Integrated Watershed Management Research for Developing Countries

Workshop Report*

by
K. William Easter
and
Maynard M. Hufschmidt
with the assistance of
David S. McCauley

September 1985

*Based on papers presented and discussed at a workshop held at the East-West Center, Honolulu, 7–11 January 1985. Organized and cosponsored by the Environment and Policy Institute, East-West Center, Honolulu, Hawaii, USA, and the US Agency for International Development, Washington, D.C.

ACKNOWLEDGMENT

In January 1985 the East-West Environment and Policy Institute with the cooperation of the University of Minnesota and the University of Arizona, and the sponsorship of the United States Agency for International Development, conducted a Workshop on Integrated Watershed Management. The Institute gratefully acknowledges the cooperation of these collaborators. The workshop was coordinated by Dr. Frank Bollman, Fellow at EAPI, whose organization resulted in a most successful meeting. This workshop report is based in part upon reports prepared by workshop participants as summarized in the notes of rapporteurs Kenneth Brooks, Frank Bollman, K. William Easter, Christopher Gibbs, David McCauley, and Mervin Stevens, and on post-workshop involvement by Kenneth Brooks and Peter Ffolliott.

CONTENTS

FOREWORD

The Environment and Policy Institute (EAPI) of the East-West Center conducts research and education programs through multinational collaboration on environmental aspects of policy and decision making in the East-West region. The program of the Institute emphasizes (1) analysis of dependence and impacts on natural systems and thus on the objectives of the policies, and (2) assessment of scientific and technical information about natural systems for more coherent policy formulation and implementation through planning and management. This systematic approach avoids the polarization of environmental values versus sectoral goals.

Much of the Institute's recent work focuses on the management of land and water resources. An integrating theme for many of these issues is watershed management, which deals with interacting physical and social processes and activities. In seeking ways to improve watershed management, EAPI joined with the U.S. Agency for International Development (USAID) to conduct a workshop in January 1985 with the following objectives:

1. To review national watershed programs conducted in the Asian region
2. To review the status of knowledge concerning management strategies and methods
3. To discuss and identify watershed management research needs

The workshop brought together watershed management experts, USAID mission representatives from selected Asian countries, officials of the Asia Bureau and the Science and Technology Bureau of USAID, and most of the research staff of EAPI. The expertise included the areas of forestry, watershed management, economics, agroforestry, anthropology, soil conservation, and water resources management. Material was presented on the following topics:

1. Rationale for and problems involved in using the watershed as a management unit
2. Conceptual framework for integrated watershed management
3. Basic natural processes involved in watersheds and their management
4. Formulation of watershed management strategies and approaches, involving land use adjustments and physical measures
5. Economic analysis of watershed management strategies and approaches
6. Behavioral and social factors of significance in land use changes in watersheds
7. Implementation of watershed management strategies and approaches
8. Institutional and organizational context of watershed management activities

In presenting these topics, emphasis was on "what we know" and "what we need to know" to achieve effective watershed management. By identifying inadequacies and gaps in information, the needs for research on various aspects of watershed management were highlighted.

The country and regional experts were asked to review the watershed management experiences in their countries or regions. Emphasis was on identifying those aspects of the projects or programs that have been successful and on the problems that have been encountered. These reviews provided a basis for identifying information and research needs.

Following these presentations, small working groups discussed selected problems and issues, information gaps, and researchable questions, developed revised statements covering these aspects, and prepared lists of high-priority research needs and approaches. A synthesis of the workshop presentations, discussions, and working group reports forms the basis of this report prepared by EAPI Fellows K. William Easter and Maynard M. Hufschmidt, with the assistance of David S. McCauley, who wrote the synopses from the workshop papers.

People attending and participating in the workshop did so in their individual capacities and did not represent or speak for their organizations or countries. This report of the workshop's findings, conclusions, and recommendations presents the spectrum of views expressed at the meeting. It should not be assumed that every participant subscribes to every statement, although a broad consensus was reached on most major points.

This report is the first step in communicating some of the results of this workshop. In future publications and in follow-up meetings, we anticipate that the work begun will continue and reach a wider audience. In this way, we hope that we are contributing to a creative resolution of issues that are vital to national and international interests of countries in the region.

William H. Matthews, Director
Environment and Policy Institute
East-West Center

DEFINITIONS

A *watershed* is a topographically delineated area that is drained by a stream system. The watershed is a hydrologic unit that has been described and used both as a physical-biological unit and as a socioeconomic and sociopolitical unit for planning and implementing resource management activities.

A *river basin* is similarly defined but is of a larger scale (for example, the Mekong River Basin, the Amazon River Basin, and the Mississippi River Basin).

When the term *watershed* is used in this report, it refers to a subdrainage area of a river basin.

Integrated watershed management is the process of formulating and implementing a course of action involving natural, agricultural, and human resources of a watershed, taking into account the social, economic, and institutional factors operating within the watershed and the surrounding river basin and other relevant regions to achieve specific objectives. Typically this process would include establishing watershed management objectives, formulating and evaluating alternative resource management actions involving various implementation tools and institutional arrangements, choosing and implementing a preferred course of action, and, through monitoring of activities and outcomes, evaluating performance in terms of degrees of achievement of the specified objectives.

The *watershed approach* is the application of integrated watershed management in the planning and implementation of resource management and rural development projects. Imbedded in this approach is the linkage between uplands and lowlands in both biophysical, socioeconomic, and institutional/organizational contexts. For example, upland watersheds are source areas for surface water and groundwater recharge while downstream agriculture and urban development are directly dependent upon such water supplies.

SUMMARY

Regardless of the nature and scope of rural development, the watershed is a significant and useful spatial unit for analysis during planning. Physical aspects of the watershed, if ignored, can cause serious problems for project implementation. Furthermore, in numerous cases, the watershed is the appropriate unit for project implementation. The watershed management approach includes both the natural and the social systems, with special emphasis on the linkages between upland and lowland areas and their respective human and physical endowments. A conceptual framework embodying the watershed management

approach helps to identify important research problems and issues that arise in the management of natural resources.

Research and Information Needs

The primary objective of the workshop was to identify watershed management research and information needs. Twenty-four important needs were identified and grouped under five themes. (Those shown in boldface type deserve, in the opinion of the authors, special emphasis and priority.)

Information Systems and Flexible Planning Models

- **Develop a rapid diagnostic methodology to assess the condition of watersheds and to formulate and evaluate possible courses of action (p. 13).***
- Devise a land capability classification system for upland tropical and subtropical watersheds in Asia (p. 13).
- Adapt multiple objective planning methods and systems analyses to the limited data conditions of developing countries (p. 15).
- Devise procedures for developing flexible plans and implementation approaches appropriate to Asian watershed conditions (p. 15).
- Develop and test alternative procedures for incorporating monitoring, assessment, and evaluation methods into project management during the implementation stage (p. 19).
- Devise alternative techniques for measuring and incorporating soil productivity losses and downstream damages into watershed monitoring and evaluation systems (p. 20).

Quantification and Valuation of Upstream-Downstream Relationships

- **Develop improved methods for measuring and valuing the downstream impacts of soil erosion in tropical and subtropical watersheds (p. 15).**
- Devise methods for quantifying and valuing the on-site effects of long-term soil and nutrient loss due to soil erosion and leaching under various land use and management practices (p. 14).
- Evaluate the transferability of alternative resource management actions and technologies for controlling soil erosion (p. 14).
- Study the linkages between hillslope and channel processes to determine changes in sediment quantities, water qualities, and bed and bank processes in downstream channels. Analytical models are needed that are appropriate for predicting changes in tropical and subtropical watersheds (p. 14).

Participation in Watershed Management

- **Adapt training and extension methods to develop effective staffs of field-level change agents for work in upland watersheds (p. 17).**
- Develop and evaluate alternative approaches for involving local participants in project planning and implementation, including concerns for: local capacities for implementing practices, obstacles to participation, bureaucracies as catalysts for local action, and activities best performed through local groups (pp. 13, 18).
- Develop procedures for educating the hill or upland people of Asia concerning the environmental consequences of alternative land uses and practices (p. 17).
- Devise and evaluate alternative systems for providing relevant local information to project decision makers (p. 18).
- Determine the contributions which nongovernmental organizations and the private sector can make to watershed management (p. 19).

Using Past Experience to Improve Watershed Management

- **Evaluate alternative management activities to determine the incentives required**

* The page numbers in parentheses refer to later discussion of the research.

for small-scale farmers to adopt management practices that sustain long-term soil productivity and reduce downstream damages (p. 17).

- Study actual experiences in implementing land use changes in tropical and subtropical watersheds of Asia (p. 13).
- Evaluate the land resettlement experience of selected Asian countries (p. 17).
- Develop information concerning the impact of road construction in upland tropical and subtropical watersheds on downstream areas and on human migration into upland areas (p. 16).
- Develop farming systems that are appropriate for steep slopes (p. 14).

Organizational, Institutional, and Policy Concerns

- **Review resource management policies of individual sectors—agriculture, energy, forestry, and mining—to identify the major inconsistencies and conflicts with national resource management objectives, including those for watersheds (p. 20).**
- Evaluate the effectiveness of legal and policy instruments that affect land and water use and determine how these instruments effect the incentives for alternative land uses and management practices (p. 18).
- Analyze management approaches to determine how organizational structure, leadership, communications, authority, and flexibility affect project implementation (p. 19).
- Study the effect of country food and development policies on the implementation of watershed management programs (p. 20).

Research Approaches

Much past research on watershed management has been an ad hoc response of individual researchers to small parts of the overall management problem. Improving the management of upper watersheds requires an integrated approach. Biophysical and socioeconomic research and information must be organized and designed so that the results can be readily used by planners and decision makers.

A combination of information exchange, case studies, action research, and pilot projects can be used to address many of the research topics. Research should be designed to provide generalizations that can be used for planning and implementing watershed management projects. These studies should include the following elements: (1) methodologies for the interdisciplinary analysis of watersheds based on the framework discussed in the workshop and presented in this report; (2) formulation of hypotheses using questions presented in this report as a starting point; (3) collection and analysis of information concerning the actual implementation of watershed management programs; (4) devising measures to test the feasibility and transferability of resource management actions and implementation tools to specific watershed situations; and (5) devising methods for monitoring and providing local feedback on the performance of watershed management projects.

This research is needed to provide a clearer picture of past and ongoing Asian experience with watershed management. The work must be a collaborative effort where researchers from various countries and institutions work directly with people in the watershed.

INTRODUCTION

A growing concern exists that many parts of the developing world will continue to have problems providing food and fuel well into the next century. Agricultural production has expanded during the past two decades with the help of new crop varieties and greater use of inputs such as irrigation water and fertilizer. Yet these increases in production have barely kept ahead of growing populations in many countries. The rapidly rising population in Asia will put increasing pressure on the agricultural and forestry land and water resources, especially in the upland areas.

A growing number of experts warn about high levels of soil erosion in the upper watersheds of Asia that not only reduce forest and agricultural productivity but also cause sedimentation and water pollution problems downstream. Flooding is aggravated by sedimentation in river channels. Reservoirs to provide flood control, irrigation, or power production are silting up at rates much faster than anticipated. In many cases, the useful lives of reservoirs are being substantially reduced.

Many current resource management approaches—such as forest preservation, fragile lands protection, agroforestry, farming systems, and integrated rural development—do not take adequate account of these upstream-downstream interactions. In contrast, an integrated approach to watershed management gives promise of enabling planners to include these interactions in planning and implementing development projects. This suggests that serious consideration should be given to the wider use of the integrated watershed management approach in developing countries and to use it as an important element in planning all types of resource development and management projects and programs.

Rationale for the Integrated Watershed Management Approach

In general, the objective of regional resource management or rural development is to exploit the productivity of natural systems to improve the welfare of the affected population within the national development objectives. Simultaneously, such programs should minimize conflict, social disruption, unsustainable use of natural resources, inequitable distribution of benefits and costs, and adverse environmental impacts. The watershed is a spatial unit that fits many of these concerns. It highlights the physical aspects of the landscape, which, if not recognized, can lead to serious problems in project implementation (Figure 1). When development involves intensive use of land and water resources, the watershed unit contains the principal linkages and issues that should be considered.

The rationale for the watershed approach to rural development projects, whether directed toward agriculture, forestry, rangelands, water resources, or a combination of these, can be summarized as follows:

- The watershed is a functional region that includes the key interrelationships and interdependencies of concern for land and water management.

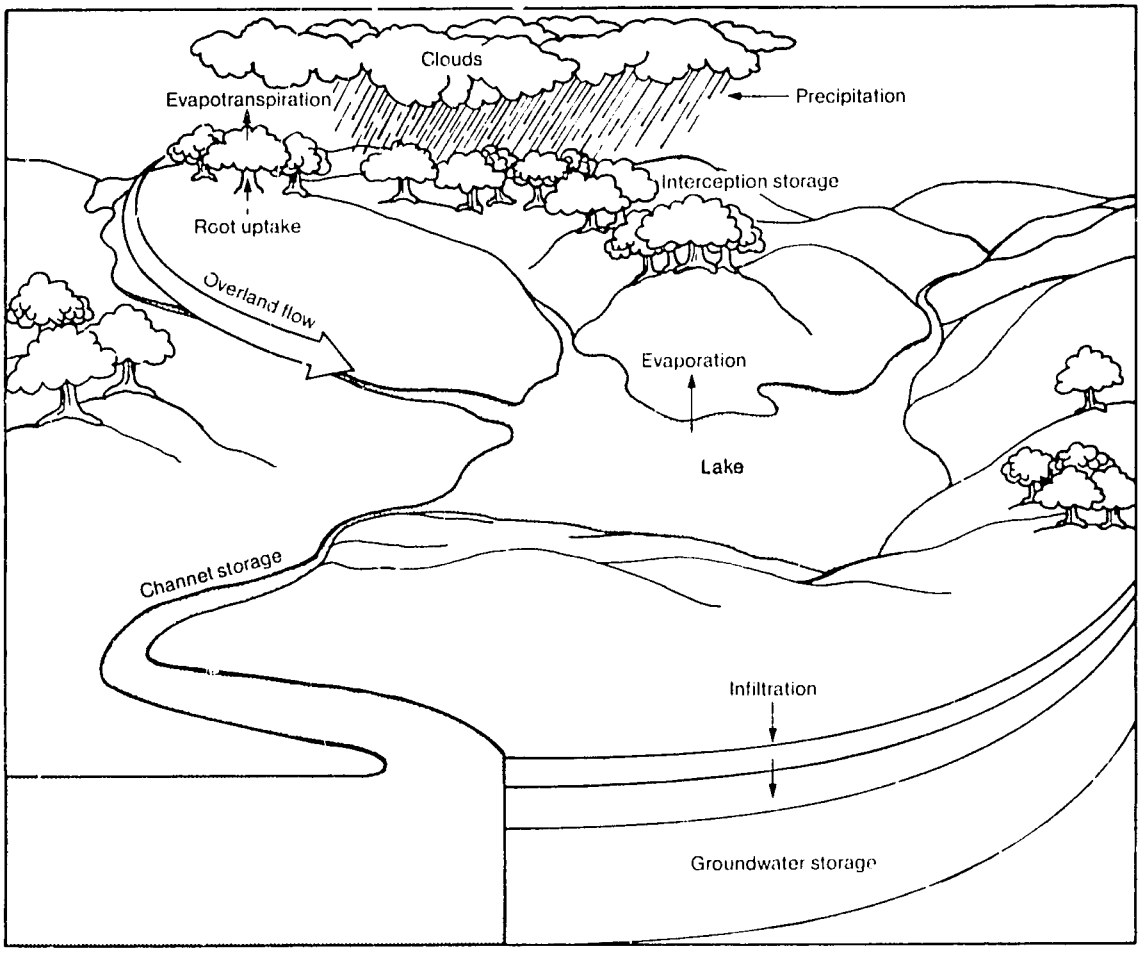

Figure 1. Hydrologic cycle for a watershed (Source: Adapted from Warshall 1980).

- The watershed approach is logical for evaluating the biophysical linkages of upstream and downstream activities.
- The watershed approach is holistic, enabling planners and managers to consider all relevant facets of resource development including on-site and off-site changes and impacts. This approach accounts for the whole complex of biophysical, social, economic, and institutional factors that bear directly on the development of sustainable management programs.
- There is a strong economic logic in the watershed unit since it internalizes many of the externalities involved with land management practices.
- The watershed allows for ready assessment of environmental impacts including the effects of land use activities on ecosystems, both upstream and downstream. Thus, the effect of upland disturbances, which often result in a chain of downstream consequences, can be readily examined within a watershed context.
- The watershed framework allows for consideration of human interaction with the environment.
- The watershed approach can be inte-

grated with other programs, including forestry, soil conservation, rural and community development, or farming systems.

In summary, the watershed approach can be used to examine upstream activities and their biophysical and social consequences. The outcomes of continued watershed use or degradation can be evaluated in terms of on-site and off-site impacts, and needed adjustments can be identified. Recommendations from the evaluation flow back to management, which can then take remedial actions.

Properly applied, the watershed management approach includes both the natural system and the social system. This is in contrast to some rural development projects that focus on the social system and consider the ecosystem as a constraint. They pose the question: What must we do to the natural system to extract more income and services for the social system? The opposite view has also been taken under natural resource-based rural development projects, which pose the question: How can we remove the people so we can preserve the ecosystems?

CONCEPTUAL FRAMEWORK

The conceptual framework is used to help sort out the important problems and issues that arise in watershed management. It is based on work done at the East-West Center on natural systems assessment and valuation and on water resources management over the past five years (Carpenter 1983, Hufschmidt et al. 1983, Bower and Hufschmidt 1984). This framework is equally valid when the watershed approach is used to plan and implement a wide range of sectoral projects such as agriculture, forestry, energy, mining, transportation, human settlements, fisheries, and wildlife (Hufschmidt 1985).

Major Elements of the Framework

The framework consists of three dimensions, each representing a different but related analytical approach. The dimensions are: (1) watershed management as a *process* involving separate but closely linked stages of planning and implementation; (2) watershed management as a planned *system* of resource management actions and implementation tools applied to a watershed through a set of institutional and organizational arrangements; and (3) watershed management as a set of linked *activities* for which specific management *tasks* are required.

The Process of Watershed Management

The conventional delineation of watershed management occurs as sequential steps of project planning, design, installation, operation, and maintenance, with monitoring and feedback of information to earlier steps of the process (Figure 2). In developing countries, actions on watershed management often begin with the perception of a problem, which leads to a decision to prepare a project or program plan. Plan formulation leads to a project feasibility report that provides the basis for a decision to implement the project. The planning stage is completed with the design of the project. Typically, implementation begins with installation of resource management practices, often involving substantial capital expenditures. This stage of implementation (which may involve detailed designs) may take several years and is followed by an ongoing program of operation and maintenance.

Monitoring and evaluation will be required throughout as watershed management pro-

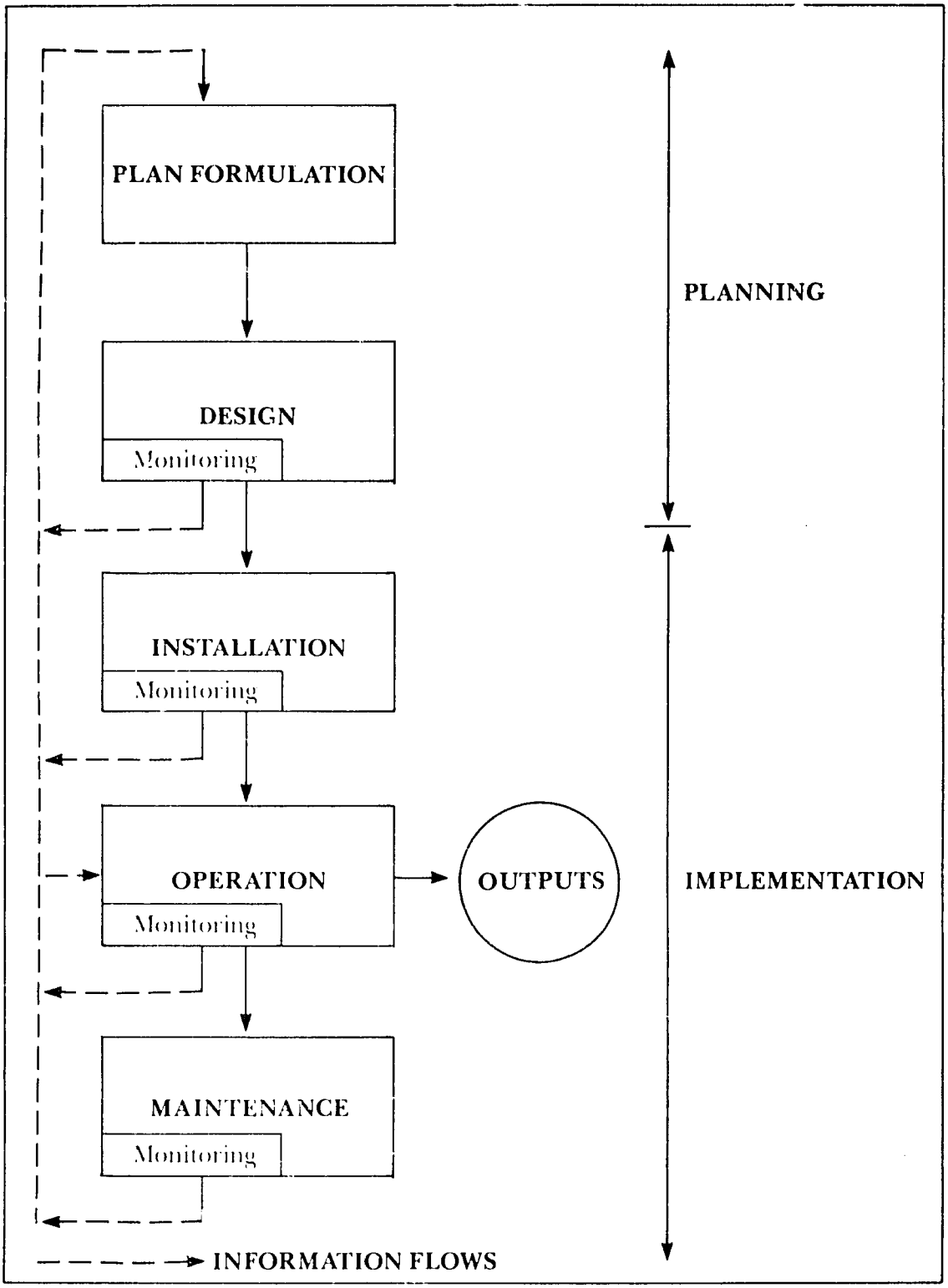

Figure 2. The five stages of integrated watershed management (Source: Hufschmidt 1985).

ceeds. Each land use or management practice must be evaluated in terms of its on-site and off-site (downstream) effects. Measurement of off-site effects on natural systems will require a separate physical and economic analysis, which extends beyond the site boundaries. Monitoring and evaluation will be an iterative process where a land use or management practice is introduced and physical changes and associated benefits and costs are measured. After the evaluation, the practice may have to be altered or dropped and new practices applied.

Watershed Management as a Planned System

In this dimension watershed management is seen as a planned system of (1) resource management actions, including land use assignments, on-site resource utilization and management practices, and off-site management practices; (2) implementation tools for carrying out the resource management actions; and (3) a set of institutional and organizational arrangements within which implementation proceeds (Figure 3).

The planned system makes a clear distinction between resource management actions—"things to be done"—and implementation tools—"ways of getting things done." Watershed management planners often concentrate on designing resource management actions without designing implementation tools to an equivalent level of detail, which often leads to serious problems at the implementation stage.

This system also specifically identifies institutional and organizational arrangements as key elements in planning and implementation—elements that play an important role in the success or failure of watershed management plans.

Watershed Management as a Set of Activities and Tasks

Watershed management is seen as a set of linked *activities* for which specific management tasks are required to produce the desired outputs and effects on the natural system. For example, as a first activity, the entire watershed area would be subdivided into various types of existing or prospective major land uses (agriculture, grazing, agroforestry, commercial forestry, multi-use forestry, protection forestry, mining, transportation) based on a land use assessment. Next, for each operating unit in a given type of land use, the *on*-site resource utilization and management practices would be developed. For agriculture, on-site practices would include the types and rotations of crops, soil conservation methods, tillage methods, and other farm practices. For commercial forestry, on-site practices would include tree species to be grown and harvested, rotation policy, and methods of tree planting and harvesting.

Finally, to handle the downstream effects of the on-site land use activities, a set of off-site management practices would be applied in-stream and along stream borders. These include debris removal, channel improvements, and stream bank protection by riparian buffer strip preservation, revegetation, or riprapping.

Application of the Framework

Each of the three dimensions represents a different but related analytical approach to the watershed management problem. The analytical task could be approached by selecting an element from one dimension and analyzing it in terms of the other two dimensions. For example, one may wish to focus the analysis on the planning stage of the management process dimension (Figure 2). To begin this analysis, one would construct a table (Table 1) in which management activities would be arranged in rows and management system elements in columns. The table would then be completed by listing the task required in each of the boxes. For example, if the important concern was planning the implementation tools for on-site resource utilization and management practices, the appropriate row and column of Table 1 lists the required tasks as planning for education, technical help, economic incentives, marketing assistance, and regulation.

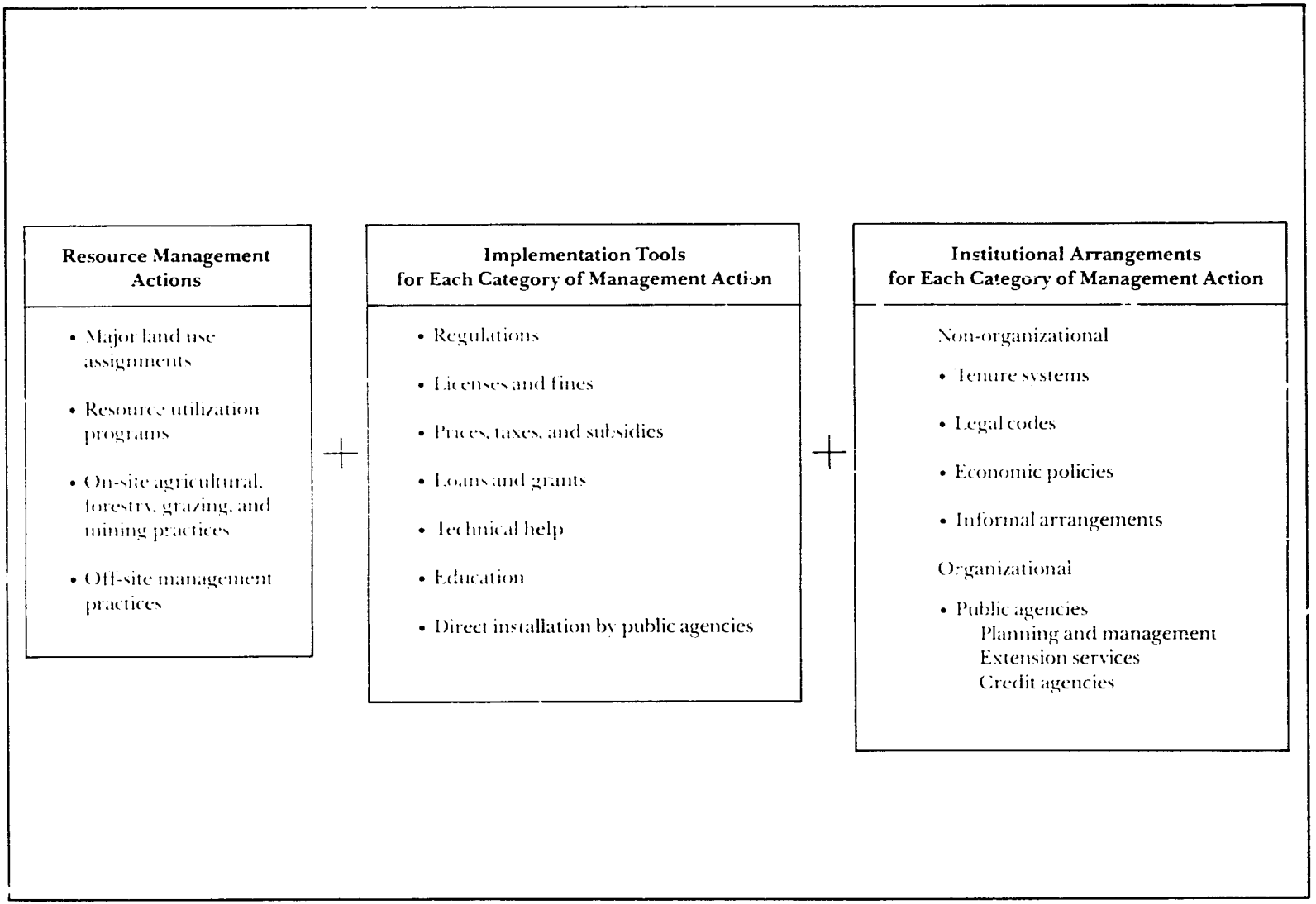

Figure 3. Watershed management as a planned system (Source: Hufschmidt 1985).

Table 1. Examples of Watershed Management Tasks Required at the Planning Stage, Classified by Management Activities and Management System Elements

MANAGEMENT ACTIVITIES	MANAGEMENT SYSTEM ELEMENTS		
	RESOURCE MANAGEMENT ACTIONS	IMPLEMENTATION TOOLS	INSTITUTIONAL ARRANGEMENTS
LAND USE ASSIGNMENT	• Land capability analysis • Land suitability analysis • Formulation and benefit-cost analysis of alternative land-use plans	Planning for • Regulation • Economic incentives • Education	Planning for • Ownership/tenure systems • Public regulation systems • Organizational changes
ON-SITE RESOURCE UTILIZATION AND MANAGEMENT PRACTICES	For agroforestry • Agronomic, forestry, and economic analyses of types, distribution and rotation of tree and low crops • Planning for methods of tilling, methods of cropping, erosion control practices	Planning for • Education • Technical help • Economic incentives • Marketing assistance • Regulation	Planning for • Extension services • Credit/financial aid • Ownership/tenure systems • Soil Conservation Agency
OFF-SITE MANAGEMENT PRACTICES	Planning for • Stream bank vegetation, protection or revegetation • Channel dredging • Riprapping • Intake water treatment	Planning for • Education • Technical help • Economic incentives • Public installation and maintenance	Planning for • Extension services • Credit/financial aid systems • Soil Conservation Agency

Source: Hufschmidt 1985.

Used in this way, the analytical framework enables one to isolate specific aspects of watershed management for detailed examination, and provides a basis for studying specific watershed management experiences. For example, a case study using this analytical framework may show that major emphasis is placed on installation of resource management facilities, to the neglect of their operation and maintenance. Alternatively, planning for resource management actions may receive much more attention than planning for implementation tools and institutional arrangements. With such analyses, management failures can be traced and specific steps for improvement justified.

RESEARCH AND INFORMATION NEEDS

Watershed management problems and associated research and information needs are grouped under two broad headings—planning and implementation—taken from the conceptual framework. Although some items overlap in each of these categories, the classification highlights the importance of problems encountered at the planning and implementation stages. Finally, several broad development and food policy issues related to watershed management are listed under a third category, policy research issues.

In the summary, a different classification is used. Issues are grouped to emphasize important common elements of research problems identified in both planning and implementation. This provides the reader with an alternative way to organize the research issues and brings out different complementaries.

Planning

Watershed management planning generally begins with the identification of a natural resource problem, need, or opportunity and the development of related social, economic, and natural system objectives to serve as a guide to planning. The planning process continues with the basic biophysical, economic, demographic, social, and institutional analyses required for the formulation of alternative watershed management plans. Projections are made of future demographic and economic conditions and trends. Plans include various combinations of resource management actions, implementation tools, and institutional and organizational arrangements for conducting resource management actions. Alternative watershed management plans are evaluated using criteria developed in terms of the basic objectives, and the planning stage concludes with the selection of the preferred plan for subsequent implementation. The major steps of this planning process are summarized in Figure 4.

Plan formulation is an iterative process that starts with postulating initial land use assignments to major uses such as agriculture, forestry, mining, and human settlements. For each initial land use assignment, on-site resource utilization actions and management practices are formulated. On-site and off-site biophysical, economic, and social effects are then quantified and evaluated. Based on the results of these analyses, the land use assignments, resource utilization actions, and management practices are revised. A set of accompanying off-site management practices are formulated, and the total watershed management plan is evaluated. This process may undergo several iterations and may include formulation of two or more alternative watershed management plans.

Effective planning is an integral part of successful rural development programs. Regional rural development planning that ignores watershed characteristics is likely to result in serious environmental problems. Thus the water-

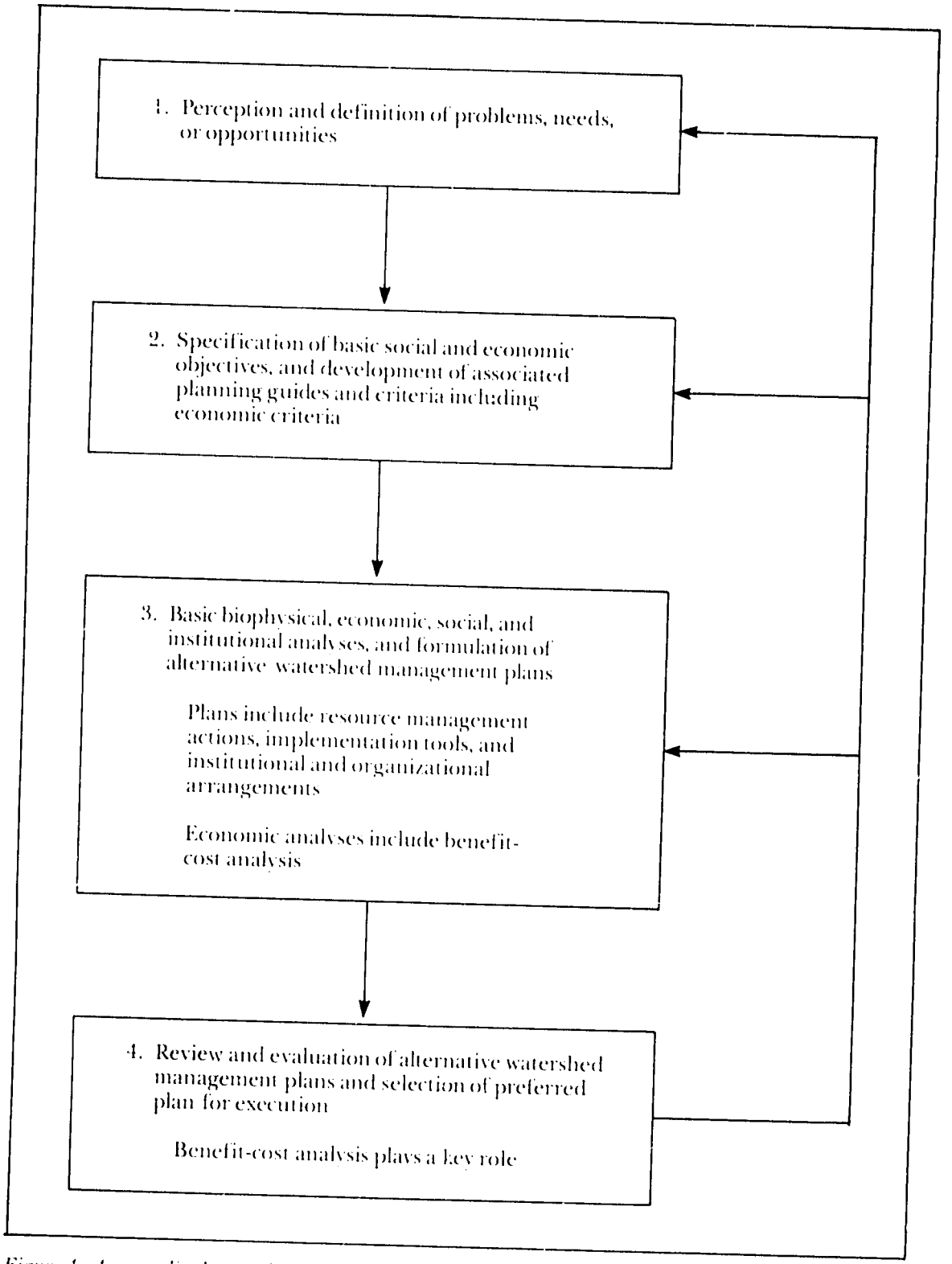

Figure 4. A generalized watershed management planning process.

shed management planning steps should be an important part of planning for regional rural development.

Watershed management problems encountered at the planning stage and the associated needs for research and information are grouped under seven headings.

The Overall Planning Process

Planning methodology. To provide timely information for policymaking and program development, diagnostic methodologies are needed for rapid assessment of the biophysical and socioeconomic conditions of a watershed and to formulate and evaluate possible courses of action. Such rapid appraisal methodologies must be adaptable to the limited data and analytical resources usually encountered in developing countries.

Local participation in planning. Watershed management projects usually involve the activities and interests of many people who occupy and use the land or who are affected by such land uses. This is especially true in many upstream watersheds where shifting cultivation is a common practice. Yet rarely are local groups brought into watershed planning because of the gulf that often exists between planners and watershed inhabitants (Lovelace and Rambo 1985). The irrigation experience has shown that effective implementation of watershed management projects would be furthered by active participation of affected local groups at the planning stage. Studies are required to formulate and evaluate alternative approaches for involving local participants in planning, including disadvantaged groups and women.

Land Use Assignments

Assignment of watershed lands to suitable uses requires information both on existing land uses and on the inherent capability of land for various uses. Such assignments usually involve a balancing of these two often competing factors. At one extreme, the inherent land capability of an undeveloped watershed based on biophysical factors such as geology, soils, climate, topography, and vegetation would be given great weight in making assignments to major land uses. At the other extreme, for a heavily populated watershed, such biophysical factors would be given less weight and existing conditions would receive much greater attention. Even here, however, these factors, often expressed in terms of biophysical limitations, might point to desirable land use shifts to slow down reductions in on-site land productivity and to reduce adverse off-site effects such as flooding and sedimentation.

Analysis of land capability. An important tool in guiding land use assignments is a system for land capability classification. Although a number of such systems have been developed and tested for temperate zone use, few are available for tropical and subtropical watersheds in Asia, especially for uplands (Haderlie 1985). There is a need for systems that can be applied under conditions of limited data and which are acceptable to various resource management agencies in developing countries. Also involved is the carrying capacity concept (with varying amounts of inputs) as a possible aid in land classification. In addition, there is need for the standardization of definitions, units, and techniques of analysis.

Experience with existing land uses. In some heavily populated watersheds, such as Java, the pattern of existing land use imposes severe constraints on achieving more suitable land uses as indicated by the land capability analysis. Yet where on-site and off-site damages are serious, some changes in land use may be socially and economically desirable. Of crucial importance at the planning stage is information on the experience with implementing land use changes in such critical areas. For example, experience may show that relatively modest changes from agriculture, including shifting cultivation, to agroforestry have been successful (Vergara 1985). Accordingly, studies of actual experiences in implementing land use changes are needed as inputs to the planning stage.

On-site Resource Utilization Actions and Management Practices

Biophysical analysis of land productivity. Biophysical information is needed to develop sustainable farming systems for the full range of soil, topography, and climate encountered in tropical and subtropical regions. According to Haderlie (1985), "The farming systems appropriate to steep slopes (50% and steeper) have not been adequately developed. . . . There is good evidence that sustainable silva-pasture, agroforestry and even limited annual cropping could be put in place *on steep slopes*, but a substantial research effort to support this is needed."

Biophysical and economic analysis of on-site effects. There is need for site-specific methods of quantifying the on-site effects of long-term losses of soil and nutrients via erosion and leaching under various land uses and management practices. Even when such information is available, it is difficult to translate into estimates of productivity losses and the associated economic effects. The economic consequences of soil erosion depend on management decisions and on such factors as rainfall intensity. Thus, models such as soil rating indexes developed for temperate zone situations need to be adapted specifically to tropical and subtropical watersheds.

Effective transfer of appropriate technology. In devising resource utilization plans such as cropping systems and management practices for soil erosion control, there is need to analyze the transferability of the technologies to the affected rural groups. The willingness and ability of the people involved to adopt new techniques is related to the social and economic suitability of the technology and to the cultural characteristics of the people. Biophysical, social, technological, and economic evidence from experimental stations and "early innovators" is not always shared by less advantaged groups or even by the majority of the population (Raintree 1983). Care must be taken to ensure that technologies are adoptable by a majority of the group and especially by the disadvantaged. There is need for application of results of basic research in social and agricultural systems, so that technologies appropriate to the existing social structure are selected.

Biophysical analyses of off-site effects. It is often difficult to identify and quantify off-site biophysical effects of land uses and management practices in tropical and subtropical watersheds. The ability to quantify the effects of upstream land management practices on downstream sediment yield and on water yield, quality, and time distribution diminishes rapidly as one moves away from the upstream site.

To deal with these problems at the planning stage, there is need for a site-specific network of measurement stations for streamflow discharge, water quality, erosion rates, and sediment transport and delivery rates to provide the basic data. There is also a need for analytical models to estimate the physical impact of alternative land use and management practices that are appropriate for watersheds in tropical and subtropical regions.

Also needed are methods of rapid identification for especially sensitive areas of watersheds—that is, areas subject to mass wasting and high rates of erosion from cultivation, grazing, logging, and road construction. The linkages between hillslope processes and channel processes are often neglected in studies of erosion and stability of forest lands. This is a key research gap in watershed management because the major costs to society from headwater degradation are the changes that occur in sediment quantities, water quality, and bed and bank processes in downstream channels (O'Loughlin 1985).

Techniques for predicting sediment loads from upper watersheds and its distribution in reservoirs are limited. Methodologies for the rational extrapolation of both discharge and sediment rating relationships also are needed. In some cases given adequate data, sediment ratings can be extrapolated by the use of sediment transport functions to calculate transport rates.

Fundamental biophysical principles of watershed management including upstream-downstream linkages are fairly well understood. A lack of local knowledge and data hinders the adaptation of resource management actions and practices to specific conditions so that they can be successfully integrated into land management systems.

Assessment and economic valuation of off-site effects. Even with adequate information on the off-site biophysical effects such as stream and reservoir sedimentation and water pollution, serious problems arise in quantifying and valuing the consequences on downstream fisheries, wildlife, agriculture, hydroelectric power production, irrigation water supply, domestic and industrial water supply, and flood regulation. Also needed are physical response models for particular uses, such as sediment-fishery response models and better methods of economic valuation of the downstream physical responses to upstream activities. In particular, improved methods are required for valuation of adverse effects on recreational resources and amenity values. Furthermore, studies are needed to determine the linkages or relationships between upland and lowland groups that may influence watershed management activities (see Russell and Nicholson 1981, pp. 43–75).

Off-site Management Practices

Problems of formulating appropriate off-site management practices are closely linked to problems of quantifying and valuing the off-site effects of upstream land management. Also, the economic justification for various off-site practices depends upon the relationship of the costs of the practices to the damages that such off-site practices would prevent. Accordingly, models and analytical methods are needed to provide physical and economic inputs to the design of off-site management practices.

Implementation Tools

Many problems arise in the implementation of watershed management plans, which could have been anticipated so that solutions could have been developed at the planning stage. Specific problems associated with implementation tools, and related information and research needs are discussed in the implementation section.

Institutional and Organizational Arrangements

Existing institutions, organizational arrangements, including administrative or political boundaries often impose severe constraints on implementation of watershed management plans. It follows that institutions and organizational arrangements should be considered as variables at the planning stage. In fact, if adequately understood and adapted, existing arrangements may offer important opportunities. The major institutional and organizational problems that require information and research are discussed in the implementation section.

Overall Plan Formulation and Evaluation

Both the underlying theory and the application of approaches to plan formulation and evaluation have been well developed for natural resources in general and for water resources, including river basins, in particular. This is true for some developing as well as for developed countries.

Specialized planning methodology. There is a special need for the adaptation of the planning approach to the realities of integrated watershed management in developing countries. Upstream-downstream linkages are socioeconomic and political as well as biophysical. Ethnic diversity is a common feature in many upland areas of developing countries. Also, the multiple objectives of watershed management—efficiency, equity, and natural resources sustainability—and the multiple uses for the land and water resources add to the complexity of the planning problem. Development of a specialized watershed planning methodology for developing countries and its trial application in specific watershed planning projects are needed.

Flexible planning methods. Another aspect of watershed management in developing countries concerns (1) the uncertainty that pervades the estimates and assumptions on which plans are based, and (2) the many actors involved in watershed management, especially the large number of users of the land and water resources. These uncertainties point toward the need for plan flexibility and adoption of an implementation policy of "learning-by-doing." This will require early monitoring and evaluation with rapid feedback to watershed managers. Flexible planning and implementation approaches need to be developed and tested on specific watershed management projects (Easter and Gibbs 1985).

Implementation

Problems associated with implementation of watershed management plans result from a number of factors, including: (1) little or no local participation, (2) inadequate extension and technical assistance programs, (3) inadequate testing and development of resource management actions, (4) delays in the delivery of key inputs, (5) a fragmented government organizational structure, (6) conflicting interests among various actors, (7) inappropriate institutional arrangements, and (8) political boundaries unrelated to watershed boundaries. While this is only a partial list of reasons for inadequate watershed management, it highlights the difficulties facing government officials and the need for better information, which research can provide. To improve implementation of watershed management plans, research is needed in resource management actions, implementation tools, institutional and organizational arrangements, and evaluation and monitoring.

Resource Management Actions

Watershed management programs involve a variety of resource management actions that are diffuse and generally occur over a long time period. In the simplest case, such programs involve a set of well-understood management practices. However, watershed management programs are often more complex and involve significant changes in land use. In many cases the projects must include practices that not only protect soil and water resources but also offer increased opportunities and income for farmers.

An additional concern is with the transferability of technology and the social and behavioral aspects of particular groups. The ability of people to adopt new resource management actions must be considered both at the planning and implementation stages. It may not be clear until the implementation stage that people are having difficulty with new practices. Research is needed to determine if flexibility can be built into a program so that practices can be adjusted or new implementation tools such as training and education programs can be developed.

Roads in upper watersheds have a major impact on both the physical and social conditions of the watershed. Our information on these impacts is largely from temperate areas. Since the effects of roads on soils and slopes in the tropics and subtropics are generally greater than in temperate zones, research is needed to measure these impacts under a variety of climatic conditions. The effect of roads on social conditions, particularly the impacts on migration patterns in the upper watersheds, needs special research attention.

Implementation Tools

A task as important as selecting the appropriate resource management actions is to determine how each will be implemented. A range of implementation tools, or policy instruments, can be used (Hufschmidt 1971, Baumol and Oates 1979). These include regulations, prohibitions, taxes, subsidies, education, technical assistance, resettlement, increased off-farm employment, pricing, zoning, licenses, fines, grants, and direct public installation. The key task is to provide the appropriate incentives, economic and other-

wise, and then make sure the users understand the management action and the incentives. The use of implementation tools must be as carefully planned as the various management practices that are to be installed.

Resettlement experience. Because one of the important concerns for many watersheds in Asia is the pressure of population on the natural environment, land resettlement programs have been tried in a number of countries. An evaluation of this resettlement experience is needed in countries such as Indonesia and Sri Lanka. Studies should compare the results under different levels of population pressures, employment rates, land resettlement opportunities, and adjustment problems. These studies can help establish guidelines for resettlement programs in upper watersheds.

Incentives for implementation. Two basic problems in upper watersheds involve economic incentives and the need to design implementation tools that will apply the appropriate incentives. First is the difference between the small-scale or low-income farmer's need for short-term soil exploitation to obtain a minimum subsistence and society's interest in maintaining long-term soil productivity and land resource stability. The second key problem is the difference in benefits and costs received by upstream cultivators whose actions generate high rates of soil erosion and downstream interests who experience the mostly negative sedimentation impacts. The research problem is to develop, test, and evaluate alternative implementation tools to determine how best to deal with these problems.

Extension and training. Training and extension methods need to be developed to provide effective field-level change agents for implementing watershed management projects. Specific research and extension needs include determining how to: (1) identify existing resource management systems and rural conditions quickly and reliably; (2) assess the productivity of farming and agroforestry systems, especially for staple food crops; (3) identify or devise technologies that raise household productivity; (4) identify the skills needed by change agents to interact effectively with the local community; (5) simplify and apply the analytical tools of production economics to upland farming and agroforestry systems, based on farmer information, to ensure program efficiency and to monitor change; and (6) develop methods to effectively demonstrate watershed management benefits to watershed residents.

Local environmental education. A related research project is to develop an effective and acceptable procedure for environmental education among the hill or upland people of Asia who tend to be isolated and separated from the rest of society. Educational materials must use terms that are understandable. The delivery system must reach the hill people in their village settings, allowing for a two-way flow of information. Dani (1985) suggests that a starting point for research might use the following steps:

1. Determine farmers' perceptions of environmental resources and the largest social group with which they identify.
2. Discuss with farmers the nature of ecological processes and do a joint evaluation of alternative strategies for resource conservation.
3. Examine with farmers the highland-lowland interactive ecological problems and the lowland policymakers' perceptions of ecological problems.
4. Jointly evaluate the various programs for development that would require watershed management actions.
5. Review with farmers the pros and cons of various watershed management actions and assess the possible benefits to them and to lowlanders.
6. Develop a joint management strategy for implementation and maintain a dialogue concerning the ongoing process of envi-

ronmental education and the success of the strategy.

To be truly effective the process would have to be flexible, and a similar dialogue would be necessary between lowlanders and decision-makers. In that case, the roles of lowlanders and the uplanders would be reversed (Dani 1985).

Location specific information. Research should be conducted to determine what local information is needed during the implementation stage and how that information can best be collected. These comparative studies would involve: (1) traditional resource management systems and environmental knowledge; (2) environmental awareness of watershed occupants and how their awareness levels can be raised; (3) socioeconomic and political character of watershed communities and the boundaries of their influence; (4) biophysical characteristics of the upper watershed; (5) resource tenure, and security of access to resources; (6) nature of farming and agroforestry systems, especially the annual cycles and productivity trends of staple food crops; and (7) the actual distribution of project benefits and costs as compared with the expected distribution.

Institutional and Organizational Arrangements

Institutions are collective conventions and rules that establish acceptable standards for individual and group behavior, reducing individual uncertainty concerning the actions of others (Bromley 1982). Organizational arrangements involve how firms or government agencies achieve goals; this includes how a central planning agency decides to implement an irrigation project or how a ministry of power and irrigation decides to allocate water for irrigation rather than for power generation. Institutions also help define organizations through laws and administrative decisions, which establish principles and guidelines for their formation and conduct.

Institutional and organizational arrangements often have been neglected in project planning and implementation. When a proposed project will significantly change land use, it will have a major effect on the area's institutional arrangements. To ignore these effects usually condemns the project to poor performance or outright failure.

Legal framework. There is a dearth of information available on the formal legal framework under which watershed projects are planned and implemented. Traditional land use rights are seldom well documented, appreciated, or understood. Work should be directed into exploring legal foundations for effective land and water resource management on a country-by-country basis. The existing legal and policy instruments that affect land use must be evaluated to determine what incentives they provide for alternative land uses. Finally, institutions that encourage the desired land use and help mediate conflicts arising from competing land rights and land use patterns must be developed.

In addition, security of land tenure for watershed occupants is necessary if occupants are to conserve and protect the watershed. Very little research indicates how best to provide this security and to evaluate the response of farmers to different levels of security (Saplaco 1985). In some cases a form of private ownership will likely be appropriate, but in others community ownership works best. Alternative property rights need to be tried and evaluated under different socioeconomic conditions.

Local participation. As mentioned earlier, participation by target beneficiaries in both the planning and implementation of rural development projects is recognized as a necessary but not a sufficient condition for success. Resource management projects that do not include local participation from an early stage generally fail to produce the desired results. However, some aspects of watershed management, such as negative downstream effects, are unlikely to be considered by upper watershed residents, and the management agency must

maintain responsibility for basin-wide interactions.

Participation by watershed occupants in planning, designing, implementing,and evaluating watershed management projects will require information about organization at three levels: (1) the policy level, making the participatory approach legitimate; (2) the agency level, organizing people to facilitate participation; and (3) the village level, organizing people to solve local problems and to become more involved in the choice and implementation of projects.

Important research topics include deciding how to build local capacities for implementation of watershed management projects, which can further the sustainability objective; pinpointing the obstacles to effective participation in watershed management at the policy, agency, and village levels, examining the lessons of successful participatory approaches used in natural resources management or rural development that may be applicable to watershed management, and determining whether certain activities and tasks are best performed using participatory means; determining what we can learn from existing (or historic) traditional systems of resource management that may be applicable to watershed management; and analyzing how we can help bureaucracies to become enablers of local action if that is the appropriate strategy.

Management approaches. Analysis of available management approaches is needed with specific concern for the organizational and administrative problems. The analysis should consider organizational structure, leadership, communications, authority, and flexibility. These factors should be related to: (1) the type of project under investigation (single purpose or multi-purpose and single agency or multi-agency), and (2) the effectiveness of the project in meeting the goals of both the agency and the watershed occupants. One general question that needs to be answered is under what circumstances is it best to use central watershed-based authorities for implementation versus local (political) administrative units? Watershed management programs and activities need to be linked with other forms of rural development that focus on related problems. The techniques developed in implementation research should be used in this analysis (Easter and Gibbs 1985). Finally, the results of case studies should be synthesized in order to draw out the most important common conclusions and implications for future project planning and implementation.

Involvement of other organizations and groups. Participation in watershed management programs usually focuses on government agencies and personnel, the research community, and members or segments of the targeted population. This focus frequently overlooks other organizations whose involvement can make a positive contribution.

Two particular groups deserving attention are nongovernmental organizations (NGOs) and private/commercial firms. NGOs can be of many different types, ranging from associations of resource-consuming industries to charitable and religious/missionary groups. Analyses are required to identify which NGOs exist and are appropriate for assisting in planning, implementing, and evaluating particular watershed programs.

The private commercial sector can also play a positive role in the long-term, sustained solution of such problems as deforestation. Research is needed to determine how watershed management policies will encourage or discourage involvement by this sector. Consideration must also be given to the types of incentives that will encourage the private commercial sector to be positively involved in the planning and implementation of watershed management programs.

Evaluation and Monitoring

If a "learning-by-doing" approach to project implementation is adopted, evaluation and monitoring (assessment) become a continuous process to provide feedback to field-level implementers and managers at headquarters.

Implementation should not rigidly follow a set plan established at the planning stage but should change in response to information gained from assessment and evaluation.

Evaluation for management. How can assessment and evaluation best be incorporated into the management structure to achieve effective implementation of watershed-related projects? What is needed is a system in which the information is effectively communicated among villagers, field workers, and agency managers. Proper design of watershed management plans for achieving a full range of physical, economic, and social objectives requires an understanding of existing social conditions and the opportunities and constraints posed by these conditions. These objectives need to be explicitly integrated into the watershed management plans and specific strategies developed for implementation and adequate monitoring.

Additional questions are involved in incorporating evaluation with ongoing management. What particular constraints are involved in using evaluation as a "learning tool" in management? What evaluation methods are appropriate under different circumstances? What information is most important at each level of project activity, and how should this information be reported? How can the maintenance of a community-level data base aid in the evaluation and assessment task?

Measuring soil productivity and downstream damages. How can better techniques be developed to measure and incorporate the impacts of soil erosion both on downstream areas (off-site) and on soil productivity (on-site) in watershed evaluation and monitoring systems? For a given watershed many different types of downstream damages can occur. In addition, some of these damages will be cumulative, while others relate closely to major rainfall events.

Policy Research Issues

Development and food policies. A number of broad development and food policies can influence watershed management; these include migration, employment, population growth, food production, and incentives for private sector activities. For example, a country may pursue an all-out policy of increasing food production that works against a watershed management program trying to reduce soil erosion with agroforestry practices. Thus research is needed to study the effects of different development and food policies on the implementation and success of watershed management programs. How do migration and population growth policies help or hinder watershed management efforts? How can regional growth and employment policies help reduce population pressure in upper watersheds? Will the results of these policies be too far in the future to be of any help?

Separate sector policies. Countries have tended to develop individual policies and relatively autonomous agencies for each natural resource sector—forestry, agriculture, irrigation, energy, mining, fisheries, and wildlife. The problem is that many of these policies are either fragmented or inconsistent. For example, the upstream mining policies in the Philippines are in conflict with energy and irrigation policies. This suggests the need to (1) review the individual resource sector policies (e.g., agricultural policy) for consistency with national resource management objectives, including those for watersheds, and (2) study the various natural resource management policies to determine how inconsistencies can be reduced. It is particularly important to understand exactly how resource use activities in upstream areas influence downstream uses.

Another area of potential conflict is the difference among local, regional, and national purposes for watershed management. Local participants tend to concentrate on the on-site effects and tend to ignore important off-site effects. The regional (river basin) and national purposes must be recognized so that these off-site effects can be taken into account. Local residents may be resistant to any practices that are primarily to help the urban population.

Are there implementation tools and incentive systems that will overcome this resistance?

Finally, in policy terms, the importance of the implementation stage of program management has to be fully recognized. In watershed management programs a key element in implementation is flexibility. This strategy must be incorporated in the planning stage so that managers are not left with practices and incentive systems that do not work or need to be greatly refined. Research on flexible planning methods, local participation, and local information systems will provide some important insights into the question of program flexibility.

RESEARCH APPROACHES

A number of approaches can be used to obtain the necessary information to improve watershed management. One of the important considerations will be how to improve research capacity of each country. Currently watershed management research is a neglected topic, and most Asian countries have only limited research capabilities to work on watershed problems (FAO 1982). Thus there should be support for research in universities, research institutions, and similar organizations within Asian countries. Research activities of the type being started by the International Centre for Integrated Mountain Development (ICIMOD) and by the Association of Southeast Asian Nations (ASEAN)– United States Watershed Project should be supported and expanded. These types of organizations can be of particular importance in establishing networks and studying watershed management problems that cut across national boundaries. They can also act as facilitators and coordinators in their regions.

Past research on watershed management has tended to consist of piecemeal responses to problems. This approach provides useful information, but the nature of the problem suggests a more vigorous and integrated effort. Investments must be made to increase research capacities and to start new integrated research projects, while efforts are made to redirect some of the ongoing research.

Biophysical information and research must be organized and presented so that it is readily used by planners, economists, and decision makers and can be integrated with economic, social, political, and institutional studies. The emphasis should be on watersheds where future development is anticipated so that information is available before decisions concerning development have to be made.

The types of technical relationships needed for watershed analyses vary but should relate the watershed condition and management actions to physical outputs that have meaning in economic, social, environmental, or management terms. Even more important than the biophysical relationships is the information concerning the economic, social, cultural, political, and institutional situation. It is this latter information that is needed to develop strategies and activities to provide solutions that are acceptable to local people and institutions. However, to obtain these results will require a redirection of research efforts.

The Approach

Selected integrated case studies can be an effective approach particularly in the legal, policy, economic, institutional, and organizational fields. Research should be based on theory and not be merely descriptive. For the case study approach to be effective, the cases should involve five elements:

1. Refinement of conceptual frameworks, models, and methodologies for interdisciplinary analysis of the behavior and performance of biophysical, social, economic, institutional, and organizational elements of watersheds. The starting point could be the conceptual model discussed earlier in this report.

2. Formulation of testable hypotheses and researchable questions with respect to relationships among the physical, biological, social, economic, political, institutional, and organizational factors operating in the concerned watershed. Again, the section on research issues would be the starting point.
3. The collection, analysis, and interpretation of information on actual experience with resource management actions, implementation tools, and institutional and organizational arrangements in watersheds.
4. Devising measures to test the feasibility, adaptability, and transferability of resource management actions and implementation tools to particular watershed situations.
5. Devising appropriate measures for monitoring the performance of watershed management implementation, including ex-post analysis, and for obtaining feedback concerning changes in practices, tools, or institutions.

Case studies should examine past experiences and progress of ongoing projects in developing countries. Special attention should be given to successful projects so that there is a careful analysis and documentation of what has worked. In addition, problems and constraints should be identified and studied to determine where the greatest difficulties are likely to arise. Finally, the research should develop an overall picture of past experiences, including the key opportunities, constraints, and lessons to be learned from experience with past watershed projects.

Any such research must be a collaborative effort where researchers from developing countries work directly with those from developed countries. Researchers and research institutes in developing countries must play a key role since they will continue the work over the long haul. To be successful, the research effort must be a long-term program (10 to 20 years) to build research and institutional capacities.

Another research approach is "action research" where researchers actively participate in planning and implementing a watershed management project. This approach has been supported by USAID in its work in irrigation water management. The emphasis is on research results which can change the operation of an ongoing project as research is conducted. It is different from traditional case studies, which tend to look at completed projects and develop information solely to improve future projects. Both kinds of research are needed and would involve the five elements suggested for case studies.

A related strategy would be to use a pilot project approach in which watershed management practices are tested under actual field conditions before the full project is implemented. This would mean selecting a trial area in the watershed and having villagers use these management practices and cropping systems, including trees and grasses. Different tools would be used to induce the villagers to adopt the desired measures. Such approaches would help to build solid causal theories for watershed management projects and strong local political support.

The pilot stage may have to be preceded by a research program that would design and test alternative cropping or agroforestry practices and systems. Once some of these systems are developed, the pilot plan could begin. Until these practices and systems can be tested under actual farming and forestry conditions, full-scale watershed management project implementation should not start.

In some situations, farmers will need to be shown that the new practices are actually profitable. For these cases, a combination of pilot project, technical assistance, and training may be necessary. Thus the first phase of the project's implementation might be a pilot project along with staff training. Farmers could also receive training at the pilot project stage.

A further consideration in research approaches is the involvement of local people in the research. Where possible, they should be active participants in the research, rather than

merely subjects of research. In this way, villagers will feel that they are part of the solution rather than merely part of the problem. The involvement should start as soon as possible, even at the planning stage of the research. Local people may have objectives and information needs that, when added to the research effort, will increase their interest in the study. Local involvement is essential when research is being conducted concerning local information systems, training, extension, environmental education, and incentive systems.

An important part of any watershed management research effort is concern for the dissemination of results. Special efforts and funding are needed to facilitate the exchange of information among researchers and between researchers and decision makers. This can be done through research networks, workshops, and training programs. Regional organizations such as ASEAN and ICIMOD should play an important role in this type of information transfer. The East-West Center, with its experience in sponsoring workshops and training programs on Asian and Pacific problems, can also play a role throughout the region.

SYNOPSES OF WORKSHOP PAPERS*

An Overview of Watershed Management Research Needs

Integrated Watershed Management in Asia and the Pacific
K. William Easter and Kenneth N. Brooks

Among the most important problems facing the countries of the region are the need for a continued increase in agricultural production to meet rising food demands, the management of forest and fuelwood resources, and the control of excessive soil erosion that is silting reservoirs and irrigation systems, exacerbating lowland flooding, and depleting the productivity of upland areas. The use of the watershed as the management unit in both the planning and implementation stages can aid in efforts to overcome these challenges. The use of a watershed approach is by no means new and is increasingly taking hold in Asia. The application of the concept usually focuses on managing the upper reaches of river basins. There are few examples of its use in the context of fully linking upland and lowland development.

The approach has proven difficult to use in the past for reasons concerning the nature of the resource management problems that it seeks to mitigate. Most management activities conducted in watershed-based projects, such as soil conservation practices or reforestation efforts, are spatially and temporally diffused. Since their immediate returns are not apparent, and most benefits accrue during a longer term, the political and financial attractions of such activities are limited.

However, based on existing knowledge of the interactions among natural resources, human resources, and social institutions in tropical and subtropical watersheds, one can conclude that management problems are both formidable and in need of immediate attention in many locations. Research has shown, for example, that large floods are nearly inevitable but may be further aggravated by river sedimentation and channelization; the quality

*Not all authors of papers had an opportunity to comment on these synopses; responsibility for any inaccuracies is assumed by the authors of this report. Some of these papers will appear in altered form in a forthcoming book, *Watershed Management: An Interdisciplinary Approach*, edited by K. William Easter, John A. Dixon, and Maynard M. Hufschmidt. For more information on the book, contact the East-West Center. For original versions of the workshop papers, contact the authors (see List of Participants).

of water in streams, rivers, and lakes and of groundwater can be drastically altered by watershed disturbances; and erosion and sedimentation are closely related to soil cover and are interrelated with changes in hydrologic processes. Unfortunately, these biophysical data are seldom produced in usable formats for decision makers.

Research relating to the implementation of watershed projects, the institutional context within which projects are implemented, and the economic criteria used to evaluate projects is much less developed than the biophysical knowledge. A greater understanding of the institutional arrangements, which can inhibit or facilitate implementation of watershed management activities, is needed. Strong evidence indicates that a key element missing from most rural resource management and development programs has been a clear mechanism for ensuring the participation of local communities in the planning and implementation process.

Three recent EAPI workshops focused on the linkages between research and effective watershed management. The first workshop investigated the role of natural systems assessment as a tool for policymakers and showed how technical information and knowledge can be used to generate policy alternatives for resources management. The second workshop, on river and reservoir sedimentation, stressed the need for analytically based case studies to provide guidelines for watershed management. The third workshop considered the effects of forest land use on erosion and slope stability and stressed soil management over tree maintenance as a key to improved upper watershed management.

The major causes of these resource management problems stem from greatly increased demands for land and land-based products. Very large development projects are often implemented without adequately accounting for their adverse impacts, such as soil erosion caused by road construction. Few efforts to quantify damages are available and while the fundamental principles behind erosion and sedimentation are understood, specific data from Asia and examples linking hillslope and channel processes are lacking. Finally, a serious undersupply of trained people to support management activities and multiple objective planning, and a need for greater political will to conduct such planning, are still critical problems.

The time is right to initiate an integrated interdisciplinary research and training effort on watershed management in Asia and the Pacific. Such an effort should be based on learning from past experience and knowledge, which then should be incorporated into ongoing and future programs and projects. It must be interdisciplinary, using methods capable of combining the most rigorous analysis of many disciplines. This major effort must also be long-term and collaborative, ideally on the same order as the program to develop Asian agricultural universities during the 1950s and 1960s.

The Watershed as a Management Unit and a Conceptual Framework for Integrated Watershed Management

The Watershed as a Unit for Planning Rural Development Projects
Lawrence S. Hamilton

The choice of administrative boundaries for planning and implementation of rural development programs and projects is not an idle concern. Boundaries must be relevant to the principal planning issues, cover sufficient natural and social linkages to operate as a functional unit, and allow objective plan implementation. They may be defined on the basis of administrative, economic, social, political, vegetative, or topographic factors or some combination of these.

Under certain circumstances, a watershed can serve as the most appropriate unit for planning rural development programs and projects. Where interactions among land, water, climate, and people are the major focus of development, the watershed appears to have many advantages as a unit, since these interactions are most strongly expressed within its boundaries.

Several criteria may be used to evaluate the appropriateness of the watershed unit. The kind of development envisioned—especially the extent to which control or management of water resources is involved—can be an important indicator. The watershed should also be distinguishable from other units on the basis of its providing sufficiently strong linkages among economic, social, political, and natural systems. The development envisioned should largely be contained within the river basin with a minimum of leakages in either biophysical or social terms. The topography must allow for an adequate definition of the watershed boundaries. The institutional and organizational arrangements should either exist or be developed to support the use of a watershed as a management unit. Finally, the unit is easier to use in areas where the economic and social systems remain relatively simple and confined within a spatially constrained area.

The watershed is capable of integrating natural and social systems to effectively plan and manage rural development programs and projects. It captures the major biophysical pattern of downstream water flow, the process of downstream energy flows in the form of kinetic energy to be tapped for hydropower, and the transfer of nutrients, sediments, and pollutants. The watershed boundary can also capture many significant social system linkages—especially in developing countries where upland-lowland and valley-to-valley differences in ethnic groups and economic specialization occur. In rural areas social systems are interwoven with ecological systems, and ecologic processes are highlighted in watershed planning.

Finally, while the watershed has great validity for planning under many circumstances, the institutional and organizational arrangements necessary for the use of the watershed in the implementation phase of the management process are seldom in place. The management unit for water use and for human services (i.e., the farm, a state forest, an ethnic community's boundaries, or a political district) is seldom coterminous with the hydrologic unit. This creates an inherent challenge for the use of watersheds in the implementation stage. Planners should suggest the various implementation strategies and those appropriate groups, power structures, institutions, and management units that appear to be the most likely candidates for change to aid in the use of the watershed unit. Continuous information exchange and education concerning the basic validity of the watershed as an integrating unit will always be required.

Watersheds as Functional Regions: A Case Study of the Hawaiian Ahupuaa
Joseph R. Morgan

An example of the validity of using watersheds as planning units for rural development can be found in the ancient Hawaiian land use system. A most important unit of land was the *ahupuaa*, a functional region with boundaries determined by topographic divides that separated individual drainage basins or watersheds. The *ahupuaa* was both a natural region in which there were sufficient resources to completely sustain the community inhabiting it and a political division under the control of a chief. The chief, or *ali*, was thus both environmental manager and political ruler. Since the *alis* were dependent on the product of the land and its sustainability, and were also bound by a number of sensible rules (*kapus*) that had evolved over hundreds of years, they tended to manage the resources prudently. The *ahupuaa* system worked exceptionally well for the subsistence societies of pre-contact Hawaii.

The system began to break down after 1778, when Captain James Cook opened the islands to Western influence and introduced the Hawaiians to a trading economy that subsequently supplanted their former subsistence economy. The breakdown was accelerated by a general loss of faith in the *kapus*, which also were religious in nature, and a shift from a feudal system of land use to one based on individual ownership of land. Finally, a Western-style government, in which administrative units no longer coincided with the watersheds, evolved.

Although it operated in a subsistence economy, the *ahupuaa* system of land use—with its attendant management of resources for sustained productivity—provides lessons that can be valuable to today's environmental and political leaders.

A Conceptual Framework for Analysis of Watershed Management Programs
Maynard M. Hufschmidt

As an aid in classifying the important problems and issues that face watershed management projects and programs, a conceptual framework for watershed management is suggested. To accommodate watershed management, defined as the process of formulating and implementing a course of action involving manipulation of the natural system of a watershed to achieve specified objectives, the framework is designed with three elements.

The first element is concerned with the manner in which discrete projects are planned and implemented. From this perspective, watershed management can be thought of as a sequential process of separated but linked stages, namely, planning, design, installation, operation, and maintenance. In addition to this linear sequence, monitoring and evaluation mechanisms provide feedback of information to allow for improvements in project planning and implementation. In the second element of the framework, watershed management is perceived as a planned system consisting of management actions, implementation tools, and institutional arrangements. Here the emphasis is on drawing clear distinctions among things to be done, ways of getting them done, and the agency, legal, traditional, and other institutional and organizational bounds that make up the context in which the planned system must operate. The third element of the framework approaches watershed management from the standpoint of the activities and tasks that are to be planned and implemented. These activities consist of land use assignments, on-site resource utilization and management practices, and off-site management practices.

The three dimensions of the conceptual framework may be combined to define 45 discrete tasks in watershed management, but in practice it may be more manageable to deal with one or two of the dimensions in isolation. The framework provides a useful checklist both for analyzing planning and implementation tasks and as a guide for ex-post analysis. Whether used as a planning or diagnostic tool, the framework highlights the importance of considering the role of institutions and organizations in watershed management.

Biophysical Principles for Integrated Watershed Management

Multiple Use Implications of Watershed Management
Peter F. Ffolliott

Multiple use is cited as a guiding principle in many discussions of watershed management. However, while there has been little difficulty in gaining acceptance of the multiple use concept, it has had less success as a working tool of watershed management. The multiple use concept may be area-oriented and applied to units of land or it may be resource-oriented and applied to particular natural resources. When applied to land units, it refers to the production and management of various resources on a specific land management unit. When applied to a particular natural resource, multiple use refers to the utilization of a resource for various purposes.

The basic objective of multiple use is to manage the natural resource complex for the most beneficial combination of present and future uses. Three overlapping options for multiple use management of watersheds are concurrent and continuous use of watershed resources; alternating, rotating, or combining resource products; and/or geographic separation of resource uses.

Problems with the application of multiple use planning in watershed management stem in part from the resource-oriented bias of planners relative to the area-oriented concerns of implementers. In addition, the need

to have estimates of natural resource production and to express the internal and external benefits and costs of a land management system present particular challenges to the application of multiple use principles in watershed management.

Despite these challenges, the multiple use framework can be used to provide watershed managers with an array of economic relationships designed to aid decisions. However, it should also be anticipated that there may be policy and institutional issues that must be resolved before a land management system becomes operational within a multiple use context.

The Potential Role of Agroforestry in Integrated Watershed Management
Napoleon T. Vergara

Significant populations of upland farmers located in upper watersheds of Asia must be accommodated both now and into the future. Both lowland farmers displaced by population pressures and upland ethnic communities are reluctant to move from upper watershed catchments. Unfortunately, farming practices of these populations, under increasing land pressures, are leading to a greatly increased scale of land degradation in the uplands. Attention should be focused on formulating land use strategies that can make feasible and acceptable the use of these uplands by farming communities. This paper proposes that agroforestry systems—combined forestry/food crop farming—meet these criteria and represent an important potential land use pattern for upland watershed areas.

Among the several candidates for upland land use systems, including forests, food crop farming, and pasture-grasslands, agroforestry has some significant advantages. Properly designed and maintained, systems combining tree and food crop cultivation can provide slope stabilization and erosion control while producing crops in demand by subsistence farm families. Agroforestry systems can maintain the productivity of upper watershed land resources through reducing the export of plant nutrients, minimizing erosion and runoff losses, increasing the rate of natural nutrient inputs through the use of nitrogen-fixing trees and food crops, and the judicious use of fertilizers to add nutrients from outside of the system.

Sustainable agroforestry systems, by making possible continuity of upland production, could eliminate many reasons for resettlement of upland farmers. There is evidence that where former swidden cultivators have been allowed to choose their own mix of tree and seasonal crops, agroforestry systems can offer an acceptable sedentary alternative to shifting agricultural practices. Research studies also show the long-term economic viability of many agroforestry systems.

Significant challenges remain in further extending the use of agroforestry systems as upland land use alternatives. Forest administrators remain largely opposed to nonforestry uses of upper watersheds, but many are beginning to understand the need to deal with people as well as trees. Land tenure insecurity will continue to inhibit the viability of agroforestry systems for some time to come. The inaccessibility of upland areas, perishability of many agroforestry products, and small production scale associated with agroforestry systems create marketing problems that further constrain their viability. Efforts to include local communities in the design of agroforestry systems will need to be increased if technology adoption problems are to be overcome.

Needs for further research to support these efforts can be divided into two categories. Biophysical research should focus on the identification of areas suited to agroforestry, on the consequences of its use, on design of viable systems, and on the systems' relationships to broader watershed management objectives. Socioeconomic research should concentrate on adoption constraints, economic viability of systems, and the interaction between local and regional management objectives.

Economic, Behavioral, Social, and Institutional Factors in the Planning and Implementation of Integrated Watershed Management Projects

Economic Aspects of Integrated Watershed Management
John A. Dixon and K. William Easter

There is a natural logic to the watershed as an organizing unit for physical and hydrological analysis stemming from the unidirectional flow of cause and effect relationships. Likewise, there is a strong economic logic for the use of the watershed as an analytical unit. This follows from the flow of physical factors and the fact that actions in one part of the watershed can have effects on another, sometimes distant and usually downstream, part of the watershed.

A key role of economic analysis in the watershed approach is to identify and then internalize externalities (i.e., where some of the benefits or costs of an action are received or borne by individuals who are not involved in decisions relating to the action). Most of the benefits or costs of decisions can be included in the analysis when the watershed unit is used, since most of the externalities are internalized within its boundaries.

Economic analysis of a watershed project or plan will usually be done in a benefit-cost or project evaluation framework. A financial analysis may be conducted in which only those benefits or costs that directly affect individuals or firms are considered. Alternatively, an economic evaluation may be made in which externalities are included, and benefits and costs are counted as they affect society's welfare. Such analysis often indicates that policy actions and the development of institutional and organizational arrangements are needed to make the project both financially and economically profitable. Institutions or administrative procedures must often be established so that people upstream, for example, can gain from actions taken to benefit people downstream.

Certain evaluation techniques aid in the effective analysis of watershed projects. A cost-effectiveness approach may be used to compute the cheapest way to achieve a predetermined goal when the volume or value of benefits from this goal is difficult to estimate. With and without analysis compares the situation that will likely occur if the project is implemented with the no-project situation. Ex-ante analysis provides assistance in decisions relating to alternative actions before the project is built, while ex-post analysis allows us to learn from experience after the project is operating. Discounting, an essential component of benefit-cost analysis, provides a mechanism whereby benefits and costs that occur at different points in time may be compared and weighted. Many techniques for the valuation—quantification and monetization—of the various inputs and outputs of watershed-based projects exist, and innovative approaches are rapidly developing. Sensitivity analysis is a useful means for identifying critical assumptions in watershed management plans.

While economic analysis is only one part of the watershed management process, it is important to have the economics of the project clearly defined. The use of both financial and economic analysis is crucial to this process. New procedures for valuing project benefits and costs make the analysis much more comprehensive, and this is aided by the use of the watershed as the unit for analysis. A critical gap, however, remains in our quantification of the downstream impacts of upstream resource uses, and a concerted effort to better quantify these downstream effects is needed to further improve the quality of economic analysis applied to watershed-based projects.

Behavioral and Social Aspects of Integrated Watershed Management
George W. Lovelace and A. Terry Rambo

An analysis of the behavioral and social aspects of watershed management is best conducted from a human ecological perspective in which two semiautonomous and interrelated systems, the natural ecosystem and the

social system, are seen as interacting with one another. The two systems are linked through exchanges of energy, materials, and information—the natural system being altered to suit social system needs and the social system coevolving with the natural in continuous adaptations.

These systems are open, and relatively discrete pairs of systems in the upper, middle, and lower portions of watersheds interact with each other through both direct and indirect flows. In upper watersheds, for example, communities with very different social systems may be in close proximity, with one group practicing sedentary agriculture on the valley floor while the other maintains a system of shifting cultivation on nearby hillsides.

In contrast with the generally downstream direction of flows within the natural systems of a watershed, there is a decidedly upstream flow of social and cultural influence as lowland populations encroach on those in the uplands. Watershed planners and implementers must recognize that social system factors such as culture, ideology, ethnic relations, and religion often affect the viability of management measures just as strongly as economic or technical considerations. Moreover, lowland and urban biases tend to exist among planners; these biases further inhibit understanding of social and behavorial variables operating in upland areas.

The application of a human ecological framework to the analysis of social and behavorial obstacles to effective watershed management highlights the complexity of the systems and of the management task. It also directs project planners and managers to options relating either to the improvement of existing land use patterns or to the introduction of new patterns that are sustainable within both the natural and the social systems. The current state of knowledge in this area is weak, with inherent problems in the transferability of such knowledge. Much greater efforts are needed to meet the information and institutional development requirements of watershed management plans, which seek to adequately consider the social and behavioral aspects of their implementation.

Implementation and Institutional Aspects of Integrated Watershed Management
K. William Easter and Christopher Gibbs

Growing concern about high levels of soil erosion in the upper watersheds of Asia and the downstream effects of such erosion has prompted increasing efforts to improve watershed management. The introduction of effective management measures has been hampered, however, by neglect of institutional and organizational arrangements in the implementation phase of watershed-related projects and programs. Institutions are defined as the rules that govern individual or group behavior, while organizations are more formalized manifestations of conventions such as families, firms, governmental agencies, or political units.

For each alternative watershed management measure considered in the planning phase, a range of implementation tools and institutional and organizational arrangements must be considered if the necessary tasks are to be combined in an effective implementation system. The literature on policy implementation provides guidance to the key questions that must be answered at the program or project level if a reasonable opportunity for effective implementation is to be assured. A central conclusion, which may be drawn from an analysis of this literature, is that user participation and flexibility—the ability to learn and change as the program progresses—must be built into both the planning and implementation phases.

Institutional analysis indicates that it is not sufficient to define new watershed management practices that are technically and economically superior to those currently in use; new or modified institutional arrangements must complement these techniques if they are

to be adopted. Thus, at the policy, institutional, or operating levels of decision making on natural resource management alternatives, institutional arrangements are more usefully considered as variables than as assumptions (i.e., the status quo). Moreover, institutions in their nonorganizational form are embodied in property rights, which define opportunities and create incentives.

Useful lessons regarding incentives for individual action, for collective action, and for resource conservation may be drawn from the experience with irrigation water management in Asia. This literature also provides helpful guidance relating to organizational issues such as farmer participation in planning and implementation, organizational incentives, coordination within organizational hierarchies, and criteria for evaluating management tasks.

Research Needs for Improved Watershed Management in Selected Asian Countries

Status of Watershed Management Research and Identification of Needed Research in Indonesia
Engkah Sutadipradja

Indonesia faces several pressing watershed management problems. On the densely populated islands of Java and Bali, forest lands are encroached upon because of population pressures, and in the uplands, steeply sloped nonforest lands are used intensively for food crops, resulting in very high levels of soil erosion. In less densely populated areas *alang-alang* (*Imperata cylindrica*) grasslands and other critical lands are expanding rapidly.

In response, during the Fourth Five Year Development Plan (1984–89), the Government of Indonesia identified 22 "super priority" watersheds among 36 priority watersheds for the conduct of reforestation on forest lands and regreening (afforestation) of nonforest lands. The objectives of these programs are to control or minimize upland soil erosion and adverse lowland effects of deforestation, to increase upland productivity and farm incomes, and to strengthen the natural resource conservation awareness of upland farmers. These programs are a cross-agency cooperative effort and are implemented at the provincial and district levels, with special assistance from the Ministry of Forestry and its 11 Land Rehabilitation and Soil Conservation Centers. Since 1976, more than 1,250,000 hectares have been reforested and almost 3.5 million hectares regreened, with the latest tree survival rates at 67.5 percent and 56.3 percent, respectively, for the two programs. In addition to the tree planting, bench terracing and check dam construction are also increasingly important components of the regreening program. Gains from the program include greater farmer awareness of conservation, better coordination among agencies for watershed management, good results with bench terraces and dryland cropping systems for some agro-climatic zones, particularly those with slopes of less than 50 percent; and good results with the use of the *taungya* system for reforestation, with check dams, and with the corridor system for reforestation on islands other than Java.

Research is needed to respond to factors that have limited the success of these programs. Immediate attention is needed to better document watershed information, develop viable land use practices for slopes of more than 50 percent, devise an inexpensive and standardized land evaluation process for Indonesia, develop better forest fire control techniques, develop better information concerning the relationships between logging and soil erosion, adapt conservation techniques to particular agro-climatic conditions, conduct off-farm employment studies in the uplands, develop better information on grass and forage crops for use on terrace risers and for agri-silviculture, establish permissible soil loss rates by soil type, devise better upland extension methods and curriculum for watershed management training, develop alternatives to shifting cultivation, and study the legal aspects of watershed management. This research will be challenging due to weak coordination, standardization, and information transfer among the existing research agen-

cies. Better links need to be formed with policymakers who currently do not use research findings and are often more interested in lowland issues.

Soil Conservation Research in Tropical Watersheds: Status and Implications for Future Research Programs and Institution Building
Van K. Haderlie

Indonesia's watersheds can be broadly classified into humid watersheds that are either densely or sparsely populated and drought-prone, sparsely populated watersheds. In the past, land use management problems associated with each of these three watershed types have largely been dealt with on a project basis. Efforts are now under way in Indonesia to develop a national program of conservation and watershed management coordinated by the directorate general of Reforestation and Land Rehabilitation.

Past research efforts have focused on biophysical aspects, but the direction is beginning to change in favor of greater attention to socioeconomic and institutional aspects of watershed management. Efforts are also needed to overcome the lowland bias of past agricultural research. A long biophysical research agenda includes improved soil loss measurement techniques; development of a standardized land capability classification system capable of accounting for the special needs of densely populated uplands; work on the productivity of dryland terraces; better integration of soil moisture management and soil conservation research; crop residue management studies; field testing of the data on cropping systems and integration of this information into a farming systems approach, including livestock and tree crops; development of steep slope (>50%) management techniques and farming systems; work on developing vegetation for highly degraded critical lands; and studies on open grazing management practices for the eastern islands. Research of a non-biophysical character is needed to develop better extension techniques and the means to obtain and use local information in the planning and implementation stages of watershed projects. Economic evaluation techniques to measure the benefits and costs of watershed management practices need further development and application. Both horizontal and vertical communication channels for the transfer of information relating to watershed management need improvement. The issue of land use efficiency and the possibility of exchanges of steeply sloped agricultural lands for flatter forest lands will eventually need to be studied. Greater attention needs to be given to the socioeconomic and soil erosion influences of roads in upland areas. While the capacity to conduct much of this research already exists in the Ministry of Forestry, the Ministry of Agriculture, and the universities, a national research forum or some other mechanism is badly needed to help with the coordination and programming of the research effort.

Status of Watershed Management Research and Identification of Needed Research in Nepal
Kuma P. Upadhyay

Nepal's natural environment can be divided into three zones: the mountain zone above 4,000 meters; the hill zone between 500 and 4,000 meters; and the terai zone below 500 meters. Population pressures on the mountain and hill zones within the agriculturally based economy are causing high upstream soil erosion and runoff rates. The consequences are downstream sedimentation and flooding through the terai zone and into northern India.

Nepal has a good history of efforts at integrated watershed management during the past two decades. Among the strengths of these programs and projects are concerted attempts to achieve local community participation. Nevertheless, these efforts have had problems in achieving measurable benefits. Participation has proven difficult to achieve, and assumptions regarding the resiliency of the natural systems have been overly optimistic.

Although both applied and basic technical research have been conducted by several agencies, such research is still in its infancy. Aside

from some limited work in the area of increased community participation in watershed project activities, institutional and planning research relating to watershed management is also just beginning. Research priorities include studies of management strategies for community-owned lands; development of land use evaluation models to aid in analyzing land use options for farmers; pilot activities to investigate the nature of fragile or highly eroded land and to develop rapid assessment methods for measuring erosion rates; a study of appropriate design criteria, suitable structures for different forms of erosion, and a benefit-cost study on structural measures for erosion control; and development of guidelines for impact monitoring and evaluation of watershed management projects. To obtain timely applied results and funding support, an action research approach should be adopted.

Restoring the Balance: A Methodology for Research and Implementation
Anis Ahmad Dani

During the past century, political, economic, and demographic changes have created pressures on the geologically young and naturally fragile Hindu-Kush Himalayan region. Upland deforestation caused by agricultural expansion, fodder requirements, and fuelwood collection is proceeding at a rapid rate—exceeding the natural regenerative capacity of the forests in many areas. Erosion resulting in sedimentation of reservoirs and river channels, and consequent downstream flooding, are all of major concern to governments of the region.

The International Centre for Integrated Mountain Development (ICIMOD) seeks to promote the economically and environmentally sound development of the mountain ecosystem and to improve the living standards of mountain populations. It intends to serve as an information clearinghouse and a consultative center in scientific and technical matters for all countries of the region. The emphasis is on the application of knowledge to actual development situations.

ICIMOD takes a broader view on watershed management than just the soil and water conservation aspects—a view that involves the use of watershed boundaries to define logical regions for planning and implementation of management activities. The combination of the natural ecosystem and the social system within the watershed management approach is vital as a basis for conceptualizing and designing programs for the countries of the Hindu-Kush Himalayan region.

Upland communities have traditionally remained outside of the mainstream of society; they are physically and economically isolated. They are increasingly being drawn into the affairs of nation states, however, and they fail to understand why they are asked to pay the price of conserving resources to benefit lowlanders. Conversely, many lowlanders maintain stereotyped attitudes toward upland residents whom they perceive as backward and irrational. Fortunately, an appreciation for the uplanders' environmental and land use management knowledge is growing. Nevertheless, uplanders are only marginally involved in decisions affecting management plans for their communities.

Thus, social, political, and economic imbalances may be as great as ecological imbalance, and the latter cannot be restored without restoring the balance in human relationships. A suggested approach to restoring this balance focuses on the power of information and the establishment of a process of environmental education in which upland communities participate fully in the dialogue about the wise management of upland resources.

Management of Angat Watershed, Norzagaray, Bulacan, Philippines
Jose P. Castro

The National Power Corporation of the Philippines has the authority for protection, development, and conservation of natural resources in a number of the nation's upper watershed areas. Together with the National Irrigation Authority, the Bureau of Forest

Development, and other related agencies, the National Power Corporation seeks to develop the potential of these watersheds. Their objectives involve hydroelectricity production, flood control, upper watershed preservation, and the provision of domestic, industrial, and irrigation water supplies.

An example of these efforts can be found in the management of the Angat upper watershed in Central Luzon and its dam, completed in 1965. Significant biophysical data are available on the evergreen dipterocarp forests, soils, and geology of this 568-square kilometer drainage area watershed. A new study seeks to determine the 35-kilometer reservoir's sedimentation rate during the past two decades. Conservation aad protection strategies focus on maintaining the forest through reduction of unauthorized forest use and the construction of fire breaks. The development and utilization strategy includes experiments with agroforestry and fisheries development to assist the Dunagat cultural minorities as well as local fishing communities in the watershed.

Watershed Management Research and Identification of Needed Research in Thailand

Kasem Chunkao

Characteristics of Thailand's watersheds vary greatly according to climatic and soil differences. Agricultural growth in Thailand during the past several decades has largely taken place through expansion of agricultural lands into forested areas.

Only during the past decade has a regionally and biophysically comprehensive research program on watersheds been started. Priority areas for future research include development of guidelines for land capability classification and land use planning; studies of water resources development and water quality; work on sediment transport and land deterioration as related to land and resources utilization; evaluation of forest cutting policy; studies of land use certificate (Sor Tor Kor) policy guidelines and rural development policy; development of better policies relating to private forests; guidelines for watershed and forest lands zoning for protective and productive uses; evaluation of forest laws and forest protection and reserve policy; and the development of a national forest policy as an essential component of national environmental and resources planning.

Status of Watershed Management Research and Identification of Needed Research in ASEAN Countries

Severo R. Saplaco

An ASEAN-US Watershed Project was begun in 1983 to develop a network to produce watershed management research for productive and protective uplands, with emphasis on reducing soil erosion and improving water quality, quantity, and distribution. Under the assumption that the ASEAN countries share certain common watershed management problems, this project began by holding a series of seminars in the Philippines, Indonesia, and Thailand.

Based on the evidence presented at these meetings, it is clear that, due to manpower, financial, logistical, and institutional support constraints, very little research is available in usable form to watershed management planners and implementers within the ASEAN region. This includes research on hydrometeorologic, socioeconomic, and institutional topics.

A number of priority research needs were identified, including the study of the biophysical and non-biophysical effects of changes in upland forest, bush, and grass vegetation; changes in farming and agroforestry systems in the uplands; changes brought about by land management practices; and, more generally, the process of upland land use intensification. Also needed are model watershed development experiments, greater efforts to conduct integrated and interdisciplinary watershed research, attention to the need for liberalization of upland land use rights in favor of upland

residents, standardization of research methods and reporting, and greater attention to the links between research and the needs of watershed management planners, implementers, and policymakers. Also needed are better use of scarce research expertise and greater financial commitments to watershed management research and manpower development efforts.

REFERENCES

Baumol, William J., and Wallace E. Oates. 1979. *Economics, Environmental Policy, and the Quality of Life.* Englewood Cliffs, N.J.: Prentice-Hall, Inc.

Bower, Blair T., and Maynard M. Hufschmidt. 1984. "A Conceptual Framework for Analysis of Water Resources Management in Asia." *Natural Resources Forum* 8 : 0): 343 – 356.

Bromley, Daniel W. 1982. "Land and Water Problems: An Institutional Perspective." *American Journal of Agricultural Economics*, pp. 834 – 844.

Carpenter, Richard A. (ed.). 1983. *Natural Systems for Development: What Planners Need to Know.* New York: MacMillan Publishing Co.

Dani, Anis Ahmad. 1985. "Restoring the Balance: A Methodology for Research and Implementation." Unpublished paper presented at the EAPI/USAID Workshop on Integrated Watershed Management, 7 – 11 January 1985, in Honolulu.

Easter, K. William, and Christopher Gibbs. 1985. "Implementation and Institutional Aspects of Integrated Watershed Management." Unpublished paper presented at the EAPI/USAID Workshop on Integrated Watershed Management, 7 – 11 January 1985, in Honolulu.

Food and Agriculture Organization. 1982. *Proceedings of the Government Consultation on Watershed Management for Asia and the Pacific.* FAO:RAS/81/053, Government Consultation Report, Rome: U.N. Development Programme.

Haderlie, Van K. 1985. "Soil Conservation Research in Tropical Watersheds: Status and Implications for Future Research Programs and Institution Building." Unpublished paper presented at the EAPI/USAID Workshop on Integrated Watershed Management, 7 – 11 January 1985, in Honolulu.

Hufschmidt, Maynard M. 1985. "A Conceptual Framework for Analysis of Watershed Management Programs." Unpublished paper presented at the EAPI/USAID Workshop on Integrated Watershed Management, 7 – 11 January 1985, in Honolulu.

Hufschmidt, Maynard M. 1971. "Environmental Quality as an Objective of Public Policy and Planning." *Journal of the American Institute of Planners* 37 (3):231 – 242.

Hufschmidt, Maynard M., David E. James, Anton D. Meister, Blair T. Bower, and John A. Dixon. 1983. *Environment, Natural Systems, and Development: An Economic Valuation Guide.* Baltimore: The Johns Hopkins University Press.

Lovelace, George W., and A. Terry Rambo. "Behavioral and Social Aspects in Integrated Watershed Management." Unpublished paper presented at EAPI/USAID Workshop on Integrated Watershed Management, 7 – 11 January 1985, in Honolulu.

O'Loughlin, Colin T. 1985. *The Effects of Forest Land Use on Erosion and Slope Stability.* Workshop Report, 26 pp. Honolulu: Environment and Policy Institute, East-West Center.

Olson, Mancur. 1965. *The Logic of Collection Action.* Cambridge: Harvard University Press.

Perrens, S. J., and N. A. Trustrum. 1984. *Assessment and Evaluation for Soil Conservation Policy.* Workshop Report, 31 pp. Honolulu: Environment and Policy Institute, East-West Center.

Raintree, J. B. 1983. "Strategies for Enhancing the Adoptability of Agroforestry Innovations." *Agroforestry Systems* 1:173–187.

Roth, Alan D., Lynn Hewitt, Michael Carroll, and Kasem Chunkao. 1983. *Evaluation of Mae Chaem Watershed Development Project.* Washington, D.C.: Development Alternatives, Inc.

Russell, Clifford S., and Norman R. Nicholson (eds.). 1981. *Public Choice and Rural Development.* Baltimore: The Johns Hopkins University Press.

Saplaco, Severo R. 1985. "Status of Watershed Management Research and Identification of Needed Research in ASEAN Countries." Unpublished paper presented at the EAPI/USAID Workshop on Integrated Watershed Management, 7–11 January 1985, in Honolulu.

Vergara, Napoleon T. 1985. "The Potential Role of Agroforestry in Integrated Watershed Management." Unpublished paper presented at the EAPI/USAID Workshop on Integrated Watershed Management, 7–11 January 1985, in Honolulu.

Warshall, Peter. 1980. "Streaming Wisdom: Watershed Consciousness in the Twentieth Century." In *The Next Whole Earth Catalog: Access to Tools*, ed. S. Brand, 64–67. Sausalito, Calif.: Point.

LIST OF PARTICIPANTS

U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT

MR. JERRY PAUL BISSON
Office of Rural and Agricultural Development
16th Floor, Ramon Magsaysay Center Building
1680 Roxas Boulevard
Manila, PHILIPPINES

DR. ERIC CHETWYND
Chief
Regional and Rural Development Division
Office of Rural and Institutional Development
S&T/RD/RRD
Department of State
Washington, D.C. 20523

MR. DAVID A. DELGADO
Project Manager
Mae Chaem Watershed Development Project
Northern Agricultural Development Center
Suthep Road
Chiang Mai, THAILAND 50000

DR. L. WORTH FITZGERALD
Senior Water Management Specialist
S&T/AGR/RNR
Department of State
Washington, D.C. 20523

MR. FRANK L. GILLESPIE
Chief
Upland Farming Systems Division
Office of Agriculture and Rural Development
American Embassy
Jl. Merdeka Selatan 3–5
Jakarta Pusat, INDONESIA

MR. ROBERT F. ICHORD
Chief
Energy, Forestry and Environment Division
Asia/TR/EFE
Department of State
Washington, D.C. 20523

MR. WILLIAM K. KNOWLAND
Regional Environmental Advisor
Bureau for Asia
c/o American Embassy
Jl. Merdeka Selatan No. 3–5
Jakarta, Pusat, INDONESIA

DR. RAYMOND E. MEYER
Soil Scientist
S&T/AGR/RNR
Department of State
Washington, D.C. 20523

DR. EDWARD J. RICE
Agricultural Research Specialist
Agriculture and Rural Development Division
Asia/TR/ARD
Department of State
Washington, D.C. 20523

DR. JOHN D. SULLIVAN
Director
Office of Forestry Environment and Natural Resources
S&T/FNR
Department of State
Washington, D.C. 20523

DR. GEORGE F. TAYLOR II
Assistant Agricultural Development Officer
USAID/NEPAL
Rabi Bhawan
Kathmandu, NEPAL

WATERSHED MANAGEMENT EXPERTS

INDONESIA

MR. VAN K. HADERLIE
Soil Conservation Adviser to the Ministry of Forestry
c/o U.S. Agency for International Development
American Embassy
J. Merdeka Selatan No. 3–5
Jakarta Pusat

IR. SOENARNO, DIPL. H. E.
Planning Manager of Brantas Project
Brantas River Basin Development Office
Directorate of Water Resources Development
Ministry of Public Works
Jalan Surabaya, No. 2a
Malang

MR. ENGKAH SUTADIPRADJA
Sub-Director for Watershed Management
Directorate of Soil Conservation
Directorate General of Reforestation and Land Rehabilitation
Ministry of Forestry
Jl. Gatot Subroto, Senayan
Jakarta

PHILIPPINES

MR. JOSE P. CASTRO
Manager
Watershed Management Group
National Power Corporation
Cor. Quezon Avenue and BIR Road
Diliman, Quezon City

MR. ALEXANDER G. COLOMA
Resident Manager
Watershed Management and Erosion Control Project
National Irrigation Administration
Campsite, Patabangan
Nueva Ecija

DR. SEVERO R. SAPLACO
Director
ASEAN-U.S. Watershed Project
University of the Philippines at Los Banos
College, Laguna 3720

MR. VICENTE P. VERACION
Supervising Science Research Specialist
West Central Luzon Research Center
Forest Research Institute
Baguio City

NEPAL

DR. ANIS AHMAD DANI
Social Scientist
International Centre for Integrated
Mountain Development
Kathmandu

MR. KUMAR P. UPADHYAY
Chief Soil Conservation Officer,
Dept. of Soil Conservation and Watershed
Management
His Majesty's Government,
Ministry of Forest and Soil Conservation
Babarmahal
Kathmandu

THAILAND

DR. KASEM CHUNKAO
Faculty of Forestry
Kasetsart University
Bangkok-9

DR. RAMACHANDRA D. DESHPANDL
Regional Advisor for Asia and the Pacific
Regional Office for Asia and the Pacific
United Nations Environment Programme
United Nations Building,
Rajdamnern Avenue
Bangkok 10200

MR. PETER W.C. HOARE
Extension Training Officer
Rural Development Services
40/20 Soi 3 Huai Kaeo Road
T. Suthep
Chiang Mai

UNITED STATES

DR. KENNETH N. BROOKS
Associate Professor, Forestry Hydrology
Department of Forest Resources
College of Forestry
110 Green Hall
University of Minnesota
1530 North Cleveland Avenue
St. Paul, Minnesota 55108

DR. SAMIR A. EL-SWAIFY
Professor and Soil Scientist
Dept. of Agronomy and Soil Science
University of Hawaii

DR. PETER F. FFOLLIOTT
Professor in Forest Hydrology
School of Renewable Natural Resources
College of Agriculture
The University of Arizona
325 Biological Sciences East Building
Tucson, Arizona 85721

DR. JEROME J. HAMMOND
Director of International Activities
Soil Conservation Service
U.S. Department of Agriculture
Washington, D.C. 20013

DR. RICHARD G. JONES
President
Agriculture Industries, Inc.
West Sacramento, CA 95691

DR. MERVIN E. STEVENS
Acting Manager
Forestry Support Program
Forest Service USDA
12th Independence, S.W.
Washington, D.C. 20013

DR. W. DAVID STRIFFLER
Professor of Watershed Science
Dept. of Earth Resources
College of Forestry and Natural Resources
Colorado State University
Fort Collins, Colorado 80523

EAST-WEST CENTER

DR. FRANK H. BOLLMAN
Research Fellow
Environment and Policy Institute

MR. RICHARD A. CARPENTER
Research Associate
Environment and Policy Institute

DR. JOHN A. DIXON
Research Associate
Environment and Policy Institute

DR. K. WILLIAM EASTER
Research Fellow
Environment and Policy Institute
and
Professor of Agricultural and Applied Economics
University of Minnesota

DR. CHRISTOPHER J. N. GIBBS
Research Associate
Environment and Policy Institute

DR. LAWRENCE S. HAMILTON
Research Associate
Environment and Policy Institute

DR. MAYNARD M. HUFSCHMIDT
Research Fellow
Environment and Policy Institute

DR. BRUCE M. KOPPEL
Research Associate
Resource Systems Institute

DR. GEORGE W. LOVELACE
Research Fellow
Environment and Policy Institute

DR. WILLIAM H. MATTHEWS
Director
Environment and Policy Institute

DR. DAVID S. McCAULEY
Research Fellow
Environment and Policy Institute

DR. JOSEPH R. MORGAN
Research Associate
Environment and Policy Institute

MR. NAPOLEON T. VERGARA
Research Associate
Environment and Policy Institute

The East-West Center is a public, non-profit educational institution with an international board of governors. Some 2,000 research fellows, graduate students, and professionals in business and government each year work with the Center's international staff in cooperative study, training, and research. They examine major issues related to population, resources and development, the environment, culture, and communication in Asia, the Pacific, and the United States. The Center was established in 1960 by the United States Congress, which provides principal funding. Support also comes from more than 20 Asian and Pacific governments, as well as private agencies and corporations.

Situated on 21 acres adjacent to the University of Hawaii's Manoa Campus, the Center's facilities include a 300-room office building housing research and administrative offices for an international staff of 250, three residence halls for participants, and a conference center with meeting rooms equipped to provide simultaneous translation and a complete range of audiovisual services.

THE EAST-WEST ENVIRONMENT AND POLICY INSTITUTE was established in October 1977 to increase understanding of the interrelationships among policies designed to meet a broad range of human and societal needs over time and the natural systems and resources on which these policies depend or impact. Through interdisciplinary and multinational programs of research, study, and training, the Institute seeks to develop and apply concepts and approaches useful in identifying alternatives available to decision makers and in assessing the implications of such choices. Progress and results of Institute programs are disseminated in the East-West Center region through research reports, books, workshop reports, working papers, newsletters, and other educational and informational materials.

William H. Matthews, Director
East-West Environment and Policy Institute
East-West Center
1777 East-West Road
Honolulu, Hawaii 96848