
- range restoration and fodder development ($200,000).

The United Kingdom's ODA will lead a multi-donor review of the forestry sector as a follow-up to the FAO Tropical Forests Action Program.

In 1986, IUCN supported research on Kalahari wildlife and the preparation of a National Conservation Strategy.

BURKINA FASO

According to UNEP, "Burkina Faso is encountering serious problems of desertification engendered by bush fires in the south, clearing for cultivation and cutting trees for fuelwood in the Mossi plateau, and over-grazing in the north." (UNEP, 1985).

In 1986, A.I.D. was supporting only one project related to natural resources: a community forestation effort in the southwest (Project 686-0934) executed through AFRICARE, with collaboration from the Peace Corps. A.I.D. funding is $1.0 million.

USAID supported the Dinderasso Forestry School, during 1982-85 ($5.9 million).

In late 1985, the government of Burkina Faso was working with CILSS and UNSO in the preparation of a national strategy to combat desertification.

The national government began a village forestation program in 1979. Actions to date to combat desertification include:

- a 14.5 million World Bank project to strengthen the forestry service, plant 1,600 hectares, manage 1000 hectares of natural forest, and plant 325 hectares of community woodlots;
- numerous village woodlot projects supported by various donors - Sweden, Switzerland, and the Netherlands - totalling $5.75 million;
- UNSO-funded afforestation and related research in the Sampone area (formerly project 601);
- UNDP support to strengthen hydrological and agrometeorological services ($2.1 million) (until 1988).

Other UNDP projects of note include (from 1986 UNDP sources):

- well drilling ($613,000);
- "development" of forest and wildlife resources (1.3 million; preceded by a $500,000 inventory of wildlife resources);
- village forestation in Bulkiemde and Sangie provinces ($861,000);
- creation of a national soils institute ($1.6 million);
- Ecological and socio-economic research near the Oursi Swamp, supported by France through DGRST.

BURUNDI

Burundi is located in the tropical highlands sub-region.

In 1986, USAID was supporting:

- a project to preserve the Bururi Forest (last of two remaining high-altitude forests in Burundi) by establishing fuelwood plantations around its circumference in concert with plantations sponsored by other donors, and by developing new sources of firewood and construction timber for communities in the environs (No. 693-0105, $1.1 million during 1982-86);

- a peat utilization project to provide an alternative to wood fuel. (No. 695-0103, $9.0 million, 1982-87).

UNDP supported:

- strengthening of topographic mapping and cartography ($1.0 million) and hydrometeorology ($712,000) in the Institut Geographique;

- forestry training ($1.7 million);

- support to the Faculte des Sciences Appliquees ($3.9 million).

CAMEROON

Desertification affects the narrow, northern wedge of Cameroon, which extends north to of Lake Chad, where livestock raising dominates. UNSO helped Cameroon develop a strategy to combat desertification in 1979, which consisted, to date, of research on dryland ecosystem functioning and impacts of environmental degradation.

In the sub-humid belt, and the humid coast, Cameroon is experiencing soil erosion, deforestation, and urban expansion problems.

In 1986, A.I.D. was supporting the following actions related to natural resources and the environment:

- agriculture among small farmers ($600,000);
- an exploratory visit by IIED scientists on behalf of A.I.D. to examine the possibility of undertaking a phase II environmental profile in Cameroon.

A.I.D. has not joined the multi-donor group working on a forestry action program for Cameroon. (See below.)

Various actions were undertaken in the early 1980's to combat desertification:

- shelterbelt plantings, with World Bank assistance, in Diamare and Mayo Danay districts, until 1987 (originally begun in 1956);
- UNEP and UNDP supported planning for integrated development of the semi-arid northern zone;
- in 1986, UNDP was supporting a $1.9 million project titled, "Mesures de lutte contre la desertification dans le nord Cameroon" (until 1987), and agro-meteorological and hydrological work in northern Cameroon.

Under the aegis of the Tropical Forests Action Program, a multi-donor assessment of Cameroon's forestry sector was underway. IIED was pursuing a complementary review of forestry policy, with CIDA support. UNDP is the lead agency for the multi-donor forestry sector review, which should be complete in late 1986 or early 1987.

Elsewhere, UNDP was supporting:

- development of a soils service in ONAREST ($872,000);
- strengthening of the National Soil Center ($1.2 million).

CAPE VERDE

Cape Verde's desertification problems vary among its 10 major islands; however, degradation of vegetation and erosion are common to all the islands, relieved only be a low rate of fuel wood consumption relative to elsewhere in Africa.

It is estimated that existing and proposed reafforestation projects will be able to satisfy the country's fuelwood needs by the year 2000.

In 1986, there were no USAID projects dealing with natural resources or the environment; however, during 1978-1984, USAID supported watershed treatment of four watersheds on Sao Tiago Island (e.g., infiltration ditches, gully plugs, and check dams, and similar work supported by UNSO).

Other donors and USAID have supported:

- soil conservation and other watershed treatment measures on the islands of Santo Antao (Netherlands-supported) and reafforestation on the island of Maio;

- several small-scale water and wind energy development projects, supported by Denmark and the Netherlands as well as A.I.D.

In 1986, UNDP was supporting a $0.9 million project to control desertification in the San Joao Baptista valley, and was contributing $200,000 to strengthen agro-meteorological and hydrological services.

CENTRAL AFRICAN REPUBLIC (CAR)

The CAR lies almost entirely within the sub-humid tropical uplands sub-region.

USAID was supporting the following in 1986:

- operational activities of the Ministry of Fisheries' national inland fisheries program as part of a $1.0 million rural development project.

UNDP was supporting:

- groundwater surveys ($453,000);
- wildlife management ($1.2 million);
- agricultural extension ($2.4 million);
- development of soil survey and soil conservation service ($672,000);
- organization and development of agro-climatological and hydrological services in the Meteorological Bureau ($620,000).

CHAD

UNEP states that "wind erosion, sand encroachment and shifting sand dunes, deterioration of both grazing and crop lands, exacerbated by a general concentration of livestock in the south due to much reduced grazing in the northern part, generally typify the desertification problem in Chad." (UNEP, 1986).

Chad stands out for early work in agroforestry with Acacia albida and wild Acacia senegal (gum arabic), assisted by CARE and the Peace Corps. The civil war disrupted this work until its resumption in 1985.

USAID has a small mission in Chad, but no projects specific to natural resources and the environment. A PVO "umbrella" grant will seek to rehabilitate and improve traditional irrigation with groundwater, however.

In 1986, UNDP was supporting:

- two forest species nurseries ($800,000), wells for human and animal consumption;
- a $5.7 million technical assistance preparatory effort for rural water development;
- a $1.9 million project to strengthen hydrological and agro-meteorological services.

COMOROS

The four islands in this archipelago lie between the north coast of Madagascar and the Mozambique coast. They are part of the Indian Ocean Islands sub-region.

There are no A.I.D. activities in Comoros. The US Embassy manages a small ($10,000) self-help development fund (as in every other African embassy).

In 1986, CARE was carrying out a five-year rural-assistance project that includes soil conservation, agroforestry, and reforestation, with partial funding (matching grant) from A.I.D.

UNDP was supporting:

- water surveys and development ($1.8 million).

CONGO

Congo is entirely within the humid equatorial lowlands sub-region.

A.I.D. activities in agricultural development in Congo support various production inputs for smallholders, but not natural resources management *per se*.

In 1986, UNDP was supporting:

- rural fish culture ($668,000).

DJIBOUTI

Tiny Djibouti lies entirely within the arid and semi-arid tropical sub-region, on the Gulf of Aden.

A.I.D. is supporting the development of marine fisheries, now in its second phase (Fisheries Development, Phase II, $3.0 million), and the development of energy conservation and new energy sources, such as solar energy (infrastructure and Energy Initiatives, $4.0 million).

ETHIOPIA

All of Ethiopia is affected by desertification or land degradation, in both cases due to over-grazing, cutting and land clearing, and over cultivation. In 1982, UNSO was helping to prepare a national plan to combat desertification.

Ethiopia spans tow sub-regions: (1) the arid and semi-arid tropics sub-region, which entirely surrounds it, and (2) the tropical highlands sub-region.

Recent or current actions to combat desertification include:

- fuelwood plantings supported by the African Development Bank and the World Bank (both loans), UNDP, Denmark, Finland, Australia, and the Federal REpublic of Germany, as well as numerous NGOs;

- watershed treatment supported by the World Food Program;

- various catchment treatment projects conducted by the World Bank (Sirinka pilot catchment) and the Netherlands (Colina-Hormat catchment).

UNDP also was supporting:

- national land use planning, executed by FAO ($4.1 million), and cartographic training ($0.9 million);

- $2.6 million in assistance to the Phase II Soil and Water Conservation Program;

- $1.2 million to strengthen the National Soil Service.

GAMBIA

Gambia's annual rainfall of around 800 millimeters places it in the southern, more humid margins of the Sahelo-Sudanian zone. Bush fires set by nomadic pastoralists are the principal cause of land degradation in this tiny country bordering the lower Gambia River. A different kind of degradation has resulted from the reduced flow of the Gambia River during the drought. Its estuary has become so saline, and freshwater inputs so reduced, that mangroves are dying as a result. Swamp rice cultivation has also been adversely affected.

USAID recently completed an environmental assessment of the impact of dams and other forms of river basin development in the Gambia River Basin. The assessment recommended against a salt barrier dam as well as a large hydropower dam upstream. A.I.D. has also sponsored range ecology and management research undertaken by the University of Colorado (1979-86, $9.0 million).

From 1978 to 1987, A.I.D. has supported institution-building and planning for soil and water conservation through a contract with the U.S. Soil Conservation Service. Activities include management support to the Ministry of Agriculture and Natural Resources. (Project No. 635-0202, $2.7 million).

Four Peace Corps volunteers in agroforestry were posted in Gambia in 1985.

In 1982, UNSO and other donors were supporting fire prevention work. In 1986, donor support had shifted to improved wood stove development and dissemination.

The FRG was assisting in the preparation of a master forestry plan.

In 1986, UNDP was supporting numerous activities related to desertification and degradation:

- construction of small dams and protection of agricultural lands from salt water intrusion ($470,000);

- rangeland management and protection of land around livestock watering points ($400,000); development of watering points for livestock ($850,000);

- strengthening of the agro-meteorological and hydrological services of the Department of Water Resources ($546,000).

GHANA

Ghana's territory spans the humid coastal lowlands and the sub-humid tropical uplands.

In 1986, USAID was not supporting projects concerned with natural resources and the environment.

IBRD led a multi-donor review of the forestry sector in early 1986.

GUINEA

Guinea's northern half lies within the sub-humid tropical uplands sub-region, while the coast is within the West African humid coastal lowlands. Drought touched the northernmost portion and herders from the Sahel migrated to Guinea during that time, putting pressure on grazing resources and aggravating the problem of bush fires. These pressures, plus deforestation in the Fouta Djallon massif, are damaging the catchment areas of the Senegal, Gambia and Niger rivers, all which have their origins in Guinea.

In 1981, UNSO helped Guinea to draft a national plan to combat environmental degradation, which included watershed management, forestation, bush-fire control, and sensitization of local people to issues of environmental degradation.

France will lead a multi-donor review of the forestry sector in 1986, as a follow-up to the FAO Tropical Forest Action Program.

Also, in 1982, UNDP and World Bank were supporting the development of a master plan for water resources development.

In 1986, UNDP was supporting or had recently completed:

- assistance to the national hydrological service for watershed management in the uplands ($2.0 million);
- water resources planning ($2.0 million);
- forestry training and construction of a demonstration center ($1.2 million);
- reforestation, protection and management of the Kokoulo river basin ($1.2), and the Fetore, Koube and Tene basins ($3.4 million);
- strengthening of the national meteorological service, Phase II ($1.6 million).

GUINEA-BISSAU

This former Portuguese colony lies at the drier extreme of the humid coastal lowlands. Inland, it falls within the sub-humid tropical uplands sub-region.

In 1986, USAID was supporting a $4.5-million rice development project, nearing completion, but no activities concerned with natural resources or the environment.

UNDP was supporting:

- integrated development of the Bijagos Islands ($400,000);
- rural water works ($1.8 million).

A National Conservation Strategy was in preparation, with IUCN support, in 1986.

IVORY COAST

A.I.D.'s West African REDSO office is located in the Ivory Coast, but currently there is no A.I.D. program in this "middle-income" country.

UNDP was supporting the following activities related to natural resources and the environment:

- fisheries development ($1.3 million);
- rural fish culture ($866,000);
- strengthening of the climatological and agro-meteorological offices ($510,000).

The IBRD will lead a multi-donor review of the forestry sector in 1986 as a follow-up to the FAO Tropical Forests Action Program.

A National Conservation Strategy was in preparation, with support from the IUCN.

KENYA

Kenya's territory generally embraces the semi-arid sub-region to the north and east, the sub-humid uplands to the west, and the highlands in the center.

Expansion of cultivation into marginal (steep or arid) areas, exploitation of woody vegetation for fuel, and unmanaged stock watering pints have combined with drought and erratic rainfall to cause degradation and desertification in Kenya.

Compared to other drought-afflicted nations, considerable governmental and non-governmental efforts are being expanded to combat degradation and desertification. There are 95 non-governmental organizations in Kenya, with a coordinating organization, KENGO. Multilateral and bilateral projects are so numerous as to present a major problem with respect to coordination. In December 1983, USAID surveyed over 400 projects in Kenya concerned with natural resources and the environment. Only a few are mentioned here.

USAID-supported activities:

- during 1982-85, USAID supported planning and related environmental profiles at the district level, as part of the government's initiative to decentralize planning. This is a structural change considered to be a key to effective resource management;

- through the Energy Initiatives for Africa regional project, USAID was supporting a variety of NGO activities, coordinated by KENGO, such as fuelwood lot plantings, agroforestry, improved woodstoves development and diffusion, and range and livestock management;

- a very successful, five-year agroforestry project (Kenya Renewable Energy Development Project) has recently come to a close;

- Winrock International recently terminated a long involvement the Kiboko Research Station's development of range and livestock management systems east of Nairobi.

Various projects supported by other donors have been underway since the early 1980's aimed at easing the pressures on range resources:

- IPAL, or Integrated Project for Arid Lands, is a UNESCO- and FRG-backed, long-term research effort to establish the ecological and related socio-economic basis for a more rational and conservative use of range resources threatened with degradation in Marsibit, northern Kenya;

- grazing blocks, initially supported by an A.I.D. project, are being continued by the GOK, with the aim of better managing range.

Cooperative ranching is also being assessed by the government as a range management alternative.

- The World Vision Relief Organization was also attempting the establishment of a cattle ranching approach for the Samburu tribe, who are nomadic pastoralists;

- UNDP has furnished long-term support for the development of forage plants ($800,000) in 1985-88).

A forestry sector review was being undertaken by a multi-donor group led by the World Bank in 1986, as a follow-up to the FAO Tropical Forests Action Program.

Dryland forestry was being promoted in various ways:

- research and planting trials of 40 species of potential use in rehabilitation projects;

- USAID support (in 1982-83) of reforestation and erosion control in Kitui district;

Other actions:

- dryland farming research development (UNDP, $4.0 million total);

UNDP was supporting, in addition:

- a management plan for the catchment of Lake Victoria ($1.47 million);

- exploration for geothermal energy (Phase II, $1.9 million);

- the Green Belt Movement ($110,000);

- coastal agriculture ($134,000).

UNEP's review of Kenya's progress in combatting desertification singled out the special success of women's groups in environmental rehabilitation efforts.

LESOTHO

This tiny (approximately the area of the state of Maryland), landlocked state in the subtropical highlands of Southern AFrica is perhaps more severely eroded than any comparable region in Africa outside of the Ethiopian highlands. At the same time, efforts to control erosion in Lesotho have been exerted since colonial times, and continue now with international assistance, especially through the World Food Program, as well as USAID.

Most of Lesotho's arable lands are at lower elevations, which have lost an estimated 30 centimeters of soil, and where over 30,000 hectares have been destroyed by gullying (Flannery, 1979).

In 1986, USAID was supporting:

- land conservation and range development, a $12.0 million, 7-year project begun in 1980;
- forest and wildlife management within a larger rural development grant, 1980-88;
- development of renewable energy technologies based on wood, sun and wind ($3.3 million).

UNDP was supporting:

- a pilot solar energy and biogas project ($680,090);
- strengthening of the hydrological service ($696,000), and a five-year post for a conservation forest officer;
- animal feeds and fodder for drought relief ($270,000).

LIBERIA

Liberia occupies the humid coastal strip of West Africa.

No A.I.D. activities were planned or underway dealing with the management of natural resources or the environment.

UNDP was supporting:

- development of a natural resources administration ($1.0 million);
- management and legislation for a water resources policy ($932,000).

MADAGASCAR

Madagascar is the most important of the islands in the Indian Ocean Islands sub-region. The reknowned uniqueness and precarious status of its endemic flora have attracted international attention. A National Conservation Strategy was prepared and was adopted by the government in 1984, and a conference on its implementation took place in November, 1985.

Proposed A.I.D. activities in 1986 were the following:

- agroforestry training through ICRAF and IITA;

- use of counterpart funds to support local or other donor projects, e.g., Swiss projects for (1) demonstration and training in natural forest management, West Madagascar, and (2) farm agroforestry;

- a REDSO "pre-assessment" of the role of energy, forestry and natural resources in sustaining agriculture, followed by the testing of a few interventions;

- analyses of potentials for farm forestry/conservation projects, and of the current training and support of extension staff dealing with forestry and soils;

- workshop to discuss forestry/natural resource research issues.

AID/W may finance a survey of soil erosion and vegetation that would be added to a natural resources inventory proposed for Madagascar by the World Bank, in its "Agricultural Institutions II" project.

UNDP was supporting:

- assistance to the Department of Hydrography and Oceanography, in the Institut National de Geodesie et de Cartographie ($460,000), and other assistance to the Institut ($811,000);

- research and development program for renewable energy ($200,000);

- marine fisheries development ($117,000);

- agriculture and freshwater fisheries development (672,000).

MALAWI

Malawi lies entirely within the sub-humid tropical uplands sub-region. It share lake Malawi with neighboring Mozambique and Tanzania.

A.I.D. was funding agroforestry research, as part of a $14.0 million agricultural research extension project (612-0215) for the period 1985-90 which is still in the start-up phase.

UNDP was supporting:

- strengthening of hydrological services ($656,000);
- a national water resources master plan ($423,000);
- forestry training ($423,000);
- strengthening of the national meteorological service ($400,000).

MALI

Over half of Mali is in the hyper-arid Sahara, into which the Niger River loops before flowing southest into Niger. Most of its population is located in the southern sub-humid uplands, however.

Cattle raising in mali replies substantially on the Niger's interior delta, which as been progressively drying up, jeopardizing the dry-season floodplain pastures as well as draw-down agriculture and fishing. This comes at a time of increasing competition among farmers and herders for the delta's humid soils. Many farmers and pastoralists have moved southward, some into Bamako. Herders have concentrated in the more humid, southern areas of Mali, corresponding to a portion of the sub-humid uplands sub-region, as well as the adjacent semi-arid regions in the latitude of Bamako.

In 1982, UNSO assisted in the preparation of a national plan to combat desertification.

Into the early 1980's, block-forest plantations were being pursued, notably in a World Bank project. By 1985, this approach has been abandoned in favor of small-scale village woodlots and agroforestry approaches, supported by the World Food Program, Canada, EEC, FAO/World Bank, FRG, Italy, Netherlands, Norway and A.I.D.

In 1986, A.I.D. was supporting:

- a livestock production project totalling $14.0 million. Range management is not a specific output of the project, however;

- research on semi-arid crops--sorghum, millet and cowpeas--which was nearing completion at the end of 1985. Cost: $4.7 million;

- a three-year farming systems research within Mali's Institute of Rural Economy, begun in 1985. Cost $6.6 million;

- village reforestation in the fifth region ($3.6 million);

- resettlement of 11,000 Malians displaced as a result of construction of the Manantali Dam ($18.5 million);

- a $15.5 million, 10-year forestry project which was in the start-up phase (Project 608-0235, Forestry Sector Development). It is designed to strengthen the Malian Forest Service in the Fifth Region.

In 1986, UNDP was financing:

- development planning in a zone that has been cleared of river blindness ($764,000);

- oasis development on the "salt route" ($1.4 million);

- groundwater resources development (since 1977, $16 million);

- strengthening of agro-meteorological and hydrological services ($620,000);

- assistance for the production and marketing of cattle ($2.4 million), for cattle development in the western Sahel ($2.0 million), and for "support centers" for cattle development ($1.4 million);

- resettlement studies of people who will be displaced as a result of construction of the Manantali dam ($320,000);

- studies for development of fisheries, bee-keeping, and agricultural development on the Goubo plain.

FAO will lead a multi-donor review of the forestry sector in Mali, as a follow-up to the FAO Tropical Forests Action Program.

MAURITANIA

Shifting sand dunes, their encroachment on oases and towns, over-grazing, and salination of irrigated lands in the delta of the Senegal river are the essential environmental problems of this nation, which has not been able to feed itself since 1975.

The nation has a national plan to combat desertification, and Sweden was supporting a public education program regarding desertification in 1985.

In 1982, DANIDA was supporting the planting of a greenbelt around Nouakchott to buffer it from sand and dust.

EDF was supporting a gum arabic regeneration project in 1982.

In 1986, USAID supported:

- rural dam building and treatment of waterborne diseases ($8.9 million);
- integrated development of oases in southern Mauritania ($6.0 million);
- small-scale irrigation along the Senegal River ($460,000);
- agricultural research in Kaedi and related support structures ($3.8 million).

In 1986, UNDP was supporting:

- dune stabilization ($3.0 million);
- well repair ($1.0 million) and earth dam construction ($1.5 million since 1981);
- groundwater development ($380,000) and development of improved well operation ($485,000);
- strengthening of agro-meteorological and hydrological services ($1.2 million).

IUCN was assisting in the preparation of a plan to conserve endemic flora and fauna. Other non-governmental organization activity included OXFAM's support of fuel-efficient stoves.

UNEP makes special mention of the role of local religious leaders in the conservation of forest reserves, and the significance of local customary authorities in this regard. Also noted in the surprising recovery of local flora and animal species in the greenbelt area around Nouakchott as a result of its protection from grazing (UNEP, 1985).

MOZAMBIQUE

Except for its arid southern coastal plain, Mozambique lies within the sub-humid tropical uplands sub-region.

Currently, A.I.D. has not program in this country, although there is an American Embassy located there.

In 1986, UNDP was supporting:

- establishment of a water resources institute ($2.17 million);
- a natural resource survey and land evaluation ($3.0 million);
- marine fisheries development and training ($5.0 million);
- trypanosomiasis and tsetse fly control ($680,000);
- the Forestry Engineering Department, Faculty of Agronomy ($1.1 million);
- forestry development and forest industries production ($3.0 million).

NIGER

All of Niger lies within the arid and semi-arid sub-region, and most of Niger's territory is in the Sahara desert. Niger suffers from sever desertification over much of its territory, resulting from unrelieved cutting, grazing and browsing during the long drought. Livestock raising and fisheries appear to be in a slow decline. The physical environment is suffering from spreading desertification; pastures are taking longer to re-establish themselves after grazing, while fallow periods for cultivated soils have been reduced. Nevertheless, in years of adequate rainfall, e.g., 1985, Niger can feed itself and even produce a surplus.

Niger has announced a major commitment to combat desertification (Engagement de Maradi). IUCN has initiated the planning process for a national conservation strategy in Niger.

A.I.D. activities:

A.I.D. projects in recent years have included support for forestry, agroforestry, and land-use planning, but all of these activities are being terminated by December 1987. The results and technologies developed are to be incorporated into various other projects in the portfolio.

The Niger mission has drafted a new development strategy that will support irrigated agriculture (for "drought-proofing"), agricultural research and support to local development groupings, and strengthening of institutional capacities for policy analysis, planning and management. The mission also intends to engage contract staff working on various other projects to assist the National Forest Service in developing a national strategy for anti-desertification.

In 1986, USAID projects involving natural resources were:

- forestry and land-use planning (FLUP project), a 7-year, $2.46 million project to be terminated in 1987. Results from the Guesselbodi range management site have yielded new insights on the social and ecological aspects of range rehabilitation;

- an agricultural production support project, a $14.7-million project that seeks to strengthen the Ministry of Rural Development and its various services and operations;

- reforestation training in ten rural training centers, as a component of the Niamey Department Development project. The centers promote and fund multi-faceted development;

- partial assistance to CARE for its windbreak plantings in the Majjia Valley;

- assistance to the Niger Basin Authority to plan and identify projects for development in the river basin. This project is being phased out early because of the Niger government's inability to comply with conditions related to staff salaries;

- integrated livestock production ($5.0 million, which was to yield a range management plan, including re-seeding and conservation. Drought has undercut the project, which is being phased out;

European and U.N. agencies were supporting a variety of anti-desertification and forestry efforts:

- sand dune stabilization--Denmark through FAO, Church World Service;

- agroforestry and billage forestry, windbreaks--Netherlands, Norway, Sweden, France, Catholic Relief Services, CARE;

- Institutional support and strengthening to the forest service--France, World Bank, FRG.

UNDP was supporting:

- an extension of the Acacia albida regeneration project in Dosso;

- Sand dune stabilization around Bilma (perhaps the same as Denmark's project, above) ($1.4 million);

- soil mapping ($3.1 million since 1978);

- shelterbelt plantings around Tahoua ($480,000);

- rural water supply development ($1.8 million);

- research and training for agricultural implements in the Sahelian zone ($2.0 million);

- strengthening of agro-meteorological services ($775,000).

In addition, 17 Peace Corps Volunteers were assisting in agroforestry and village woodlots in 1985.

NIGERIA

Nigeria is not an A.I.D. country; however, A.I.D. does support research at the International Institute of Tropical Agriculture in Ibadan, where ground-breaking research in alley cropping has been pursued over the last 8 years.

Nigeria's territory spans three sub-regions: the West African humid coastal lowlands, the sub-humid tropical uplands, and the semi-arid portion of the arid and semi-arid tropics sub-region.

Several anti-desertification projects are underway, aiming to establish shelterbelts and woodlots at various scales.

Forestry projects elsewhere include:

- World Bank loans for industrial plantations;
- technical and vocational training supported by Denmark and the World Bank;
- UNDP technical assistance in forest management and wood utilization.

UNDP was also supporting:

- artisanal and inshore fisheries development ($2.6 million);
- range management in Sokoto ($231,000);
- development of a forest management capability ($3.0 million);
- livestock development in grazing reserves ($2.9 million);
- development of a national earth resources database for soil conservation and land-use planning ($220,000);
- establishment of gene bank facilities for conservation and utilization of horticultural germ plasm ($438,000).

RWANDA

Rwanda lies entirely in a portion of the East AFrican highlands sub-region. It is one of the most densely populated nations in Africa (an average of 265 persons per square kilometer), and is especially threatened by land degradation from a combination of over-cultivation and easily eroded steep soils, which include some of the richest volcanic soils in Africa.

In 1986, A.I.D. was supporting or had recently supported:

- agroforestry activities, carried out as part of the Energy Initiatives for Africa project, centered in Nairobi;

- a regional assessment of natural resources and environmental management problems, in the Ruhengeri Prefecture, under a regional project, the Environmental Training and Management in Africa project (approximately $900,000 in two phases);

- research on soil fertility maintenance, as a sub-project of the $15.8 million Farming Systems Improvement project;

- pond agriculture (Fish Culture project, $2.5 million);

- one-time sampling of soil erosion rates at 100 sites, as part of the first national agricultural survey (Rwanda Agricultural Survey and Analysis project, $3.67 million);

- extension work in erosion control terraces, at various rural vocational training centers.

UNDP was supporting various mineral surveys, as well as work to tap methane gas in Lake Kivu.

The World Bank was funding a forestry project in the Gishwati National Forest (a proposed buffer plantation).

European donors were active as follows:

- Belgium was undertaking 1:50,000 topographic mapping;

- France was carrying out a soil survey in the Ruhengeri Prefecture, using new 1:20,000 aerial photography;

- Switzerland was funding technical assistance in forestry and agroforestry;

- GTZ recently ended a seven-year project to develop agroforestry systems in the highlands (Nyabisindu), the Project Agro-pastoral. It is now being evaluated and a final report is in preparation.

Non-governmental organizations were also active, for example:

- The World Wildlife Fund supported research on gorillas in the parc des Volcans;

- CARE was supporting village forestation and watershed forestation;

- bench terracing and related agricultural intensification were being supported on a small scale by a religious order from Belgium.

SENEGAL

Like other Sahelian countries, Senegal has developed a Plan of Action to Combat Desertification. It was recently evaluated for the World Commission intensification were being supported on a small scale by a religious order from Belgium.
on Environment and Development in Geneva by the Ecole Nationale d'Economie Appliquee, of Dakar (ENEA, 1985).

Senegal's performance in achieving the goal of the 27 recommendations of the U.N. Conference on Desertification's Action Program was found wanting. This is consistent with worldwide findings ten years after the conference. Senegal's plan to combat desertification, which was to have been produced by a committee set up in 1981, was based upon many connected, sectoral approaches.

Also, various other committees, have lacked coherence. The recent (1984) formation of a Ministry of Nature Protection, which is responsible for forestry and soil conservation as well as parks management, is a step forward.

This level of attention was sorely needed both to deal with the gravity of natural resources degradation in Senegal and to coordinate donor support. In 1986, 23 donors were supporting forestry projects in Senegal, totalling over $53 million in value.

In 1985, IUCN initiated the preparation of a National Conservation Strategy, and was planning a regional pilot project for the strategy, working with the Ministry of Nature Protection.

USAID activities in 1986 related to natural resources included:

- completion of a national survey of natural resources, consisting of 1:250,000 maps and accompanying monographs of land-use and vegetation, soils, groundwater, geomorphology ($2.0 million) (publication in atlas format of limited circulation);

- support to Africare for village woodlots ($400,000);

- decentralized farming systems research, $8.6 million during 1981-1990;

- initiation of 5-year, $8.0 million project to support agroforestry and related land regeneration actions.

Sixteen Peace Corps volunteers were working on village forestry and agroforestry in 1985.

P.L. 480-supported reforestation, dune stabilization and renewable energy development underway during the early 1980's has been terminated, and a planned second phase of an urban fuelwood plantation (Bandia forest) was cancelled following a negative recommendation from the Phase I evaluation.

Several Sahel Regional projects were being executed in part in Senegal--support to the OMVS (the Senegal River Basin Development Authority), agricultural research for the OMVS, and a study of groundwater in the Senegal River basin and the possible impacts on it from the Manantali Dam. Also, a planning support project for the OMVG (Gambia R. Basin) has been underway since 1982. Environmental monitoring and watershed management assistance were being developed in 1986 as part of a total water resources planning effort.

Lastly, A.I.D. was contributing secretariat funding ($1.0 million) to the West African Fisheries Commission (CECAF).

In 1986, UNDP was supporting the following:

- support to the OMVS National Committee in Senegal;

- dune stabilization near vegetable gardening areas ($850,000);

- forestry training ($600,000);

- an inventory of forests in Casamance and Senegal Oriental, and management of state forests ($590,000);

- strengthening of the agro-meteorological service ($945,000);

Forestry and related activities were being supported by numerous OECD members:

- the Netherlands, Finland, Sweden, and Norway supported various community forestation efforts through FAO and UNSO Trust Funds;

- FRG was financing forestation with gum arabic around well points, which have been degraded by excessive cattle concentrations, and firebreaks of cashew trees in the Sine Saloum;

- Switzerland supported forestry training in southern Senegal (Ziguinchor).

Canada was financing diverse forestry related activities: community forestry near Podor, forest fire prevention, sand dune stabilization, and assistance in forest inventory and management.

Range inventories and management projects were underway by France (research) and FAO (monitoring and surveys and management for sustained production, a former A.I.D. project at Bakel).

SIERRA LEONE

This small country is entirely within the West African Humid coastal lowlands.

A.I.D. had no activities underway in 1986 concerned with natural resources and the environment.

IUCN was supporting the preparation of a National Conservation Strategy.

SOMALIA

Arid Somalia is suited mainly for livestock raising--45 percent of the territory is grazed--except in the extreme southwest, where some dryland farming and traditional irrigated farming exist. UNEP reports that virtually all of the grazing land has been over-stocked and over-grazed. Wood cutting has depleted woody vegetation near towns. Moving sand dunes endanger coastal towns.

In 1986, A.I.D. was supporting:

- a multi-donor agricultural development effort of the Bay Region ($11.1 million);

- rangeland development, a six-year, $19,2 million, multi-donor "central rangeland development" project, begun in 1979, whose purpose is to initiate a range management program in the central region for the country by means of training, technical assistance, water development and other support. Range monitoring, grazing trials, surveys, and various management schemes and associated social organization were to be carried out. Other donors include the World Bank, IFAD and FRG;

- groundwater development aimed at establishment of a national water resource development program, through surveys, water exploitation, training, and institution-building. Sixty-six livestock wells are planned;

- forestation in the environs of refugee camps, executed through PVOs ($6.0 million);

- a master plan for the development of the Juba River Valley ($5.25 million), to be completed in 1986.

Also in the north, A.I.D. has joined with the Kuwait Fund for Arab Economic Development to develop rangelands through reserve establishment, well drilling, fodder production, demonstration, and training (setting up 2-year schools). UNEP judges this project to be successful.

Soil and water conservation support in the northwest was begun by the World Bank in 1977 and is now in its second phase, involving contour bunds and gully erosion control in an entire watershed.

UNDP supported groundwater surveys and development, including institutional strengthening, in the 1970's. Currently, the UNDP program in Somalia includes:

- strengthening and intensification of coastal sand dune fixation activities ($2.6 million);

- rehabilitation and use of rural water reservoirs ($800,000);

- establishment of a national water center ($260,000);

- fisheries development ($4.1 million);

- Peri-urban fuelwood plantations planning ($109,000).

Various donors were supporting anti-desertification work in 1982/83:

- stabilization of coastal sand dunes (Denmark, Africare);

- rural and refugee camp forestation (FRG, Netherlands, Church World Service, CARE, Inter-Church Response for the Horn of Africa, Mennonite Central Committee);

- training in Wildlife management (the United Kingdom).

UNEP reports that sand dune stabilization projects have been quite successful from the standpoints of community involvement and species used (UNEP, 1986).

SUDAN

Sudan's enormous territory extends from the Libyan desert south through the Sahel into the sub-humid tropical uplands of the Southern Provinces, through which passes the Sudd or interior delta, or the White Nile.

All forms of desertification afflict Sudan. These are being surveyed and researched and solutions to them are being sought. Sudan was one of the first countries of the region to formulate an anti-desertification program (DECARP) in 1976, when USAID resumed its program.

A.I.D. sponsored a survey of Sudan's natural resource problems in 1983. This survey was conducted by Sudanese scientists at the University of Khartoum's Institute of Environmental Studiesof natural resources issues in Sudan 1983, University of Khartoum and Clark University).

In 1986, A.I.D. was supporting or had recently supported:

- the development of rural renewable energy technologies ($4.6 million);
- diverse studies and research on resource assessment and desertification, through the Environmental Training and Management Project, carried out through the University of Khartoum's Institute for Environmental Studies, with Clark University;
- numerous village forestation projects through PVO's (CARE, Church world Service);
- research on native leguminous trees, through the NAS's BOSTID;
- surveillance of schistosomiasis in the Gezira scheme, an $8.48-million, 10-year project extending to 1991;
- re-establishment of gum arabic plantations ($500,000, completed).

UNDP was supporting or had recently supported:

- water management research ($2.6 million);
- production of fuel briquettes and improved cooking stoves ($700,000);
- fisheries development in the Sudd (1.0 million);

- re-stocking of the gum arabic belt ($1.5 million);
- management of grazing resources around permanent water supplies ($910,000);
- shelterbelts, northern region ($1.2 million);
- irrigation scheme rehabilitation ($400,000);
- regional drought rehabilitation strategies ($153,000);
- strengthening meteorological department ($190,000).

Other donors' support included:

- World Bank-funded research on dryland farming systems in the degraded and drought-afflicted western provinces. In addition, the World Bank supported a Western Savannah Project that sought to reconcile land-use conflicts between nomadic herders and farmers encroaching onto dry-season range areas, especially through innovations in grazing management;
- research on mesquite (Prosopis juliflora), supported by IDRC;
- grazing resource management around water holes (UNSO);
- re-stocking of the gum arabic belt (Netherlands, Finland);
- village fuelwood lots (FAO for the Netherlands);
- rehabilitation of Khartoum's greenbelt (Finland).

Various projects in the sub-humid Southern Provinces, including the building of the north-south canal through the Sudd, have been suspended because of the civil war.

SWAZILAND

This small nation is located at the northern edge of the subtropical highlands of southern Africa. It has a variety of climates controlled by elevation's effects on temperatures.

In 1986, A.I.D. was supporting land conservation measures (Project 645,0068, $3.0 million), including terraces, grass strips, dams, canals and diversions.

UNDP was supporting:

- training in water resources management.

TANZANIA

A.I.D. projects in Tanzania are being phased out and the mission will be closed in 1986.

Portions of Tanzania are tropical highlands, including the famed Mount Kilimanjaro, but most of the country is divided about equally between arid and semi-arid tropics (from eastern Tanzania to the coast) and sub-humid tropical uplands.

A.I.D. supported during 1980-1984:

- an Operational Program Grant to Lutheran World Relief for improvement of village water supplies and related small-scale irrigation, nurseries and vegetable/fruit gardens ($500,000);

- soil conservation, land-use planning and catchment development in 15 catchments ($590,000).

TOGO

This small neighbor of Ghana spans the humid coastal lowlands and the sub-humid tropical uplands.

No present or planned USAID activities deal with natural resources or the environment.

UNDP has supported groundwater surveys and development in Togo. In 1986, UNDP was supporting:

- a water management strategy, Phase I ($2.2 million);
- soil conservation and management ($136,000);
- reforestation in north Togo ($1.1 million).

A National Conservation Strategy was in preparation with IUCN support.

UGANDA

A National Conservation Strategy was in preparation in 1986, with IUCN support.

ZAIRE

Zaire's natural resource management problems are typically those of the humid equatorial lowlands, described in the attached background document.

A.I.D. has supported the preparation of a Phase II (field reconnaissance) environmental profile in Zaire, published in English and French.

In 1986, A.I.D. planned to support fisheries development in the Central Shaba region, within the context of an agricultural development project. Success with Peace Corps aquaculture activities has been recorded in Zaire. No other activities were underway or planned by A.I.D. having to do with natural resources or environmental management.

UNDP was supporting:

- training in remote sensing ($164,000);
- a planning mission for a program to assist forest and wildlife management sectors ($555,000);
- strengthening of the national fisheries office and improvement of artisanal fisheries ($1.5 million);
- fisheries development ($291,000).

Canada's CIDA will lead a multi-donor review of the forestry sector in 1986, as a follow-up to the FAO Tropical Forestry Action Program.

ZAMBIA

Zambia lies almost entirely in the sub-humid tropical uplands sub-region.

At present, A.I.D. supports no activities concerned with natural resources or the environment.

In 1986, UNDP was supporting:

- a wood energy consumption and resource survey ($392,000);
- a pilot fish culture project ($1.48 million).

With IUCN support, a National Conservation Strategy has been prepared and published.