Environmental Quality and River Basin Development: A Model for Integrated Analysis and Planning

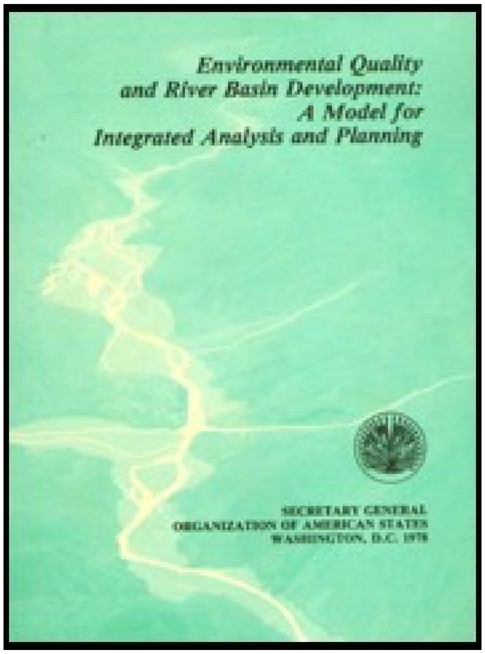


Table of Contents

Government of Argentina
Organization of American States
United Nations Environment Programme

SECRETARY GENERAL
ORGANIZATION OF AMERICAN STATES
WASHINGTON, D.C. 1978

Reprint 1979

This report was produced under Project FP/0404-75-01 with support from the United Nations Environment Programme. UNEP does not necessarily share all the views expressed, but welcomes publication as a means to encourage a wider discussion of the model.

Table of Contents

Foreword

Rapidly increasing needs for energy and water have spurred river basin development schemes throughout the world. This is especially so in those developing countries with scarce fossil fuel resources where interest in exploiting hydropower potentials is growing and regulated water supply is the key to achieving high yields of new grains, as well as more crops per year in arid and semiarid areas. Likewise, it is necessary to meet rising demands for domestic and industrial water and to offer protection from devastation by floods and sedimentation.

Although river basin planning has led to increasingly better investment choices, generally it has not incorporated the worldwide concern for maintenance of environmental quality and productivity. While it is true that techniques for identifying and evaluating the impacts of development on the environment are known, these have not been used in connection with integrated river basin development because a) generally they are not part of the project formulation activity and b) they are not always appropriate to the kinds of economic decisions that need to be made in river basin planning.

The multinational development scheme for the Plate River Basin in South America has provided a timely opportunity to determine how to incorporate environmental concerns early in the process of river basin studies. Since 1967, the Organization of American States has been assisting the countries which share the Plate River Basin in the conduct of reconnaissance surveys and data analysis, and in successively more detailed investigations leading to investments in reservoirs, hydroelectric power schemes, irrigation, and related land development projects in the basin. Prefeasibility studies for the Upper Bermjo River were completed in 1974 and for the Lower Bermejo River in 1976. These studies constitute a concrete testing ground for the addition of environmental considerations to integrated resource planning at the prefeasibility level.

This need for a clearer and more complete incorporation of environmental concerns into river basin development studies and the opportunity presented by the Bermejo River investigations led to a request from the Argentine Government's Secretariat of Natural

Resources and the Human Environment to the United Nations Environment Programme (UNEP) for support of a pilot project to propose a planning methodology for river basin development that would include the analysis of potential environmental impacts. UNEP support was obtained on the basis of Resolution 61, to help countries undertake environmental assessments in representative ecosystems, of the 1972 Stockholm conference. The OAS' Program of Regional Development acted as the coordinating agency for the pilot study from which this document evolved.

The document itself is the result of nearly two years of work by the staff of the Program of Regional Development, Argentine coworkers, and several international consultants (Appendix A). Every effort has been made to make the content and prose applicable to the needs of project directors and field staff working in the planning of river basin development. Consequently, scientific and specialized terminology have been kept to a minimum and the recommendations have been made in full consideration of the realities of developing countries. The document has been purposefully kept short to give it the character of a guidebook rather than that of an exhaustive treatise on the subject of environment and development.

Although the methodology has been designed to guide the early planning stages of river basin development in semiarid regions of the developing world, much of it is applicable to regional and sectoral planning efforts in the more humid regions. Similarly, it should find use as a text and reference material in those training centers and institutions that relate to development planning.

We welcome comments and suggestions from those who use the volume, and hope that the recommendations will be useful in introducing environmental concerns into future studies of river basin development.

Kirk P. Rodgers, Director
Program of Regional Development
Organization of American States
Washington, D.C., U.S.A.

Roberto Casañas, President
Instituto Nacional de Ciencia y Técnicas Hídricas
Buenos Aires, Argentina

Chapter 1 - River basin planning and the environment

I. Introduction

The following planning methodology attempts to deal with the problems of development and environmental changes originating with the development of river basins. Its central thesis is that environmental concerns and political, social, economic, and technological concerns work toward the same end when development is defined as an improvement in the well-being of human populations. The development process takes place within a given environment and is an effort to manipulate that environment for the betterment of the human population. Since a primary concern of the environmental movement is improvement of the long-term quality of life for human beings, a context is created in which the environmentalist and the developer, as politician, economist, social activist, planner, or technician, can work together.

The problem, therefore, is one of how and where environmental concerns can best be included in the development process. There are two primary considerations in doing this. First, to realistically include environmental interests in planning requires their evaluation from the beginning of the planning activity. Second, while recognizing that strict economic terms are not adequate to calculate full environmental costs and benefits, they must be used as much as possible if the evaluation is to be taken seriously.

This is not to say that present methodologies of river basin planning, regional planning, or even economic planning do not address the environmental consequences of development (U.S. Senate, 1962; Ordoñez, 1969; United Nations, 1970; U.S. Water Resources Council, 1973). Indeed, planning methodologies often make reference to the "intangible" costs and benefits of a project. Generally, these are interpreted to mean environmental[1]. However, for whatever reason - be it the state-of-the-art; disciplinary bias; prevailing local, regional, national, or international concerns; lack of awareness; or the fact that the methodology is not explicit - the consequences are often such that many development projects accomplish less than anticipated because of the negative environmental impacts resulting from these efforts at development.

[1] However, many of the early pronouncements concerning the development of river basins

were particularly naive in terms of their concern for the environment. Thus, the report of the Panel of Experts (United Nations, 1958) could say, with no further discussion, that: "Theoretically, transfer of water from river basins with abundant supply to other basins deficient in water, and the irrigation of arid regions, could, if practiced on an increasing scale, lead to a stage at which there would no longer be a single river discharging into the sea," and "... when, by development, the potential riches of a river basin have been realized and apportioned among the people, it may be said that the initial wild and often destructive river, had disappeared, but it lives again as a new, domesticated river, bringing only beneficial results," (page 3). These statements were later corrected in the preface to a second edition of the same report (United Nations, 1970) and in other publications of the U.N. (cf. United Nations, 1972; United Nations, 1976).

That there is a need for correction can be seen in the collection of case studies edited by Farvar and Milton[2] which describe in detail the problems of development and the environment. What these examples suggest is that the environmental impacts of many development projects have been costly - even to the degree that the overall results of a project have been negative. Either the projected benefits did not accrue or unanticipated costs accumulated after the project became operational, often cancelling the proposed benefits.

[2] Farvar and Milton, 1972. See specifically the papers by George, Scudder, Bardach, and Hay.

Negative impacts have taken many forms: exotic diseases or plagues; increased incidence of indigenous diseases; impairment or reduction of industrial production based upon an area's resources; an increase in social problems related to population migration; a weakening or over-extension of social services; loss of diversity and stability; exaggeration of both the degree and incidence of disasters occasioned by natural phenomena, such as earthquakes and hurricanes; resource impoverishment; foreclosure of future developmental alternatives; and the need for a large, unanticipated addition of financial and other resources to keep the project operational. What is common to all of these impacts is that the quality of life of the affected human population has been, in some way, decreased - the very antithesis of what development is about.

These failures at development and a worldwide recognition of the general decline in environmental quality have brought pressure to reconsider the direction and method of development through some form of explicit assessment of the environmental impact related to development efforts[3].

[3] Several critical reviews of the concepts and techniques have recently been made (Ditton and Goodale, 1973; Warner *et al.*, 1974; and Munn, 1975); a short description of each of the major techniques is presented in Appendix B.

However, a principal problem with many of the assessment methodologies is that they come too late in the process; that is, they are used after a decision has been made to appropriate money for a development project or, what is even worse, after the project has been started. The result is that legal suits or objections of a less formal nature may slow down or completely stop development projects, bringing about costly delays and potentially wasted initial investment. To illustrate: In 1970, the United States Congress authorized $100 million for surveys and construction of the Darien Gap portion of the Pan American Highway. However, on October 17, 1975, several conservation organizations in the United States successfully brought suit within the legal system to hold up nearly one-half of these funds until a satisfactory environmental impact statement could be written. At the time of this writing over one year has passed since the initial suit was filed and the problem remains unsolved. In another case, construction of the "Garrison Diversion," a project to transfer 871,000 acre feet per year of irrigation water between basins in North Dakota, has been held up and the later stages of the project have been placed in jeopardy because the Canadian Government fears adverse environmental impacts on its territory as a result of the project's construction. Early estimates of the costs for the project were set at $433 million but these now may go as high as $1 billion if it is altered to meet Canadian objections (Matthews, 1974).

With these problems in mind, the United Nations Environment Programme, the Program of Regional Development of the Organization of American States, and the Government of Argentina undertook, beginning in 1975, a pilot study to develop a methodology which would systematically incorporate environmental criteria into the process of project identification and formulation in a major river basin investigation.

A pilot study approach was utilized which drew on the experience gained by the Government of Argentina and the OAS between 1970 and 1975 in the Bermejo River Basin.

The first, "Study of the Water Resources of the Upper Bermejo River Basin," (OAS, 1974) investigated the water resources through the stage of prefeasibility in order to orient their development, particularly with respect to hydropower generation, irrigation, water supply, and sediment control, and in accordance with the priorities established in the national plans of Argentina and Bolivia - the two countries which share the basin.

The second river basin analysis, "Study of the Lower Bermejo River Basin and Programming of Its Development," (OAS, 1977) was made in cooperation with the Argentine Government and had objectives related to those of the upper basin study. Major concerns were domestic water supply, streamflow regulation, sediment control, irrigation, river transportation, and location of appropriate areas for agricultural and agroindustrial development.

The Environmental Pilot Study began with a careful analysis of the Bermejo River Basin reports but particularly the upper basin study. There were extensive interviews with government officials, especially those who had been involved with the earlier surveys. From September 1975 to October 1976, a group of Argentinian and international specialists from several different disciplines was organized to undertake the Pilot Study (Appendix A). Their objectives were to see what environmental impacts had been missed in the original analysis and to locate those points in the original studies where improvements in the methodology would have avoided problems. Their final task was to develop recommendations for methodological guidelines and detailed terms of reference for different specialists who participate in river basin planning efforts.

The Pilot Study objectives were to improve the existing methodology and to develop a more systematic treatment of environmental implications of river basin development. It did not presume to develop a revolutionary new approach to project formulation and analysis. The final product was to be an improved methodology which, had it been applied from the outset, would have yielded a study with more accurate and thorough analysis from the environmental viewpoint, but *without* adding unacceptably high additional costs to prefeasibility level investigations. It is important to underscore the fact that the prefeasibility studies of the Bermejo Basin were begun before the worldwide environmental concern had become a major issue. Consequently, the work presented in this report should not be seen as criticism of the quality of the original investigations. This study does not single Bermejo out as being especially indifferent to environmental concerns. Actually it is more typical than not of work done on river basin development before the early 1970's.

II. River basin planning

Since the Pilot Study proposes to modify river basin planning methodology to include environmental implications, a discussion of planning in general, and river basin planning in particular, is required. The biogeophysical characteristics of a basin tend to form relatively cohesive hydrological and ecological system and, therefore, river basins are often used as units for developmental planning (Dasmann *et al*., 1973; United Nations, 1970; Cooke, 1969). However, since river basin planning as a concept has been and is steadily evolving, it means many things to many people. Despite its numerous connotations, the water resource has generally been the central consideration. In the early stages, river basin planning, or *water resources planning,* was usually concerned with a specific problem, such as flood control, irrigation, navigation, or potable and industrial water supply (Forbes and Hodges, 1971). Later, the *multipurpose planning* approach to water resource development came into vogue and consisted of dividing the total water available from a structure among several different uses. Because the various uses of water are often competitive, conflicts arise which call the multipurpose approach into question. To some degree *integrated river basin planning* was an answer to this problem in that it sought to coordinate and develop the water uses of a basin in harmony with other development processes both within and outside the basin (United Nations, 1970). The idea of *comprehensive river basin planning* is an extension of integrated planning and goes beyond the specific water resource to include most other resources, as well as many aspects of socio-economic or regional planning (Forbes and Hodges, 1971). A related term, *water and related land resources planning,* is often applied to the U.S. Water Resource Council's "Principles and Standards for Planning Water and Related Land Resources" (U.S. Water Resources Council, 1973). Because these principles and standards originally proposed four equivalent objectives, the planning concept was often called *multi-objective planning,* although the term is sometimes used to mean *multipurpose planning* as well (Barbour, 1975).

These forces have tended to expand the definition of river basin planning both in terms of what is treated within a basin and in terms of the influence from, and impact on, areas outside the basin. Specifically, modern day engineering has made large scale transfers of water and energy outside the basin a fact (Fox, 1973), and quite often units of socio-economic planning do not coincide with the borders of a river basin. When this is the case, close coordination and consideration of these units and their activities, or even the development of an overall organization that includes the existing planning entities having interests in the river basin, will be required (Sweet, 1969).

III. The planning process

Planning is a process which seeks solutions to problems and needs or which develops actions that will satisfy goals and objectives. In river basin planning, the objective is to provide a decision maker with alternative recommendations for the use of the basin's land and water resources. Normally planning is not accomplished as one continuous activity but is broken down into several steps (Figure 1).

First, there are a number of preliminary activities which indicate a need for planning. These may be outside influences or they may be influences that are the culmination of a previous planning exercise.

The point to be made is that planning does not take place in a vacuum. Geographic areas having no development or plans for development are now rare. In almost all cases decisions and plans, at varying degrees of detail, scale, and commitment, have already been made and certain political, social, and economic characteristics of a region or country exist which will influence and condition the planning process. These characteristics must be considered in any planning activity because each can and does influence the degree to which environmental concerns can be dealt with.

Second, the needs and problems are defined and objectives set or refined, depending on whether or not it is the first or a later iteration of the process.

Third, an inventory is made of available resources potentially useful for solving the problems and meeting the objectives. An inventory of current demands for use of those resources is also prepared so that a balance of resource supply and resource demand can be made.

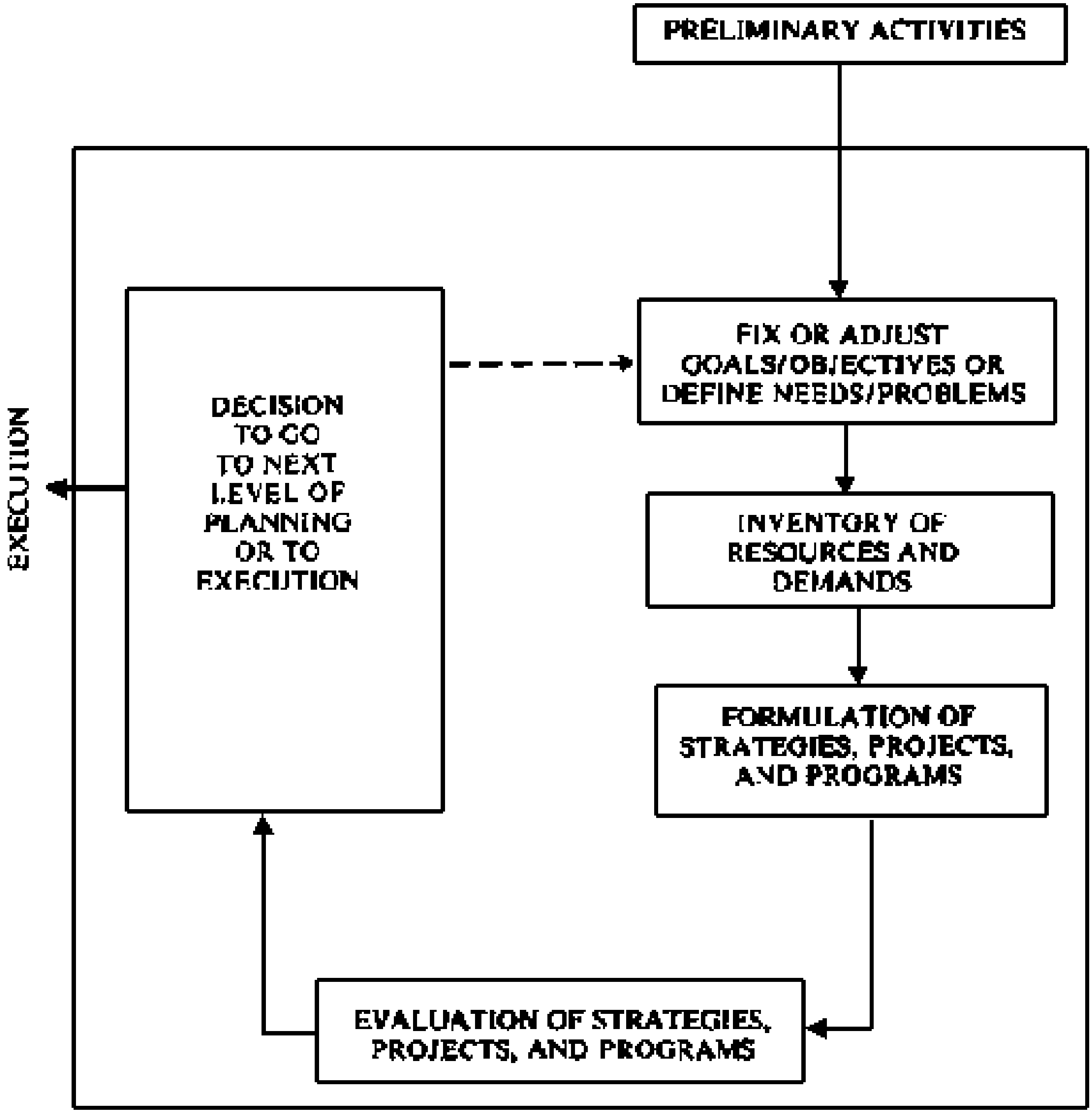
The fourth step is to formulate a set of strategies or projects and program alternatives that will meet the objectives.

The fifth step is to evaluate these strategies, projects, and program alternatives in terms of cost and benefits - which must include social as well as economic cost accounting - and to rank them according to some kind of priority.

The sixth step is to decide which of the projects may be ready for "execution," which should be discarded as not feasible, and which should be reexamined.

Thus, the planning process goes forward in a series of steps and iterations. Although these steps and iterations in developmental planning may be called by different names and variously arranged, most planning agencies undertake three or four separate studies prior to project or program execution, depending upon the amount and quality of available data. Each of these steps is more detailed. This leads to increasing degrees of commitment to a strategy, program, or project in terms of social, economic, political, and technical considerations.

Figure 1. Generalized scheme of the planning process



For the purpose of this report, the stages of the planning process are: reconnaissance, prefeasibility, feasibility, and final design.

- **Reconnaissance**

Reconnaissance is the earliest stage of planning and includes a review of previous plans, projects, and programs; a brief inventory of human and natural resource data; and a summarization of suggested development needs and projects. Relevant public and private institutions are requested to identify the geographic and subject matter areas to be investigated during the next stage. The reconnaissance stage provides the basis for prefeasibility studies and includes an estimate of the time and skills required, costs, and general terms of reference.

• Prefeasibility

Prefeasibility is the second planning stage and includes an inventory and evaluation of human and natural resources guided by the developmental objectives and findings of the reconnaissance survey; identification and analysis of areas and projects of major interest; and sometimes preliminary designs of structures. It recommends studies to be undertaken in the feasibility stage. Prefeasibility studies usually offer at least two alternatives to meet the objectives. Each alternative is examined in terms of social, economic, political, and technical costs and benefits.

The prefeasibility stage estimates the quantity of work and costs required for the feasibility stage. It formulates the terms of reference and financing. Findings from this stage should enable each project to be ranked in accordance with developmental objectives and should be presented to enable the selection of the projects to be studied in the feasibility stage.

• Feasibility

The feasibility stage includes studies made to determine demand and supply with respect to each development project and to designate projects for execution. If structures are required, detailed studies of the topography, geology, and mechanics of the selected areas are made. Detailed maps of existing and potential land use are made and technical/economic conditions are defined for achieving the potential. Project construction is planned and costs and benefits are calculated.

• Final Design

Final design is the last stage in planning and includes the design of the projects selected for construction. These projects (dams, canals, flood ways, roads, etc.) should be designed to meet the developmental objectives, including those of safety and environmental protection.

IV. Environment

The environment, the surroundings, as used herein is man-centered. It consists of the ecosystems that surround and support human life.

An ecosystem is a geographic unit or organization which comprises a community of living organisms and its nonliving environment. Since each ecosystem is somewhat arbitrarily defined, there are innumerable ecosystems in the world. A large ecosystem, such as a river basin, contains many other ecosystems, such as forests, lakes, rivers, farms, pastures, and cities. There is a biological portion which may, and quite often does, include man; there is a physical portion which influences and is influenced by the activities of the biological portion; and there are a large number of processes which condition the interactions between the components. These interactions may be defined by material and energy flows, and can be measured in calories, grams, or dollars as well as by movements and behavior of populations.

Because of mankind's overwhelming influence over many of those ecosystems with which he interacts and because many of the relationships among men and between men and their environment may be both qualitatively and quantitatively unique, environmental classifications have been established to take this into account. For example, the environment may be divided into three major interacting ecosystems (urban, rural, and natural) that are distinguished on the basis of the source and amount of energy necessary for their functioning (Odum, 1976). The urban ecosystem is dependent upon fossil fuels while the natural ecosystem is based upon the energy of sunlight. A rural ecosystem utilizes both fossil fuels and sunlight.

Another classification divides the environment between cultural and natural ecosystems and treats the cultural impact in terms of its influence on the stability and continuity of the environment.

It is not possible or practical to include all aspects of environmental concerns in river basin planning, although, to some degree, each must be touched upon. Nevertheless, relevant environmental concerns must include those related to ecology, human well-being, and natural resource management.

• Concerns having an ecological base

There are a number of principles in ecology on which a discussion of both environmental planning and environmental impact could be based. Perhaps the most important of these defines our universe as one of *linkages and interdependency;* of cause and effect. Factors of the environment that act on an individual do not act separately and independently. If one factor of the environment is changed, shifts in the quantity and quality of other environmental factors follow. And, because of the intricacy of the whole environment, anticipation of these innumerable actions is difficult and sometimes impossible. When and if changes result in the betterment of the human condition then "development" can be said to have taken place. However, in addition to changes that favor development, almost inevitably other changes occur which have a negative impact. It is the goal of development planning to ensure that, in both time and space, the positive changes outweigh the negative changes.

A second principle of the science of ecology is that of *diversity.* Although the idea that complex (diverse) ecosystems are stable has recently been called into question, the positive nature of diversity itself still appears valid (May, 1973; Goodman, 1975).

Greater species diversity tends to provide a larger number of checks and balances within an ecosystem. Outbreaks of insect pests, for example, are less possible if these insects are preyed upon by several different species. If the insect in question is preyed upon by more than one species, eliminating one of its predators is not necessarily so important for controlling it.

Intra-species diversity is also important since it provides a larger gene pool and, therefore, a wider range of tolerances. This could mean the difference between survival and extinction of a species given a change in environment. There is a practical side to this in that scientists, using the gene pool of wild races, often are able to breed new races of domesticated species that are more productive, or more resistant to disease, drought, heat, or other environmental factors. And, since the commercial or scientific value of vast numbers of wild species of both fauna and flora are still to be investigated, care should be taken in planning developmental projects not to unknowingly eliminate potentially valuable species. Each species has a different set of optimal living conditions; therefore the environment can be more efficiently utilized when a large number of different species is present.

A diversity of ecosystems, as well as a diversity of species, is important. Much of the interest in saving endangered species is really an attempt to keep a particular ecosystem intact. This is felt to be necessary because there is increasing evidence that these natural ecosystems play an important, if not generally recognized, role in maintaining the quality of human life (flood control; diminishing the catastrophic effects of natural phenomena, such as earthquakes and hurricanes; amelioration of contamination; soil stabilization; primary production; air quality; etc.) (Gosselink *et al*, 1974; Odum, 1976). An additional concern is to safeguard species and ecosystems for investigation since so much has been learned and is yet to be learned from them about the processes that affect the human population.

A concern of this methodology is to protect and use the diversity of species and ecosystems as much as possible, given the constraints of development and the realities of the areas under consideration.

It is also important to understand the *trophic level structure* and food chains in an ecosystem when planning the development of a river basin. Trophic levels describe the flow of energy from sunlight to plants (biologic producers), to consumers, and then to decomposers. Food chains describe the flow of nutrients and other materials through the same levels. At each stage some energy is lost through respiration and waste and these phenomena have their ramifications in the world's food supply. Not only is it cheaper, it is also more efficient in terms of energy use, for man to utilize the lower rather than the higher trophic levels as his food source. Likewise, species which are, or could be, economically important to man are often dependent on seemingly insignificant species at a lower trophic level - the loss of which could mean the loss of species at a higher trophic level which are actually or potentially important economically. Trophic structure is important in the cycling of certain materials, such as nutrients, where the elimination of one level within the structure may break the cycle and cause the loss of nutrients from the ecosystem. The relatively tight cycling of nutrients between soil and vegetation in a tropical rain forest is an example. Normally, nutrients released from the decomposition of forest litter are almost immediately returned to the plants. Deforestation interrupts the cycle because of the large quantities of material available for decomposition and the faster rates of decomposition due to elevated soil temperatures on the unshaded soil. Nutrients are lost through rapid leaching or washing when the lack of forest cover allows more rapid runoff of water from heavy rainfall. Man-made poisions are another means through which tropic structure may be broken by concentration of the poisons through the food chains until eventually a point is reached in which one or more members of a chain is eliminated to the detriment of the levels dependent on it.

It is, then, an environmental concern in planning to identify trophic level structures and food chains; to know their function in river basin ecosystems. Only then can predictions be made of the result of man's intervention through developmental projects and suggested projects proposed to take advantage of these processes.

A knowledge of the *successional stages* within an ecosystem may also be necessary in river basin planning. Succession is defined as "an orderly, predictable process of community changes that modifies the physical environment and culminates in the most biologically stable ecosystem possible on a given site" (Odum, 1963). It results because in the early stages of ecosystem development, organism production competes for available resources, leading to the survival of the best adapted species. Domesticated food and fiber crops are examples of man's attempt to hold succession at an early stage so that he can harvest the maximum energy. Uninfluenced, ecosystem development proceeds toward the later successional stages, arrestable only through the insertion of energy into the ecosystem. The more alien these systems are to the local environment, the more costly the energy input. Since the later successional stages often diverge from the organismal composition required by the life support system needed by man, careful control is a necessity for man's survival. It is an environmental concern in river basin planning to help identify the possibilities for and to detail the problems involved in these controls.

- **Concerns based on human well-being**

Certain concerns of human well-being are also environmental concerns in river basin planning. The first of these is the *physical and psychological health of the human population* as influenced by changes in the environment brought on by development. Air, water, and soil contamination by the residuals of development are major example. These are disruptive because contaminants are, in many ways, exotics and there is no built-in mechanism in the affected ecosystem to adequately deal with them. Consequently, they can be detrimental to human health as they eventually make their way to the human body by the air we breathe, the water we drink, and the food we eat. Once ingested, they may become debilitating and may even cause death. Or, they may become offensive to the quality of life that is expected by a population.

Environmental changes brought on by development have a large role in epidemics and disease transmission because: a) the changes take place so rapidly and, b) new habitats are created that are more conducive to the growth and development of disease vectors. Man and other species have survived because they have adapted. The problem is the time it takes to adapt. Any rapid change in the environment does not allow time for adaptation to take place.

Mental health and a related factor, human interest, are also concerns. Both involve the desire of human beings for an environment that is varied and pleasing. This means a clean environment and an opportunity for recreation in natural and rural areas as well as in urban ones. Since planning provides for the future, it should be the concern of river basin planning to take this desire into account when considering the long-term needs of man.

The role of a people's culture and history in their own well-being, be they primitive or developed, is one that is undervalued if not discounted completely by developers. Battles are fought as much over culture and history as they are over economic and natural resources.

Likewise, a change of social organization or a shift in values often leads to a breakdown of traditional land tenure and land use practices. This, in turn, leads to the destruction of vegetative cover, to soil loss, and to a deterioration of water quality.

Closely allied are religion and aesthetics. A people, at whatever level of development, hold these as intrinsic values. A people, their culture, history, religion, and sense of aesthetics have all evolved within an ecosystem and form a part of that ecosystem. Any rapid change, including efforts at development, is disruptive. Therefore, it is an environmental concern to aid in the consideration and preservation or the orderly transformation of these elements during the planning process.

- **Concerns for natural resource conservation**

Natural resource conservation concerns are based on the fact that natural resource use is causing steady depletion of resources. The fact that many of these resources are renewable does not mean that they are inexhaustible. Furthermore, overuse and abuse of these resources create a need for exploitation of as yet untapped areas over and above the needs of economic growth. Soils, water, and forests are examples and, in a very real sense, we are living off capital instead of interest on capital. In many areas of the world, new land brought into "production" through reclamation, irrigation, and land clearing barely offsets the loss of production caused by erosion and salinization (Eckholm, 1976).

At the same time that demand for water grows, water supply is decreased - made unusable due to contamination; or lost because of rapid runoff, mismanagement, and high evaporation rates that are neither necessary nor wanted.

Requirements for forest products increase also, but again, the policy too often seems to be to fulfill present requirements with little thought about future needs. Conservation does not necessarily mean "no use"; it means wise, sustained use, and it is a concern of river basin planning to insure that natural resources are wisely used.

Preservation, as well as conservation, is also of concern and may, in and of itself, be a "use." Preserved areas such as national parks and reserves are primarily developed in areas that are "environmentally" critical; upstream watersheds, estuaries, and swamps are examples. The preservation of upstream watersheds protects downstream infrastructures from too much and too little water; the preservation of estuaries protects offshore fisheries and onshore development; and the protection of swamps is a very efficient flood control measure. Indeed, the highest sustained economic return from many areas often occurs by preserving them in their natural state. As a consequence, planning should consider preservation as a viable alternative to development.

Chapter 2 - General considerations for a planning methodology

Planning literature suggests considerations that should form part of environmentally conscious river basin planning. They will serve to orient both the formulation and evaluation of alternative projects and programs which meet the objectives of development while maintaining environmental stability and productivity.

• **Environmental objective**

The reason for including an environmental quality objective is that environmental quality then becomes an integral part of the whole planning process to be treated at each of the planning stages. Further, it helps to insure that each member of the planning team has concern for environmental quality when formulating and evaluating strategies and projects.

The legal basis for explicitly stating environmental quality as a developmental objective varies among countries. In most places, however, laws exist that provide the legal basis for incorporating environmental protection as a developmental objective. Laws governing land use, management of natural resources, environmental quality, and public health provide this basis.

One example is the General Water Law of Peru (Government of Peru, 1969) which declares that all waters within Peru's territory are the property of the State and that the Government, through its Water Administration, will formulate the general policies for water use and development, and plan and administer its conservation, preservation, and rational use. Title II of this Law gives the Water Administration power to dictate and apply the necessary means to avoid the loss of water regardless of reason. Furthermore, each water user is obligated not to impair the use of water by others. The law prohibits any discharge which could contaminate the water to the degree that it endangers human health or the normal development of the fauna or flora.

Likewise, the legislation which created the Venezuelan Ministry of the Environment and Renewable Natural Resources has as its first objective the establishment of principles for the conservation, protection, and improvement of the environment of Venezuela (Government of Venezuela, 1976). And, the stated policy of the Ministry is to "... give primary attention to the participation of the State in the planning, administration and use of the renewable natural resources, in order to contribute to the conservation, defense and improvement of the human environment in Venezuela" (MARNR, 1977).

International agreements and conventions also exist which should help orient the planning objectives of individual countries and those international agencies that respond to requests for assistance in planning. One such instrument is the 1940 Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere. Most of the member states of the OAS have signed and/or ratified this Convention which commits them to take steps for managing and conserving their flora and fauna. In Resolution 218, the sixth regular session of the General Assembly of the OAS (1976) urged "... the implementation of the Convention by the member states through National Cooperation in activities such as scientific research and technical cooperation and assistance to wild flora and fauna,... (and) the adoption of measures to conserve wild flora and fauna and to protect species which are in danger of extinction."

• Explicit treatment of environmental quality throughout the planning process

Explicit treatment of environmental quality is necessary because the planning process increases in rigidity from the statement of the objective to execution of the program. Therefore insertion of concern for environmental quality after initiation of the planning process becomes increasingly more difficult. To place environmental concerns at the beginning help assure that they will be considered during the entire process at little extra cost, circumvents the environmental - development disputes that come later, and provides additional information for the formulation and evaluation of projects.

In this regard, the make up of the team that undertakes the reconnaissance stage study becomes important. Since the purpose of this team is to define the work program to fulfill the developmental objectives required by disciplines and terms of reference of the next planning stage, an environmentalist should be included.

The need for a topographic survey in the planning process is implicit. Guidelines for geographical planning usually include an explicit statement of the kind and detail of topographic survey required for planning. Environmental planning requires no less. Apart from the potential for disregarding environmental concerns not explicitly stated, there are problems of precision, direction, utility, and cost that cannot be defined without stating explicitly those environmental concerns and parameters relevant to the study. What is the degree of precision necessary? What are the terms of reference for the technician? Which professional disciplines are required and how are they to be integrated into the overall planning process? How much should they cost and how will the information be used? These are questions that require answers if there is to be an adequate environmental input, just as similar questions need to be answered for work on any other problem. They can be answered only if the concerns are made explicit.

• Consideration of dynamics and interactions

The world in which we live is one of action and interaction, of cause and effect, of movement and change in both time and space, and the planning team must pay attention to the nature and meaning of these interrelationships. To be sure, it is more difficult to measure the properties of a dynamic system than it is to measure a stationary state, but it takes only a few well chosen observations on a system to provide useful information. The number and size of the trees in a forest may be important for planning purposes, but a knowledge of the role of the forest in erosion control, water supply, as a food source, the value of its gene pool as well as its replacement potential, successional stage, and position in the nutrient cycle is important for those same planning purposes.

A number of fairly reliable techniques have been developed in systems analysis which could be and have been profitably used in planning (Walters, 1974). Fortunately, they can be used at almost any level of sophistication and can play an important role in organizing the study as well as in analyzing the ecosystems involved. The value of these methods of analysis can be seen in the results of a study of the environmental impact of hydroelectric development in the James Bay area of Quebec where the use of systems analysis showed some 26 impacts to have an opposite value from those suggested by a staff of professionals in natural resource fields who had analyzed the impacts on the basis of intuitive analysis.

• Use of interdisciplinary teams

The holistic nature of our environment requires the use of interdisciplinary teams in planning. In the past, much of river basin planning was undertaken by engineers, economists, and hydrologists for narrowly prescribed purposes. However, as the objectives of river basin planning expand to encompass interests other than the construction of major facilities or river control, there is a need also to include other disciplines in the planning process in more than a consultative role. The ramifications of river basin development are too broad, and the chance for error too great, for its planning to be left to one more or less homogeneous group. Indeed, the problem with the word "intangibles" is that what may be intangible to an engineer or economist may be well understood by a sociologist, anthropologist, epidemiologist, or ecologist. Because the reverse is also true, interdisciplinary planning teams become necessary. A team working toward a specific objective, be it engineering, social, or environmental, should include sufficient disciplines to cover any anticipated issues. Both formal and informal interaction among the team members should be encouraged to allow for the formulation of more appropriate plans and programs.

• Coordination of river basin planning efforts with other functional planning entities

Although the limits of a river basin generally are precisely defined, river basin planning influences and is influenced by conditions and planning outside these limits. Planning units exist that are larger than, or otherwise different from, a river basin. And, because data are often obtained on the basis of these planning units, they generally make a good basis for socio-economic planning. However, the river basin is also a unit whose processes act together regardless of the political borders that cross it or are imposed upon it. Water, without a large imput of energy, runs downhill. Because of this fact, and the resultant interactions, there is a great potential for environmental damage caused by development all along the drainage system whether or not that drainage system includes one or several planning entities, be they municipal, regional, state, national, or international. It is because of this damage that the river basin must be considered in relevant, environmentally sound planning. However, the interest here is not necessarily to form a planning unit having geographic boundaries that coincide with those of the river basin. The central concern is that the basin be kept intact as the focus of the planning process. All planning need not be done at the same detail or intensity throughout the basin, nor done by one agency. However, water being "offered" by the upstream watersheds must be kept at a necessary *quality* and *quantity* to supply the needs of the basin. These needs can include water to be supplied to the intake of a canal carrying it outside the basin; sufficient head to furnish power for hydroelectric energy; sufficient quantities for irrigation or for municipal and industrial use; and adequate flow to the estuary for the support of the food chain on which the country's offshore fisheries depend.

Whatever mechanisms, arrangements, or hierarchical structures for coordination are required of the various planning entities to keep the integrity of the basin as a planning focus intact, they should be developed.

• Public participation

Decisions of importance often involve a great many subjective values. This condition is aggravated when the decision involves development planning and it is especially so when that planning is in the early stages.

The participation of the public in river basin planning decisions is, at the same time, both necessary and problematical. It is necessary because development involves life quality values which vary over time as well as between and within cultures and individuals. Likewise, much of the data on which planning decisions are made are of the most subjective kind. And these decisions not only try to predict the future but also, to an even larger degree, attempt to guide the future. Since these can involve the "quality of life" of thousands or even millions of people, it is best that they themselves have the opportunity to say what they want for their future.

It is problematical because, for public participation to be of value, participation must be informed and based on a certain degree of self-understanding. Furthermore, it is problematical because cultures differ in the manner in which political decisions are made, and these vary from the completely democratic to the completely autocratic. Whatever the socio-political-cultural realities, however, efforts should be made to protect public interest and a mechanism should be provided so that public interest is considered when fixing and adjusting objectives, and when the decision on a development project is made.

It would be impossible to mention all the mechanisms whereby public concern can be included. In terms of incorporating public interest, the ideal is an informed public discussion and a vote on each decision that affects a particular public. Recognizing that this is neither practical nor, perhaps, possible, the form to be used in each case should be as close to the ideal as possible. In some areas, the most practical would be an intergroup advisory committee where theoretically each affected group, culture, and geographic area is represented and the representatives know the feelings of their constitutents sufficiently well to be able to protect those interests when necessary. The important thing is not that the committee or council be elected but rather that it represent and be able to articulate the interests of its constituents.

• Generation of alternatives

Almost any use of any resource in any place at any time will create conflicts between competing interest groups. Use of one resource may mean the destruction of another. Because river basin planning looks toward the development and use of resources, the planning activity is not immune to these conflicts and clearly their rational resolution is called for before projects are initiated; rational resolution of these conflicts necessitates the generation of alternative plans for development. The number of alternatives, of course, depends upon the number and nature of the stated objectives. If, for example, one of the stated objectives is national economic development and another is regional economic development and conflict arises between them, then at least two alternatives are called for. An additional alternative, a compromise between the two, may also be necessary. A further alternative of no action should be evaluated as well.

The number of alternative plans developed during the planning process depends on the complementarity of the objectives as well as on the conflicts between the objectives. That is, the satisfaction of one objective does not necessarily preclude the satisfaction of another.

During the initial phases of planning, a large number of alternatives may be put forth and discarded as not feasible with little more than a cursory examination. Later stages of planning, however, require more detailed work, more data, and more points of view in order to refine and/or combine the various alternatives and to assign to each alternative a fairly accurate estimate of the cost and benefits based on a number of criteria. Although the planning team may often rank the various alternatives according to an indicated priority, the final group of alternatives should be presented to the decision maker. A decision to execute a program not only depends upon its technical and economic feasibility but also upon criteria well outside the mandate of the planning team, such as legal constraints, possibilities for cost sharing, viability of competing developmental alternatives outside the river basin, and socio-political realities.

• Assignment of economic values to adverse and beneficial environmental impacts

Certainly, a large number of environmental impacts are not quantifiable at all, not to mention quantifiable in economic terms.

Many of what can be classified as environmental values have been appropriately included in the past in an economic analysis. For example, commercial forestry and fisheries losses are commonly included as a cost of a hydroelectric power project. Additionally, however, attempts have been made to further calculate environmental costs on the basis of a distinction between commodity and amenity resources (Krutilla and Fisher, 1975), and the concept can be useful in assigning values to costs and benefits at the early planning levels.

Commodity resources are those that require the intervention of some form of production technology between the resource in its natural state and its use by man; they are those resources that are allocated on the basis of some form of market mechanism. Examples are the use of forests for lumber, mining of ore for production of metals, and harnessing of a river flow for production of power.

Amenity resources are used by the final consumer without the use of production technology and may not be allocated on the basis of market processes. Examples are the scenic value of a rare landscape or the values associated with certain maintenance free services offered by natural ecosystems. Another obvious amenity service relates to the sustaining of life itself through the provision of acceptable air and water qualities. Advances are being made in the economic assessment of these and other amenity services provided by the natural, cultural, and historic resources of our environment. Persons working on the economic evaluation of projects should work together with other disciplines which may be required by the project in defining these values.

• Consideration of alternatives that do not foreclose other options

Methods of identifying a problem of option foreclosure include evaluating the uniqueness of the affected resources or processes and considering the irreversibility of the impacts of a given development project. Although difficult to evaluate quantitatively, these two methods give rise to a preservation value for unique environmental amenities. This value has been termed the option value or the option demand and it is characterized by a willingness on the part of individuals to pay for the option to preserve an area possessing important or potentially important resources and processes that could be irreversibly altered by a development action (Weisbrod, 1969; Ciccetti and Freeman, 1971).

If a dam were to be built in an area for the production of hydroelectric energy and, with the passage of time, it was determined that the value of preserving that same area would have been greater than the value of the dam, the preservation option would no longer be open. On the other hand, if the area were preserved and it was later determined that the area would have a greater value from the production of power, this development option could be implemented. Thus, where a choice is between preservation and development, and there are uncertainties with respect to future demand for the services of either alternative, there may be significant costs associated with the alternative which forecloses future option. The more unique the amenities associated with a particular environment, the greater the value of maintaining future options.

A further important aspect of assessing the values associated with a given environment treats the symmetry of future preservation benefits in comparison with those of resource development.

Technological change generally increases our ability to produce commodity goods while it is incapable of augmenting the supply of resource amenities. As technology increases the available supply of commodity substitutes, the value of the amenity services from preservation will rise relative to its use as a factor of production. If advancing technology reduces the real cost of producing the final output over time, the value of the resource as a factor of production will decline in absolute terms (Smith, 1972).

It can be argued that a given environment can have significant value in a preserved state, and these arguments do not preclude the management of that environment in a manner which enhances rather than destroys its amenities. Further, these valuation principles apply equally well to the preservation of historic or cultural assets associated with a society's endeavours.

• Display of adverse and beneficial effects

Planning should present sufficient data and information to a decision maker so that a choice between the alternatives offered by the planners can be made. A decision maker can only do this if the whole range of a decision's consequences are known. These consequences cannot be reduced to a single term, such as the benefit/cost ratio, without severe distortion. To do so vastly increases the potential for error, and the use of only one term can obscure more information than it reveals. To circumvent this danger, both the potentially adverse and beneficial effects of a project should be displayed as completely and as quantitatively as possible. These effects can often be expressed as economic values but, if this is not possible, other quantitative and qualitative factors can be used. They may be defined in other terms as well, their influence on man for example, and evaluated on a simple scale showing the uniqueness of the environmental component to be affected and the significance of any effect that is irreversible.

In addition to displaying the adverse and beneficial effects of development, some effects should be "flagged" to receive further study because of their unknown importance, and some should be "flagged" to indicate that they must receive special attention, either because of their danger or because of their value - whether or not that danger or value can be quantified.

Use of these considerations in the planning activity will help to ensure that decisions aimed at the betterment of the human condition will meet that objective. Engineering and economic considerations will not be diminished in decisions relevant to river basin planning because of these considerations. Indeed, the point should be made that sound engineering siteing and design, and valid economic and social analyses in the formulation and evaluation of development projects often can do a great deal for environmental protection since no direct environmental impact can be assigned to developmental projects that do not take place. This statement should, in no way, be construed as "anti-development," nor should it be interpreted as saying that all projects require a favorable benefit/cost ratio to be valuable. What it does say is that change is a fact of life and that inadequate analysis has all too often been the case[1]. As a result, decisions have often been made to execute projects that are marginal or worse from both the developmental and the environmental protection points of view.

[1] Changing interest and discount rates are examples. It has been stated that raising the interest rates used in calculating project costs from 3.5 percent to 5.0 percent would make one-half of the U.S. Army Corps of Engineers projects now planned uneconomical (U.S. Congress, 1975). Likewise, all costs should be included in the analysis. A recent study showed that, in 103 U.S. Bureau of Reclamation projects planned prior to 1955, the average estimated costs were running 75 percent below actual costs even after adjustments for actual costs for construction price trends and changes in project planning, design, and engineering

were made (after Scrhamm and Burt, 1970).

Chapter 3 - Methodology: An outline for the integrated planning of river basins

The general considerations of the previous chapter suggest modifications in the standard river basin planning procedures. Changes implied by these considerations relate to explicitly including environmental quality objectives, adding personnel having an orientation toward environmental planning, using environmentally related terms of reference for each individual expert, and coordinating interdisciplinary teams for an integrated effort in the formulation and evaluation of strategies, projects, and programs.

Integration is the key word. To a large degree, any river basin study that is truly integrated will have already considered environmental stability. Development of a river basin is based on socio-economic and environmental factors and is planned on the basis of multidisciplinary analyses of the human and natural resources. The problem of identifying and describing the work of the various specialists while maintaining the integrity of the whole system is what this chapter proposes to treat.

In general, the process, repeated at each planning stage, is one of definition, disaggregation, analysis, and recoupling. It consists of several steps: problem definition; identification of subsystems; location of subsystem interfaces; definition of inputs and outputs for greater detail; planning and conducting activities of data gathering and processing; recoupling of subsystems; and final evaluation and decision.

• Problem definition

Problem definition, or putting limits on the universe that will be related to the projects and program, and identifying linkages are necessary early steps. This, of course, implies the establishment of geographical and time limits (short-term, medium-term, and long-term) as well as becoming aware of the social, economic, political, and cultural factors that condition or influence the problem. It also requires some negotiation between the "client" and the planning team to clearly define the problem, set the overall objectives, and develop a general framework for undertaking the study. The makeup of the team that defines the objectives is important because, despite the general nature of the objectives and work in the early planning stages, these disciplines determine the degree to which attention is paid to the environment throughout the planning process. Therefore, in addition to the more traditional members of the reconnaissance team (river basin or regional planner, agronomist, or natural resource generalist), an environmentalist, or at least someone who has environmentally-oriented terms of reference[1], should be included.

> [1] The work of this member should be to: 1) review existing and proposed national, regional, and local legislation to describe the legal basis for the development of an environmental objective; 2) help to locate existing information, such as a) climatological data; b) hydrological data; c) species lists for both flora and fauna, their distribution, life histories; economically important species, rare and unique or endangered species; d) successional studies; e) biomass; f) ecosystem descriptions; g) soils data; h) anthropological studies; i) past, present, and potential pollution sources; j) demographic studies; k) location and description of existing environmental problems; l) existing demand for natural resources, especially the water resource, required for the functioning of the urban, rural, and natural ecosystem; and, m) demand for fish and wildlife resources; and 3) cooperate with other members of the team in a) identifying the required specialties, b) defining the objectives and terms of reference for the next planning level, and c) selecting variables and indicators relevant to the particular planning exercise.

• Identification of subsystems

The next step consists of identifying the subsystems to be analyzed and the specialists needed to provide the required data[2].

> [2] Since the number and kind of specialists to be required will vary, not all possibilities can be mentioned, let alone described and given terms of reference here. However, terrestial ecology and limnology have special relevancy to river basin planning and the environment. Terrestrial ecology is the study of the interrelations between land-based flora and fauna and the physical environment. In the context of river basin development, it is concerned with the components and dynamics of terrestrial ecosystems and the results of their manipulation by man. Because of its emphasis on defining interactions, the discipline can be important in river basin planning both in predicting environmental impacts and in suggesting developmental strategies. As in other disciplines, terrestrial ecology may be broken down into sub-disciplines and specialties if greater detail is reguired. Limnology is a discipline within general ecology which specializes in aquatic ecosystems. Because the hydrologic resource is so important in river basin development, limnology can play a major role in planning that development.

Generally speaking, the system as a whole may be considered a black box which permits inputs to be transformed into outputs without paying much attention to the internal mechanism or subdivisions of that box (Figure 2).

Previously, river basin planning tended to treat the subsystems. Although nonrelated subsystems may exist (Figure 3a), the subsystems to be investigated in river basin planning are interrelated, as in Figure 3b, and must be evaluated as interrelated subsystems. These may be defined by spatial or disciplinary criteria but the major definition in practical terms should be aimed at resolving problems or meeting stated objectives.

• Location of subsystem interfaces

After having developed the form and general structure of the subsystems, the needed inputs, and the proposed outputs, a table of interactions between disciplines may be constructed (Figure 4). Such a table helps assure an effective interface among the different disciplines. This interface matrix identifies the inputs each discipline requires of the others and the outputs each should provide. As the work is carried out, adjustments will need to be made. Examples of disciplinary concerns and interdependencies are given in Figure 4. Development of the matrix is not the job of any one individual and has no standard content. Its development should be an interdisciplinary effort and be specific to the problems at hand.

An important result of this activity is that, apart from facilitating and improving enormously the communication between disciplines, it is an excellent tool for detecting important omissions, such as the absence of a critical subject area or the unavailability of information.

• Definition of inputs and outputs

Once an effective interface is achieved among the disciplines, a detailed definition of each cell of the matrix, based on the required inputs, should be made to provide the total information needed by the study. This definition should make the work problem-oriented. Since the resolution of problems of environmental quality involve the mutual generation and resolution of problems among the cells, integration by means of a discipline interface matrix provides a mechanism for early resolution of problems.

• Planning and conducting data gathering and processing activities

The next step consists of planning the activities of data planning, collection, and analysis. This demands a sequence of activities to integrate the results of the work of each subunit of the work force. Developed in this way, data gathering and processing, are not isolated disciplinary exercises. Rather, data are gathered that will lead to the definition or resolution of a specific problem at a particular stage of planning and are processed as much as possible by teams rather than by individuals.

• Recoupling of subsystems

An important step at each stage is to reassemble the findings in such a way that the consequences of a proposed project action can be visualized. This may be accomplished through the use of tools, such as matrices, flow diagrams, or models which display a large amount of information. These tools can be used for preliminary evaluations as well as for defining terms of reference at the stages where more detailed analysis is needed. They provide the basis for construction of mathematical models of the system, facilitating sophisticated integration of the data if required.

One of these methods (Freeman, 1974) uses simple statements describing action and effects with arrows indicating the flow of the relationships and+ and - signs indicating whether the final impact is positive or negative. Figure 5, for example, represents the effects in reducing downstream sediment. This results in lower costs for dredging. However, reduction of the sediment load of a river may increase the cutting power of the river downstream thereby increasing the potential for downstream erosion and loss of infrastructure. Sedimentation in the reservoir also reduces the amount of nutrients carried downstream by the river which may reduce primary production in the riverine and estuarine ecosystems and cause a subsequent reduction in fish production and fish catch.

Other methods are more sophisticated but can provide more useful information. The selection of which tool to use must be specific to the level of investigation being undertaken. What is important is that the method chosen allows evaluation of the interaction within and between disciplines and subsystems. These methods exist and have been successfully used to identify and evaluate interactions and impacts. Further material may be found in Leopold, *et al.* 1971; Munn, 1975; Walters, 1974; and Wymore, 1976. The general methodology for developing a mathematical model using the example in Figure 5 is given in Appendix C.

• Final evaluation and decision

In addition to considering environmental protection throughout the formulation of plans and projects, each plan or project alternative should receive an environmental evaluation just as it receives an economic evaluation. This should be as quantitative as possible so that comparisons may be made between alternatives. And, to facilitate review by those who make the decisions, display of this evaluation must be simplified. The next chapter presents a methodology for impact evaluation and display.

Figure 2. Black box representation of a system showing inputs and outputs

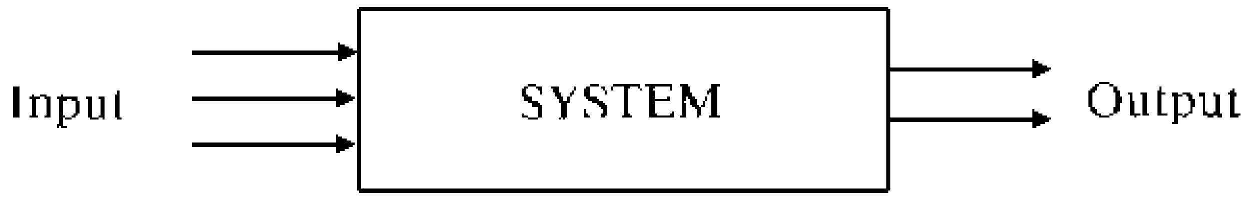


Figure 3. Black box representation of a system showing nonrelated (a) and interrelated (b) subsystems

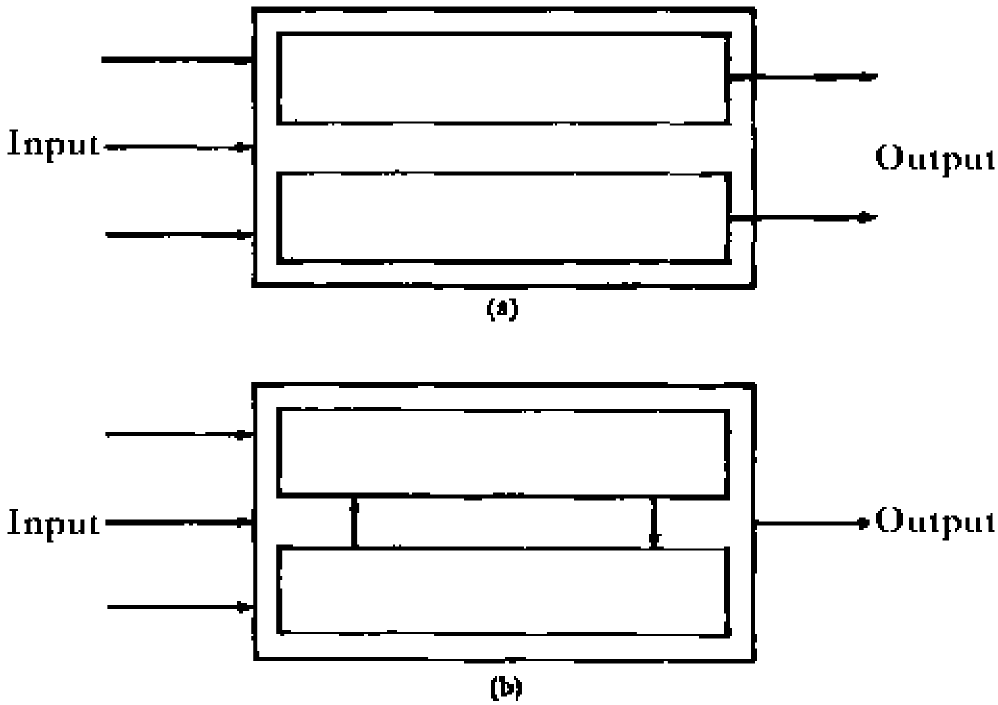
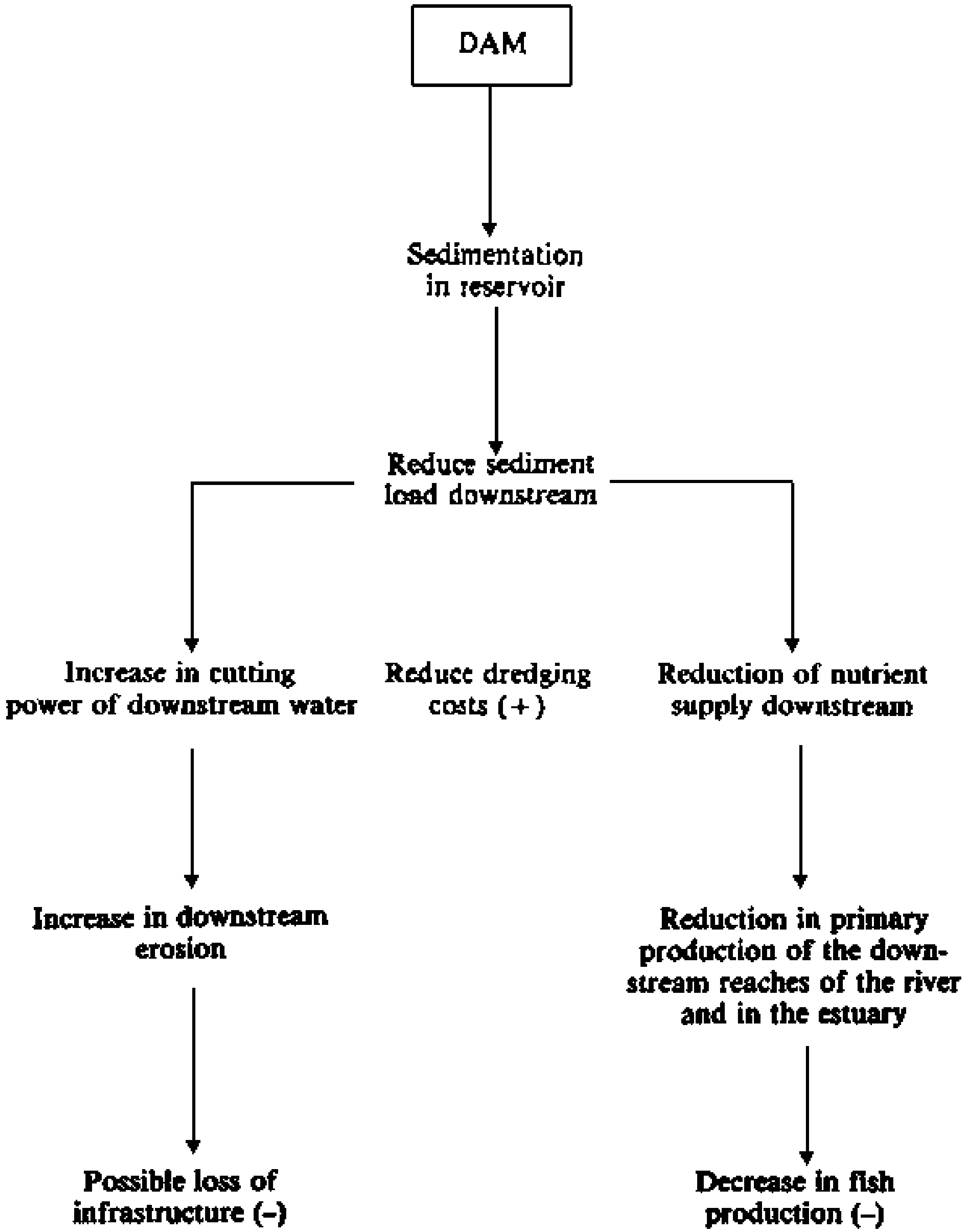


Figure 4. Matrix showing sectoral interfaces

INFORMATION PROVIDED BY	**INFORMATION REQUIRED BY**					
	HYDROLOGY	**LIMNOLOGY**	**PLANT ECOLOGY**	**SANITARY ENGINEERING**	**EPIDEMIOLOGY**	**ECONOMICS**
HYDROLOGY		Data on average, peak, and minimal flow; water quality in terms of suspended solids, bed load, and salinity.	Characterization of hydrologic cycle, runoff data, giving peak, minimum and average seasonal flow; sedimentation/erosion processes.	Data on average, peak, and minimum flow; water quality (current and potential).	Data on average, peak, and minimum flow; changes in water regime that will result with project implementation.	Estimation of probable sediment desposits in navigation areas with projects: reservoir life, water availability for irrigation, industrial, municipal use, and recreation.

LIMNOLOGY	Minimum and maximum temporal demands for water resource to sustain aquatic flora and fauna.		Community succession in wetland areas.	Characterization of water quality needs for aquatic biota.	Identification of potential disease vectors and characterization of life histories; distribution in aquatic habitats.	Identification of aquatic species; rearing areas of species having economic importance; estimate of loss of aquatic species as a result of projects.
PLANT ECOLOGY	Evapotranspiration rates of actual and potential land and water plants; erosion control characteristics of plant communities.	Plant biomass carried to stream; biomass that would be covered in reservoir area (by major species).			Identification of potential disease vector habitats.	Indication of carrying capacities of land resource for domestic and wild animals.
SANITARY ENGINEERING	Actual and potential water contaminants; demand for water resource to dilute contaminants.	Water quality data currently and with implementation of project.				Potential effects of water quality changes as a result of projects, treatment alternatives; mitigation measures.
EPIDEMIOLOGY	Characteristics of aquatic habitats required by disease vectors.	Data on biological control of disease vectors.		Actual and potential disease foci with estimates of incidence.		Identification of methods or programs for disease prevention.
ECONOMICS	Economic evaluation of impacts from proposed actions; calculation of preservation value of area's water resources.	Economic evaluation of impacts from proposed actions; calculation of preservation value associated with aquatic system resources.	Economic evaluation of loss or use of native plant species; calculation of preservation values associated with terrestrial vegetation.			

Figure 5. Flow diagram showing the effects of a dam on the process of erosion and fish production


DAM
Sedimentation in reservoir
Reduce sediment load downstream
Increase in cutting power of downstream water
Reduce dredging costs (+)
Reduction of nutrient supply downstream
Increase in downstream erosion
Reduction in primary production of the downstream reaches of the river and in the estuary
Possible loss of infrastructure (-)
Decrease in fish production (-)

Chapter 4 - The evaluation and display of environmental impacts of river basin development projects

I. Introduction

In the last few years a number of methodologies have been developed to evaluate environmental impact. Although exceptions occur, (McHarg 1969; Institute of Ecology, 1971), generally most are used to evaluate the impact of proposed projects and contribute little to the early planning activity[1]. However, following the principles and procedures for planning water and related land resources established by the U.S. Water Resources Council, the U.S. Bureau of Reclamation (1972) produced a methodology with several useful aspects:

- It is undertaken during the planning process.

- It takes into account the fact that many adverse and beneficial effects of development can only be measured in other than economic terms and that some, no less important, cannot be quantified at all.

- It explicitly evaluates many of the environmental concerns heretofore dealt with only superficially.

- It includes an evaluation of impact under a "no plan" alternative.

- The information is displayed in a logical, organized manner that facilitates decision making.

[1] See also Appendix B for a short review of several Environmental Impact Assessment Methods.

This methodology must be modified to be applicable outside the United States because:

- It is based on two major objectives in planning the use of land and water resources. These objectives, national economic development and enhancement of environmental quality, required by United States law, have equal weight in developmental planning.

- Considerable emphasis is given to public participation which, for a large number of reasons, may not always be possible.

- It requires considerable descriptive information involving financial resources and time to gather the necessary information, which may be prohibitive.

Thus, the methodology of this chapter is an adaptation of the Water Resources Council's procedures and uses only two accounts for evaluating and displaying information on environmental costs and benefits of development projects:

- *The Economic Development Account* presents environmental impacts that can be evaluated financially, and

- *The Environmental Quality Account* displays environmental impacts that cannot be evaluated financially.

The geographic areas to be considered in the evaluation will vary according to the environmental feature of interest and how it relates to the project or program being considered. The Economic Development Account and the Environmental Quality Account should include the areas to be occupied by projects or programs and their zones of influence, including those downstream to the mouth of the basin.

II. Economic development account

The procedures for evaluating economic impacts are well known and will be mentioned here only when they are related directly or indirectly to questions of environmental quality. Details of specific methods for evaluating environmental effects in the Economic Development Account are presented in Appendix D. Certain general statements, however, should be noted.

For example, prices to be used in the evaluation should reflect the real exchange values expected to prevail during the period analyzed. In addition, care should be taken to see that the discount rate is established according to realistic economic conditions and valid economic concepts.

Although the period analyzed generally covers the time period during which the plan can be expected to serve a useful purpose or until further discounting will have no appreciable effect, consideration should be given to the long-term environmental effects which may extend beyond these periods.

Uncertainty, characterized by the absence of any known probable distribution of events, can be analyzed by using a sensitivity analysis and plans should be evaluated in terms of their sensitivity to both the available data and to future economic, demographic, environmental, and technological trends. A plan that is not implemented within a reasonable time after completion should be reviewed to make sure that it continues as the best alternative for achieving the objectives.

Beneficial effects in the Economic Development Account are the increases in the value and output from services and improvements in economic efficiency. A number of activities, such as flood control and prevention, floodplain management, drainage, prevention of sedimentation, land stabilization, and erosion control, contribute to developmental objectives through protecting and improving the productivity, use, and attractiveness of resources. From the viewpoint of their contribution to economic development, the effect of these activities on the output of goods and services is an increase in land productivity or a reduction in the cost of its use.

Recreation potential may also be evaluated in the Economic Development Account. As living standards are raised, once basic needs are met, the average person uses an increasing percentage of real income to fulfill leisure time activities, such as swimming, picnicking, boating, hunting, fishing, and other forms of outdoor recreation. With widespread ownership of automobiles and improvement in highways and public transportation, travel to distant public and private recreational areas becomes commonplace. Consequently, an increasing portion of recreational demand, especially that portion which is water-oriented, should be provided for by medium- and long-term river basin development planning.

River basin plans may include specific measures to enhance fish and wildlife resources with associated opportunities for their harvest as a commercial product as well as for recreation. Benefits to commercial fishing, hunting, and trapping may be increased and this increase may be determined by comparing values of future production with and without the plan.

Adverse environmental effects may result in adverse effects on economic development. Where a physical structure is necessary to obtain the desired objective, the adverse effects on economic development will include all cash expenditures for goods and services necessary for its construction and operation. In addition moreover, where nonstructural measures are used to meet the desired objective, the adverse effects on economic development will include the purchase of easements or rights-of-way and costs incurred for management arrangements or to implement and enforce necessary zoning and protective laws.

External diseconomies are adverse economic effects of a plan that are not reflected in market prices of project inputs and also should be included as costs. They result when provision of goods and services for one group necessarily result in an undesirable effect on another group, as when a plan reduces the output of a firm or when a plan has an adverse direct effect on consumption by individual consumers.

For example, the return flow from an irrigation project may create a salinity condition for downstream water users, forcing them to adopt costly water treatment practices. The reduction in output by a group of users (fisheries) which have their output processed by another firm (cannery) may result in an inefficient operation by the processing firm; or a plan may increase congestion or pollution, resulting in increased costs to consumers.

Another potentially significant environmental impact as a result of river basin plans undertaken in designated areas is in population distribution. Both positive and negative impacts may result. Contributions of a plan to a favorable population distribution and urban-rural balance are beneficial effects. However, urbanization and population migration created by a plan may cause social, cultural, and economic problems that will require costs for their melioration. Some of these costs should be assigned in the Economic Development Account.

III. Environmental quality account

As has been shown, some of the environmental effects of river basin development may be evaluated economically although they generally are characterized by their nonmarket, noneconomic nature. Whatever the case, an evaluation of these effects can still provide important evidence for formulating and judging developmental strategies, programs, and projects.

Beneficial environmental impacts are those that result from the management, preservation, or restoration of one or more of the desirable environmental characteristics of an area under study or within its zone of influence; adverse environmental impacts are those that result from actions leading to the deterioration of desirable environmental characteristics. To the degree possible, each of the major beneficial and adverse impacts should be quantified and displayed for the use of those who must make decisions about planning and developing river basins. This requires the use of criteria for describing the impact so that the various developmental alternatives may be compared. These are presented in Appendix D. In all cases, the importance of the impact will depend upon the nature of the environmental feature being impacted and the nature of the impacting action. These may be evaluated according to the following factors and comparisons made with and without the impacting action.

a) *Quality*. How valuable is the environmental feature? Comparatively speaking, how good are the services offered by this particular feature? Are they the best known?

b) *Quantity*. How much of the impacted environmental feature is there? Or, what quantity of contaminant will be released?

c) *Human Influence*. How much is the environmental feature used by human populations and for what ends? By whom?

d) *Uniqueness*. How rare or available is the environmental feature being impacted?

e) *Degradation*. How much will the impacting action degrade the environmental feature?

f) *Reversibility*. Are the results of the impacts reversible over the short-, medium-, and long-term?

g) *Importance*. Are there any impacts or environmental characteristics that are particularly dangerous or important?

IV. Environmental evaluation

The purpose of this section is to discuss a methodology for evaluating environmental impact and for displaying the results of that evaluation. Examples of the types of questions that need to be reviewed are given along with a short general description of representative environmental categories.

- **Economic category**

The economic environment consists of such things as currency, infrastructure, and goods and services as well as processes, such as marketing, saving, investing, industrialization, and construction. Two items should be mentioned because of their impact on environmental quality which have not been sufficiently discussed in the evaluation of river basin development projects. These are fossil fuel consumption and residual generation.

a) *Fossil Fuel Consumption:* Despite the fact that many river basin development efforts offer projects for the production of hydroelectric energy, there is generally also a large increase in the use of fossil fuels both for the construction of projects and as a necessary requisite for other projects, such as agricultural or industrial development. Given the increasing cost of fossil fuel energy and, in many developing areas, the scarcity of this resource, the influence of fossil fuel consumption should be evaluated.

b) *Residual Generation:* A great many river basin development projects result in the generation of residuals. These residuals take many forms and, in most cases, result in the contamination of air, water, and soils. Thus the production, disposition, and potential use of these residuals should receive an environmental evaluation for each project alternative.

- **Social category**

This is the human component of the environment and includes demographic characteristics, spatial distribution, culture, migration, physical and psychological health, employment, productivity, education, and nutrition.

a) *Human health:* Both the general health status and specific disease and health problems of the population should be evaluated. Specifically, investigations should evaluate the susceptibility of the population to specific diseases, the proximity of the population to health hazards or unhealthy conditions, and the incidence of contact with disease vectors or conditions involved in the transmission of diseases or health problems.

b) *Population migration:* Developmental projects can influence population migration i) by interrupting the traditional migration patterns of indigenous peoples; ii) by decreasing emigration from the development area because of increased opportunity and improved conditions within the area, and iii) by increasing the immigration for these same reasons. The impacts of these changes may be positive or negative and the short-term impacts may be different from the long-term impacts; all should be evaluated.

c) *Green space and green belts* have a function in human health, welfare, and public safety as well as providing transportation corridors and recreational opportunities.

d) *Air quality* includes the chemical, physical, and biological aspects of air. Of highest quality would be air that is free from any materials that adversely affect human and biotic communities.

e) *Culture:* Human cultures and life styles that contribute to the diversity of a population will be impacted, including the cultures of new and old immigrant groups as well as the indigenous peoples of an area. To a large degree the value of a given culture depends upon how that culture views itself and what its desires are, just as it's value depends upon how it is viewed by others in the nation or region. These viewpoints may result in objectives to assimilate a culture into the mainstream of a country or a region, or they may lead to efforts to protect that culture and its life style from certain destructive effects of development. Aspects of the culture that are particularly relevant include religious and ethical concepts, family structure, customs and mores, taboos and preferences; they also include the day-to-day activities that have proven successful over thousands of years of evolution. As a consequence, many things can be learned from a culture that is in equilibrium with its surroundings and these often can be adapted for development purposes. Because of this, the impact of development on the extant cultures of an area needs also to be evaluated.

- **Archeologic/historic category**

This includes those material remains, such as occupational sites, work areas, evidence of farming, hunting and gathering, burial sites, artifacts, and structures of all types which are evidence of human occupation and activities during prehistoric periods. In addition, it includes historic evidence concerning the origin, evolution, and development of a nation, state, region, or local area, such as those places where significant historical or unsual events occurred even though no evidence of the event remains, or places associated with important historic personalities. Given the isolated nature of archeological remains and their importance in reconstructing the past; and, given the fact that historic events are not repeatable, this category should receive a uniqueness evaluation as well as discussion on the mitigation of negative impacts.

- **Natural resources category**

This category includes the renewable and non-renewable resources, such as water, soils, forest, fish, wildlife, air, minerals, etc. It goes beyond this in that it takes into account the interacting components and processes of the ecosystems under study. Thus, evaluation should be made on entire ecosystems as well as on the individual components and processes of these ecosystems. The definition and evaluation of ecosystems are facilitated by mapping the area's important life zones and through the use of conceptual models.

a) *Terrestrial and aquatic ecosystems:* Natural ecosystems can be broadly classified as terrestrial or aquatic and the ecosystem itself should be evaluated according to quantity, quality, human influence, uniqueness and reversibility of impact; critical areas or concerns and should be flagged.

b) *Flora:* This sub-category includes terrestrial, submerged, and emergent plants as individual species, as stands of individual species, and as communities of associated species.

c) *Fauna:* Both aquatic and terrestrial fauna can be broken into several important subgroups and may be discussed as subunits except where an individual species is of importance. Possible subunits are: threatened species, large animals, fur bearers, water fowl, other birds, reptiles, and amphibians, fish, crustaceans, mollusks, insects, and others. In addition to the individual wildlife species, the habitat of these species should be considered.

d) *Edaphic:* This sub-category includes soils or proto-soils and their applicability for the many agricultural, urban, industrial, and protective uses.

e) *Geologic/topographic:* This sub-category covers areas of geologic importance as future mineral sources as well as those areas of interest for the study or display of the earth's development, and for recreational purposes. It should include such things as fossil beds, potential ski slopes, caves, geothermal energy sources, areas having scenic values, and hazardous areas, such as those with severe incline and subject to landslides or mudflows, etc.

f) *Water quality:* This category includes the chemical, physical, and biological aspects of fresh, brackish, and salt water with respect to its suitability for a particular use. Of highest value would be water quality better than that which is needed for expected uses. The effects of a project on water quality may extend well beyond the immediate project area. Therefore, the total area under evaluation should be carefully considered in order to measure the cumulative environmental effects of all proposed actions.

V. Display

The display of these evaluations may be accomplished using a simple table format indicating the various project alternatives across the top and specific descriptions of the environmental categories to be impacted and the criteria along the right hand edge. Quantitative and qualitative evaluation summaries of these impacts are then presented within the table. Because each planning activity will be different, the planning team should develop its own format. Table 1, on page 40, is presented as an example to help understand the evaluation and display methodology.

Title: Social-economic development plan for "Valle de San Juan."

Time Frame: 50-year life of project.

Objective:

1) Raise production of horticulture crops in the area along the San Juan River by 40 percent. Decrease flooding costs by 20 percent.

2) Maintain productive capability of any rare, endangered, or economic species of flora or fauna. Conserve, where possible, important historic and cultural patrimony of the area.

Alternative A: Raise height of existing dam by 5 meters and build canal from existing reservoir to supply secure source of irrigation water to 15,000 hectares of cropland. Provide for full control of river.

Alternative B: Extend existing canal 10 kilometers and build additional small scale diversions to provide sufficient secure water for 9,000 hectares of cropland and water that is secure for 85 percent of all years on record for an additional 7,000 hectares. Include the maintenance of a unique prehistoric dwelling site and riverine ecosystem that would be flooded by increasing the reservoir area; plan for flood plain zoning and a reforestation project upstream to control flooding.

Table 1. Display of qualitative and quantitative effects of hypothetical socio-economic development for the Valle de San Juan

CATEGORIES	PRESENT CONDITION	ALTERNATIVE A B/C=1.75	ALTERNATIVE B B/C=1.75	NO PLAN
	US Dollar	US Dollar	US Dollar	US Dollar
PROJECT COST	-	$4,500,000	$1,865,000	-
Construction	-	3,000,000	1,200,000	-
Maintenance/operations	-	1,500,000	700,000	-

Flooding downstream	-	0	325,000	$1,000,000
Reforestation	-	0	20,000	-
Historic site main./oper.	-	0	700,000	-
Guards for wildlife reserve	-	0	620,000	-
PROJECT BENEFITS	$93,000/yr	7,850,000	6,100,000	-
Agricultural production	80,000/yr	5,000,000	3,500,000	2,500,000
Flood control	10,000/yr	2,000,000	1,000,000	-
Recreation	1,000/yr	800,000	1,500,000	1,000,000
Commercial fisheries/wildlife	2,000/yr	50,000	100,000	-
SOCIAL CATEGORY				
1. Human health				
Population 20,000				
Upper 10% of population	No health problems	No health problems	No health problems	No health problems
Middle 70% of population	10% malaria	15% malaria	10% malaria	10% malaria
	incidence	incidence	incidence	incidence
	0% bilharzia	10% bilharzia	5% bilharzia	0% bilharzia
Lower 20% of population	25% malaria	30% malaria	30% malaria	25% malaria
	50% bilharzia	50% bilharzia	55% bilharzia	50% bilharzia
2. Human influence				
Lower 20% of population	Intermittent contact with disease vector	Slight increase in contact with disease vector	Medium increase in contact with disease vector	No change
ARCHEOLOGIC/HISTORIC CATEGORY				
1. Quantity	1 temple	Flooded	1 temple	1 temple
Prehistoric habitation including temple and some dwellings	5 dwellings	Flooded	5 dwellings	5 dwellings
2. Quality	High quality	Flooded	High quality	High quality
	Average quality	Flooded	Average quality	Average quality
3. Human influence	Visited by approx. 200/yr	Flooded	Visited by 10,000/yr. Protected by year-round guards. Some reconstruction.	Steady deterioration of resource due to vandalism

4. Uniqueness	Very rare outside of planning setting - only example occurring in region	Flooded	Protected	Deteriorating
5. Degradation	Deteriorating	Totally destroyed	No detrimental effect. Ruins will be protected.	Deteriorating
NATURAL RESOURCE CATEGORY				
Aquatic ecosystem (wetland area that is nesting site for the rare musk otter)				
1. Quantity	100 hectares	Flooded	100 hectares	100 hectares
2. Quality	High quality	Flooded	Could be the most productive ecosystem of this type	Lost due to encroachment by man and uncontrolled trapping of musk otter
3. Human influence	Medium encroachment by man. Illegal poaching of wetland fauna.	Flooded	Protected by guards. Could eventually arrive at managed sustained yield of musk otter	Deteriorating resource due to encroachment by man and poaching of wetland species
Fauna (musk otter)				
1. Quantity	25 breeding pairs estimated	Flooded 0 breeding pairs	Protected. Could arrive at estimated 200 breeding pairs	Eventually lost
3. Human influence	Extensive poaching of species	Flooded	Protected and managed	Eventually lost

Chapter 5 - Environmental impact in the area of the case study

The purpose of this chapter is to: 1) identify the major environmental impacts that could result from development of the Bermejo River Basin as proposed by the earlier planning investigations (OAS, 1974, 1977); and 2) to suggest ways that these impacts could have been evaluated for possible adjustments to the Economic Development Account. First, in order to place the case study in its context, a short description of the Bermejo River Basin follows.

I. The Bermejo River basin

The Bermejo River begins in the Andes Mountains of north-wetern Argentina and southern Bolivia where the headwaters from two distinct river subsystems - the Tarija-Bermejo, coming from Bolivia in the north and the Grande-San Francisco, coming from the west. These two subsystems form the upper "basin" and join at the Junta de San Francisco, where the Bermejo River leaves the pre-Andean zone flowing in an east-southeast direction, 1,700 km across the alluvial plain of the Argentine Chaco to the Paraguay River (Figure 6). The upper section contains an area of 50,550 km^2 while the lower section covers 43,800 km^2, giving the basin a total area of 94,350 km^2.

The Bermejo River drainage system, between 21° and 25° S lat., is sufficiently distant from the equator to have a strongly seasonal temperature and precipitation. Because of the highly broken topography of the upper basin, precipitation varies from 200 mm in the Quebrada de Humahuaca at the far western edge of the basin to 1,400 mm at the Junta de San Francisco. Minimum extreme temperatures vary from 13°C down to 0°C and extreme maxima vary from 34°C to 45°C, the lower temperatures occurring in the west and the higher temperatures in the east. Precipitation in the lower basin varies from 1,200 mm annually in the far eastern portion, 500 mm in the mid portion, to 900 mm at the division between the upper and lower basins. Extreme low temperatures of -8°C occur in the southwest lower basin while highs of 40°C have been measured in the east.

Figure 6. Upper Basin of the Bermejo River

High mountains, deep valleys, and pre-Andean foothills separated by wide valleys, alluvial plains, and shallow rivers characterize the upper basin. These rivers carry water only during the season of heaviest rains and are dry or nearly dry during the remainder of the year. Extreme topography and scarce vegetation contribute to high rates of erosion which are further accentuated by human influence through forest exploitation and heavy livestock use. As a consequence, many of the rivers and streams of the basin carry enormous sediment loads (estimated at 95×10^6 tons/year) from the upper to the lower portion of the river basin. As the river enters the lower basin, most of the coarser, heavier load is lost to form a broad alluvial fan. The finer, suspended matter is transported by repeated sedimentation and erosion through the lower basin to the Paraguay and Paraná rivers where evidence suggests that it is at least partially responsible for the sediments deposited in the latter's navigation channels. Other tributaries of the Bermejo River have beds of sand and finer material and are fed by groundwater flowing through the alluvial valley soils.

The lower basin is distinct from the upper basin. Here the river moves across the vast, gently sloping Chaco plain which, in recent geological time, has been filled, and locally continues to be filled, with large amounts of alluvia brought down from and the Andes. At the point where the Bermejo River leaves the Cordillera, its elevation is 280 m above sea level; at its confluence with the Paraguay River it is only 41 m above sea level giving a gradient of 239 meters over a distance of 1,188 km, only 20.1 cm/km.

In the lower basin two distinct sections can be described: an alluvial cone formed at the foot of the pre-Andean range where the river splits into many arms in a bed of up to 3,000 m width; and a lower portion where the river narrows and continues in the form of innumerable meanders. Downstream from this change in morphology, there is a tremendous network of abandoned channels, esteros, oxbows, bogs, and marshes in varying degrees of density to the confluence of the Paraguay River. These more or less stagnant, lateral water bodies temporarily connect with the main river during flood stages.

Variations in topography, elevation, precipitation, soils, temperature, susceptibility to flooding, erosion, and sedimentation, as well as the influence of man and animals, have created a number of fairly easily defined vegetation units. These include a complex mountain forest in areas of high precipitation (1,300 mm/year); a Chaco forest occurring as semiarid, transition, and humid forms, and a transition forest situated between the mountain and Chaco forests. Grasslands in the basin may be divided into three types: eastern wetlands, high elevation grasslands, and a pyric form held at a lower successional stage because of fire.

Areas that remain more or less undisturbed contain a large and diversified fauna; of the 243 species listed in Argentina, over 60 percent occur in the Bermejo River Basin. These include five species of cat, two species of fox, tapir, at least two and perhaps three species of pecari (one of which is a recent scientific discovery), vizcacha, chinchilla, nutria, capybara, anteaters, and sloths; two species of toucans, nandu, seven species of tinamou, and a large variety of water birds; two species of caiman; several species of snakes, lizards, and turtles; and a large variety of fish, many of which migrate upstream to spawn. Several species are of local importance for sport, subsistence, and commerce in skins and live animals.

The upper section of the basin contains the most active economic zones of the provinces of Salta and Jujuy. Per capita gross national product in the area is approximately one-half the national average of U.S. $1,900 in 1974. However, the annual rate of growth of the regional product was 5.2 percent in the 1960's and early 1970's compared to 3.7 percent for the rest of Argentina.

During the last 15 years the regional economic structure has been modified considerably; agriculture decreased and the industrial sector increased in importance. As a result, participation of the industrial sector in the regional product has neared 40 percent which is similar to the national average.

The economic center of the region is Salta, San Salvador de Jujuy, San Pedro de Jujuy, and Gral. Martin M. de Güimes, where the development pole for northern Argentina is situated. This area constitutes a center of attraction for both internal and foreign migration, causing a population growth rate in the 1960's of 2.4 percent compared to a national average of 1.5 percent.

In 1970, the basin's population was 789,000, 81 percent of which lived in Argentina. Of those in Argentina, 63 percent lived in urban centers. Only 33 percent of the Bolivian population was urban-based.

II. Case study

Investigations in the basin were wide ranging and included 26 projects, many of which had been proposed previously. Eleven of these were discarded early, although two dams built during the time of the study (Zanja del Tigre and Las Maderas) were added to the study. Because it was impossible to discuss each project, only a portion of the overall development plan was evaluated for environmental impact. Specifically, the areas of analysis chosen included an area of about 130 km^2 surrounding the "Angosto de Mojotoro" and the area known as "El Acheral" containing approximately 500 km^2. Both are located in the upper basin (Figure 6).

Proposals for the development of these areas called for construction of one dam on the Mojotoro River, approximately 14 kms northeast of the city of Salta, and a second dam, Vilte, to be located 120 kms downstream from Mojotoro. In addition, a small control dam was to be built 4 kms below Mojotoro to provide municipal and industrial water to increase the security of the irrigation water supply to 8,300 hectares in the Guemas-Los Cobos area. Both large structures were to help control sedimentation and cut dredging costs downstream, and Mojotoro was to further provide hydroelectric energy for the nearby industrial area and irrigation water for 18,600 hectares of newly opened land. In addition, 24,700 hectares at El Acheral were to be irrigated through pumping from the controlled flow of the Lavayén. Specific data on the two projects are given in Table 2.

Table 2. Summary data on the Mojotoro and Vilte projects of the Bermejo River Basin in Argentina

	PROJECT	
	Mojotoro	**Vilte**
River[1]	Mojotoro	Lavayén
Size of Structure		
Height	115 m	26 m
Width	385.5 m	853.0 m
Storage capacity	629 hm^3	63 hm^3
Reservoir size	15.4 km^2	-
Reservoir life	50 years	27 years
Cost US $000	73,330	13,670

Benefits US $000	101,510	31,490
Generation of electricity US $000	23,980	-
Irrigation US $000	29,630	16,300
Control of sediments US $000	31,600	-
Pot/ind. water supply US $000	1.38	2.30
B/C		

[1] The Mojotoro River becomes the Lavayén River 4 km upstream from the proposed Vilte Dam.

III. Impacts on environmental quality

Anticipated impacts from the implementation of the case study projects can be divided into three categories: 1) those in the area of the reservoirs, 2) those resulting from the placement of structures across the stream, and 3) those downstream from the structures. These impacts are shown in the flow chart, Figure 7. Rather than analyze each one individually, only those having, or leading to, direct economic or social impacts will be discussed. These are the impacts relating to agricultural production, power generation, health conditions, fisheries, domestic and industrial water supply, downstream fluviomorphology, population and infrastructure relocation, and recreation. In addition, preservation, as an alternative to some portions of the development projects, is discussed in economic terms.

- **Agriculture**

Impacts on agriculture downstream from the structures will, in the short- and medium-term, have positive economic effects in the El Acheral-Guemes/Los Cobos areas where a fairly high agriculture production already exists. El Acheral, however, is sparsely populated and has a limited amount of dry and seasonally irrigated agriculture since much of the area is characterized by a high water table, saline soils, and extensive Chaco forest. In both areas, the availability of irrigation water will increase potential productivity. Nevertheless, a number of secondary impacts can be expected to influence agricultural productivity and methods, as well as some aspects of human welfare. These will be particularly severe at El Acheral.

Irrigated agriculture often implies intensified use of herbicides, pesticides, fertilizers, and machinery with larger and fewer farms. Irrigation waters discharged into the Mojotoro and Lavayén rivers can be expected to increase the level of contamination which, in turn, could disrupt aquatic habitats and introduce pesticides into the food chain.

Under the assumptions of the original study, agricultural benefits were estimated at $44,820,000. However, because of prevailing conditions in the area, irrigated agriculture in El Acheral may encounter significant salinization problems and these will either reduce the area's long run agricultural productivity or involve increased management and capital costs to maintain expected productivity levels. Therefore, either productivity losses over time must be estimated or, if losses are assumed to be greater than prevention costs, these costs must be included in determining agricultural rents.

The discharged irrigation water from the Guemes/Los Cobos area has a higher nutrient level and would contribute to increased rates of evapotranspiration in the Vilte Reservoir because of greater waterweed growth. Utilization of this water could aggravate the salination problem in El Acheral also and an increased evapotranspiration would reduce the reservoir water supply estimated as being available to irrigate the 43,000 hectares in El Acheral. If this is true, then the estimates of irrigable hectares would have to be reduced and benefit estimates adjusted downwards. Further complications may arise due to a significant loss of water required to maintain natural ecosystems further downstream.

Figure 7. Qualitative environmental impacts due to dams and reservoirs

- **Power generation**

Total power benefits of the Mojotoro Dam, in terms of the costs for the next best alternative of power, were estimated at $23,980. However, there is some indication that waterweed growth in Mojotoro Reservoir will contribute to increases in evapotranspiration rates and water losses from the reservoir. To the extent that further research identifies a significant reduction in the available head for power benefits, these would have to be adjusted downwards or weed management costs included in the project's operating costs.

- **Human health**

A number of factors have been identified as contributing to increased human health risks as a result of the projects. Initially, the stillwater environment of the Mojotoro and Vilte reservoirs and the associated irrigation canals will create prime disease vector habitat. Expansion of the malaria-bearing mosquito population is seen to be highly likely and this expansion, coupled with regional immigration, is expected to increase the incidence of malaria in the area. Regional immigration may bring in other vectors and parasitic hosts as well. Schistosomiasis is one of these latent dangers since aquatic weeds create adequate living conditions for the alternate host snail. Although the disease is not yet present in the region, the snail is endemic to the Plate River Basin of which the Bermejo is a part and immigration of infected human beings may help establish the disease in the upper basin.

The economic effects of the increased health risks created by the reservoirs and irrigation works may be calculated in two ways, although neither is completely satisfactory. The first is to estimate both the probable incidence of disease associated with the projects and the average per capita loss in productivity as a result of infectation. To this would be added a figure for average treatment costs per individual in order to reach a total health hazard cost. The problems with this approach are its difficulty of application and its incomplete assessment of human suffering. An evaluation of the probable incidence of disease is a demanding task for the medical statistician, but possibly fraught with no greater uncertainty than many other estimates called for in complex project evaluation.

A second method commonly used is to estimate the costs of vector control programs. Though a simpler approach, it carries the implicit assumption that the project cost is less than any social costs associated with the disease. Public health and data availability will provide the guidelines upon which a choice of approach can be made.

It is obvious that the above procedures do not attempt to account for the negative impacts to the ecosystem and human health, including suffering and loss of life brought on by the use of pesticides.

- **Fisheries**

Many facets of the proposed Mojotoro/Vilte projects could prove deleterious to the aquatic ecosystems of the Mojotoro and Lavayén rivers. For example, the structures represent barriers to the movements of migratory riverine species and, interruptions in their life cycles as well as contamination of their food chain, could prove lethal. Alterations in river hydrology could affect spawning grounds, water temperatures, and food supplies. Irrigated agriculture, a major component of the projects, can significantly affect existing fish populations by the discharge of irrigation waters high in organic matter and chemical contaminants. It is most probable, therefore, that *existing* fish populations will be negatively affected by the proposed projects.

However, the existing fisheries of the Mojotoro and Lavayén rivers are evidently not extensive and fishing activity is minimal. The major economically important species in the Bermejo system include sabalo, surubi, pacu, armado, and dorado and, although many of these species appear in the Mojotoro/Lavayén area, accurate estimates of population and catch are not available. It is not possible, therefore, to develop specific estimates of the value of the existing fisheries until longer range and more intense investigations are initiated.

The creation of still water reservoirs sometimes has the potential to compensate for loss of natural river fishery. Although reservoir fisheries will usually constitute a different species mix than the natural fisheries, they can prove to be of equal or greater value if provision is made before the reservoir is filled.

For a complex set of reasons, the reservoir should experience high initial fish production due to the rapid release of nutrients from decomposition of inundated vegetation. However, as the rate of decomposition and nutrient release declines, as aquatic vegetation begins to extract available nutrients, and as the reservoir becomes eutrophic, a decline in fish production may occur. Water vegetation and any debris remaining in the water will severely hamper both recreational and fishery activities.

The reservoir fishery potential of both the Mojotoro and Vilte reservoirs is not expected to be large. Since the Vilte Reservoir will be shallow and undoubtedly high in organic matter, it will experience relatively rapid rates of evapotranspiration and eutrophication. The Mojotoro Reservoir appears to have a greater fishery potential than does Vilte, since contamination, weed infestation, and increased rates of evapotranspiration and eutrophication are not expected. Research on the probable characteristics of the proposed reservoir and the adaptive capacities of existing riverine species or on any potential exotic species that could be used to stock the reservoir remains to be done.

Given adequate information, the effects of the proposed projects on the fishery could be evaluated in terms of the net value of commercial production and on the value of the fishery for subsistence food supply and for sport fishing.

The approach would be to determine the current and future potential value of the fishery for each of the above purposes without the effect of the project. Then, having identified the changes in fish production and catch as a result of the project, the value of the fishery should be estimated with the project. The difference between the two results would constitute one component of the fishery costs or benefits associated with the project. To this one should add the value of the reservoir fishery, net of management costs, created by the project to reflect the impact of the proposed project on the fishing sector.

• **Fluviomorphology**

Mojotoro and Vilte dams are to serve as barriers to sediment movement downriver. Containment of fine sediments (between 5 and 20 microns) would reduce their deposition in the lower reaches of the Paraguay, Paraná, and Plata rivers. This would somewhat alleviate the dredging costs required for maintaining navigation channels. However, removal of a river's sediment load often tends to increase the cutting action of downstream flows. Although the complexity of the Bermejo drainage system and the scarcity of data do not allow exact quantitative predictions to be made of the fluviomorphic impacts, preliminary conclusions suggest that nothing detrimental of any magnitude should be expected as far downstream as Guemes (50 km from Mojotoro). Below Guemes, a period of bank erosion and some stream bed degradation should occur and there will be marked instability during floods from tributaries entering the main stream between Mojotoro and Vilte. This could be a problem for some agriculture, infrastructure, and wildlands in the area.

The dam at Vilte would push this potential erosion problem further downstream, below the confluence of the Lavayén and Rio Grande (80 kms from Vilte) where the future behavior of the river becomes even more uncertain. For example, the possible effects on the islands in the Paraguay and Paraná rivers and possible bank erosion all along the Bermejo River have not been adequately evaluated. Furthermore, with stream regulation and falling discharges, some reaches may not scour adequately and, since river transport is dependent on minimum depth, short stretches of the channel may require dredging. Thus, sedimentation benefits may need to be adjusted downwards.

• Domestic and industrial water supply

The Mojotoro Dam was to provide a source of water for domestic and industrial purposes. Benefits of providing this water can be measured by either the customer's willingness to pay for water from this source or by adapting the cost of the next best alternative source. Domestic water supply benefits were not estimated in the original study because this market is given exclusive priority use in Argentina; industrial benefits were estimated at $31,000,000 for Mojotoro.

However, the expected rapid rates of evapotranspiration in the Mojotoro Reservoir require evaluation of their implications on the volume of water available for domestic and industrial purposes. To the extent that evapotranspiration would occur, the supply for the competing uses (power, industry, and irrigation) would be reduced and this would imply lower industrial user benefits than those originally estimated. In addition, surface and groundwater contamination due to salinization or pesticides imposes incremental costs in the provision of acceptable domestic water supplies over those that normally prevail. These costs should be charged to the agriculture projects.

• Relocation of population and infrastructure

Beginning with the main structure at Mojotoro, construction will require relocation of the principal Salta railway line. Only a very small number of residents in the village of Mojotoro will need to be relocated as a result of construction of the Mojotoro and Vilte reserviors. Still, their situation is real and is representative of the problems of relocation occasioned by development.

Three types of possible costs are suggested by the situation of the residents at Mojotoro: a) loss of property values, b) relocation costs, and c) distress costs.

Construction of the dam will reduce residential property values in Mojotoro to zero, thus the current market value of land and buildings in Mojotoro should be included as a cost of the dam. In addition, forced relocation will require incremental out-of-pocket costs which are also legitimate costs of the dam.

Psychic distress is often caused by forced relocation since it alters life styles, or, as a result of forces beyond their control, requires residents to give up an environment to which they had become attached.

• Recreation

Outdoor recreation is a legitimate competitor both for the direct services of water and land resources, and for the indirect services through the fish and wildlife that inhabit them. Although the proposed reservoir at Mojotoro should have a recreational potential, no actual benefits were estimated for this resource use. Neither was any mention made of the recreation or other use potential foreclosed by execution of the proposed projects.

Since outdoor recreation services are usually provided on public lands, market determined prices are seldom available. Consequently the value of outdoor recreation resources is generally measured by the willingness of individuals to pay for the services of the resource (Davis, 1963). In addition, where regional objectives are relevant, expenditures of tourists visiting the resource (i.e. food, lodging, transportation, etc.) can reflect the income and employment value of the resource to the region (Clawson and Knetsch, 1963; Knetsch, 1974).

The willingness to pay for a commodity can be approximated since the value of the commodity is a function both of the quantity of users and the price they would be willing to pay. In recreation evaluations, the commodity is a defineable area having specific recreational amenities; the objective is to determine the value of these amenities rather than the value of outdoor recreation in the general sense. Just what the beneficial and adverse impacts of the proposed projects would be on recreation cannot be adequately presented because of a lack of data.

Despite the fact that the areas of Mojotoro and El Acheral are considered to have rather commonplace amenities and the landscape, flora, and fauna are fairly common to many other areas in the general region, the costs and benefits of the projects relevant to the recreation potential should be analyzed. Of course impacts associated with the amenity services cannot be specifically valued although they can be evaluated within a framework which permits their comparison to more easily estimated economic costs and benefits.

The methodology for doing this is laid out in the next section which attempts to evaluate the loss of any of the attributes of the natural system because of execution of the case study projects.

• Preservation of natural system services

Calculating a value for preservation is an attempt to place a value on the amenity services provided by an area which would be foregone if development were to take place (Knetsch and Fleming, 1975). Amenity services, as stated earlier, are those services that cannot be valued because of the lack of a market mechanism. They consist of services provided by natural ecosystems which may not even be known nor understood but which have a life support function (ecosystem stability/diversity, primary production, hazard reduction, nutrient cycling, contamination abatement) as well as such things as the value of the natural gene pool, recreation potential, and other natural system services and the preservation of unknown future options. Calculation of a value for these services depends on the discount rate, rates of shift in price and quantity intercepts, and years to capacity constraint. This value is then compared to the potential benefits accruing with development.

For example, the net economic benefits of the case study to which environmental values would be compared is the estimate of $46.0 million. Against this assumed level of net economic gain, the value of the area were it to be preserved must be compared. Only if it can be demonstrated that the economic benefits clearly exceed the amenities foregone, should the project be sanctioned.

Rather than attempting to determine the actual value of the preserved amenities, the question to pursue is how large the environmental preservation benefits would have to be to equal the net economic development benefits. Or, to shift the "burden of proof," the question could be put in terms of what assumptions and assertions are necessary to support the presumed superiority of the development values over those of preservation. Generation of the evidence needed to make this judgement requires examination of the demand characteristics for the environment under study. The foci of this examination are the immediate demands and how they might change over time.

Ample evidence exists in many parts of the world to prove that the general demand for the amenities of natural ecosystems is growing at a very rapid rate. The same type of growth is not readily apparent in Argentina, although some of the prerequisites to developing interest in these amenities are beginning to surface. Preservation values in the case study area are modest at present, but these might be expected to grow over the long-term as expansion of Salta, Guemes, and La Caldera put pressure on nearby areas. In contrast, the benefits of power and agricultural outputs will be greater in the short-term if development takes place.

Whatever the level of initial preservation benefits, they would be represented by the willingness to pay for the environmental resource amenities. If demand for these services increases over time, this would indicate an increase in value. Generally speaking, this demand grows with increased population and income and changing needs and tastes, although growth in demand for a specific site is dependent on additional factors - increases in the amount of use for individual recreation areas or use of a river for pollution dilution purposes are examples. These and other natural amenities are subject to congestion or saturation restraints. For example, in the case study area, the alternative assumptions of growth in quantity demand are set relatively low (3%, 7%, and 10%) while the discount rate assumptions (10%, 15%, and 20%) are relatively high (Table 3).

The price people would be willing to pay for the services of a very unique area would be expected to increase more rapidly than real per capita incomes. On the other hand, if the services of the area are common and numerous areas with similar services are available, then a high degree of substitutability in the natural amenities can be expected and the price that people would be willing to pay for the services of these areas would not increase at a rate faster than the growth in per capita incomes. This is assumed to be the case for the Mojotoro and Vilte areas.

The historical growth in per capita income in the case study area has been about 1.0 percent annually; projections of the original study, however, assume a growth rate of about 4.0 percent annually. For our purposes, the assumed range of growth in the price intercept of the demand schedule is 1 percent, 3 percent, and 6 percent, and the implications of these alternatives are summarized in Table 3. Initially, the willingness-to-pay figure is assumed to equal $1. Subsequent shifts over time, based on the site specific implications of income and population growth, enlarge this value. Willingness to pay each year is taken to be the value of the benefits derived that year from the area's amenities, and the present value of the benefits derived that year from the area's amenities, and the present value of the benefit stream is obtained by discounting the annual benefits at the appropriate rate.

Assuming the discounted growth benefit for preservation of the area are: quantity growth, 3.0 percent;

price growth, 1.0 percent; and discount rate, 15.0 percent; the present value of the annual benefits would be $7.90. This figure can then be divided into development losses (the estimated net economic benefit that would accrue if the Mojotoro and Vilte sites were developed for the projects under study) to establish the value required for the initial year's preservation benefits in order for the site's preservation to be economically justified. Under the above benefit assumptions, and assuming the figure for net economic benefits ($46.0 million), the areas would require an initial year value of $5.8 million to justify preservation.

Although the preservation of the natural amenities of the case study area can probably not be justified on the basis of this value, the numerous impacts discussed above may reduce total benefits. This and the unknown value of many other environmental aspects seem to justify further investigation of the proposed reservoirs and the characteristics of the natural ecosystems which will be destroyed if the real costs of this development are to be estimated.

Table 3. Present value of one dollar of natural area preservation benefits growing over time and discounted to initial year

<table>
<tr><th colspan="6">Benefits Growing Over Time and Discounted to Initial Year</th></tr>
<tr><th>Initial rate of shift in quantity intercept</th><th rowspan="2">Years to capacity constraint</th><th>Rate of shift in price intercept</th><th colspan="3">Present value of $1 at discount rate[1]</th></tr>
<tr><th>(%)</th><th>(%)</th><th>10%</th><th>15%</th><th>20%</th></tr>
<tr><td rowspan="3">3</td><td rowspan="3">50</td><td>1</td><td>17.06</td><td>7.90</td><td>6.51</td></tr>
<tr><td>3</td><td>25.17</td><td>11.99</td><td>7.62</td></tr>
<tr><td>6</td><td>60.24</td><td>18.69</td><td>10.07</td></tr>
<tr><td rowspan="3">7</td><td rowspan="3">30</td><td>1</td><td>29.89</td><td>14.50</td><td>8.91</td></tr>
<tr><td>3</td><td>46.99</td><td>19.37</td><td>10.87</td></tr>
<tr><td>6</td><td>118.26</td><td>33.32</td><td>15.51</td></tr>
<tr><td rowspan="3">10</td><td rowspan="3">20</td><td>1</td><td>36.42</td><td>18.15</td><td>10.99</td></tr>
<tr><td>3</td><td>55.16</td><td>24.12</td><td>13.55</td></tr>
<tr><td>6</td><td>126.59</td><td>40.19</td><td>19.42</td></tr>
</table>

[1] Present value factors estimated using Ciccetti formulation but with different equations and a constant decay factor by Knetsch and Fleming, 1975.

Chapter 6 - Comparison of Bermejo river and pilot study planning methodologies

The purpose of this section is to apply the planning methodology developed by the Pilot Study to that used in the original upper basin investigation in order to see whether there are specific differences and what they are, and whether or not these differences would have changed the final result.

A critique will be made at the levels of the overall objectives of the original agreement; the reconnaissance and area surveys; regional diagnosis; development of action guidelines, priorities, and project selection criteria, identification, evaluation, and selection; suggestions for administrative structures; and scopes of work and research needed for the feasibility studies (Figure 8).

• **Formal Accord for a Water Resources Investigation in the Upper Basin of the Bermejo River**

The "Technical Assistance Accord for the Study and Development of the Water Resources of the Upper Bermejo River Basin" established the objectives, plans of operations, and specific terms of reference for the planning investigations (OAS, 1970).

Overall objectives, as given in the Accord were:

a) To undertake a reconnaissance of the water resources of the upper basin in order to identify specific development projects;

b) To evaluate these projects and make general recommendations on the sequence and time frame of their execution;

c) To develop the terms of reference for future studies of investment projects that could be submitted to international financing agencies; and

d) To supply the technical basis for making decisions on the integrated development of the water resources of the upper basin.

The Accord clarifies some environmental issues. Specifically it shows a regard for coordinating plans within the region and makes explicit a concern for the disposition of water contaminants; it attempts to deal with the potential sanitary problems related to the water resource and to establish water quality benchmarks. Further, it concerns itself with the question of recreation and an interpretation could be made for a requirement to establish a demand for pollution dilution of the water resource. Erosion control projects are mentioned, although not necessarily as alternatives to the use of reservoirs to control sediments.

A major consideration of the Pilot Study methodology is to include an environmental quality objective as one of the overall objectives of a planning investigation. This was not done in the original upper basin study - in part, because traditional river basin planning objectives seldom include environmental quality as a specific concern and, in part, because the study was initiated prior to significant worldwide concern for environmental protection. One could have been included, however, because the Government of Argentina does have laws and official policies to deal with environmental protection. For example, the National Plan for 1971-1975 includes objectives in the Agriculture, Water Resources, Public Health, and Tourism sections which emphasize environmental quality (GOA, 1971).

In addition, Decree No. 558 of August 7, 1970 (GOA, 1970) contains specific policies to:

> - "Promote the conservation, investigation, and diffusion of the nation's cultural heritage..." (paragraph 19).
>
> - "Prevent air, water, and soil contamination; to establish severe norms and assure their strict enforcement" (paragraph 41).
>
> - "Assure the preservation and promote the understanding of the natural landscapes of the country, its flora, and its fauna, especially through creation of the necessary national parks and reserves as well as through adequate conservation of those already existing" (paragraph 94).

The Accord describes seven major components to be investigated during the reconnaissance and prefeasibility activities: 1) analysis of the present situation, 2) determination of the availability of water resource, 3) determination of water needs in terms of quality and quantity, 4) studies on erosion and sedimentation processes in the upper basin, 5) formulation of preprojects, 6) an analysis and evaluation of preprojects and programs, and 7) recommendations on criteria, policies, and legislation, project priorities, and feasibility studies.

Also, despite the fact that the Accord goes beyond the normal interest in the environment on the part of planning at this stage, the new methodology would have greatly clarified some aspects of this concern. For example, the Accord requires an "analysis of tendencies in ... use of water for irrigation, potable, and industrial water, navigation, generation of energy, etc." The new methodology would have made explicit what is incorporated in "etc.," since the Accord may have meant to include environmental concerns, such as pollution dilution, recreation, and terrestrial and aquatic ecosystem maintenance.

Figure 8. Planning methodology utilized in the Upper Basin of the Bermejo River Water Resources Planning Investigation

There are some statements in the Accord that would tend to restrict the planner in the development of project alternatives. For example, it indicates that flood control and drainage projects would automatically have a positive impact when, in fact, not all flooding is negative nor all drainage positive. This is indeed the case in the lower basin where flooding plays a major role in ecosystem stability. Similarly, the Accord specifically asks for a regional economic evaluation of the projects but says nothing about an environmental evaluation.

- **Reconnaissance survey**

The reconnaissance survey consisted of two man-months of work undertaken by a specialist in water resources. Terms of reference required a review of existing information pertaining to the development of water resources of the area; contact with local agencies to better define the purpose and future activities regarding the project; preparation of a report on existing conditions and use of water in the Bermejo

Watershed; and assistance to the Mission Chief in the preparation of the study's work plan.

Environmental concerns were not explicitly considered during the reconnaissance survey. In fact, the terms of reference included only a mandate to look at the water resource. Data relevant to categories of the environment, particularly fisheries biology and agriculture, were evidently not reviewed and emphasis was given only to the immediate study area. Significant areas downstream from the study area would have received a more thorough coverage under the new methodology. Furthermore, a number of colleges, universities, and museums as well as individual scientists and research entities having substantial knowledge of environmental material within the basin were not consulted.

• **Area survey**

From the report of the reconnaissance survey, a work plan was developed for the remainder of the investigation, including objectives, terms of reference for an area survey, and the identification and evaluation of projects. Initial studies considered natural resources (with emphasis on hydrology) and the socio-economic structure of the basin; special studies and analyses were made in preselected disciplinary and geographical areas as well as on existing projects and project ideas.

As indicated in Figure 9, 15 different disciplines were used in the investigation for a total of at least 142 man months of work. During the area survey, an analysis of the actual situation of the upper basin of the Bermejo River identified problems affecting resource development, determined the availability of the water resource and its relationship to both present and future demand, and defined the trends of various water uses, to help orient their development. Existing information on cartography, surface and groundwater hydrology, geology and geotectonics, meteorology, general ecology, edaphaology, and the population and economic structure were evaluated. Inventories and evaluations of natural resources were made, including local and regional availability, quantity of and demand for surface and ground-water. Likewise, actual resource utilization in the upper basin was evaluated and an analysis of use trends in irrigation, domestic and industrial water consumption, and electric power generation was made. Studies on groundwater distribution, land use, agricultural productivity, land tenure, population structure, water rights, and concessions were made. An analysis of existing criteria, plans, programs, and projects related to development of watershed resources was also undertaken.

Figure 9. Work plan for the Upper Basin of the Bermejo River Water Resources Planning Investigation

Studies of problems affecting development were made in areas affected by flooding, erosion, drainage, and salinization problems; a study of subterranean waters focused on the valleys of the San Francisco River Watershed. Geological studies in the basin focused on the potential locations of dams and other important water works as well as on locating materials for use in future construction. Additionally, the general characteristics of the underlying stratum in areas to be irrigated and in those which may have subterranean waters were investigated as were areas having a high risk of erosion.

Surveys of the soil and vegetation resources consisted of a general analysis of photomosaics at available scales and compilation of information on maps with a scale of 1: 250,000 (soil units, natural pastures, vegetation, erosion areas, types of erosion, present land utilization); identification of areas with high use potential especially for irrigation; and identification of areas where there are problems of salinization, alkalinity, and drainage. Economic studies were carried out to provide guidance for decisions on the use of limited financial resources.

A substantial part of the planning studies focused on the analysis, formulation, and selection of alternative projects for the utilization of the water resource. Analyses of the market conditions were made emphasizing those conditions affecting irrigation requirements, electric power demand, and the relative benefits of flood, erosion, and siltation control facilities. The actual situation of agricultural and its potential development accounted for a substantial portion of the analyses although the actual situation and targets established for forestry, industry, and mining were studied with a view to planning for integrated regional development. Efforts were concentrated on comparative regional advantages and disadvantages, as well as on prospects for exporting surplus production. The work plan developed on the basis of the reconnaissance survey and the Accord was in line with both of these documents.

Many of the potential environmental problems mentioned in chapter five could have been avoided by using the methodology considered in chapters two and three, such as specific instructions and opportunities for interaction among the experts, an accounting of the concepts involved in "ecology," explicit environmental concern, a technical team that included environmentally-oriented experts, and explicit environmental quality terms of reference for use by other technical experts. Similarly, there is no indication that public concern was taken into account, nor was there a mandate to review downstream demands for the water resources or to analyse the potential effects of a possible reduction of total and seasonal water supply to downstream areas.

Experts who could have evaluated most of the potential environmental problems through the generation and evaluation of more data are indicated in Figure 10. If these were only to be "add ons" to the original study, this would have amounted to somewhat less than 15 percent of the total man/months utilized by the original technical group. Or, if adjustments were made in the overall work plan (including environmental quality terms of reference for each specialist), the work of environmental protection could have been undertaken at *no* extra cost (Figure 10). The fact that these subject areas were not included stems primarily from lack of an explicit environmental objective and lack of an environmentalist being incorporated as a member of the reconnaissance survey team. Had either or both of these been utilized, it is probable that most of the environmental problems would have been adequately covered during the study.

Of major importance is the use of a limnologist or fisheries biologist in any planning effort that proposes substantial changes in the hydrologic regime of a major river basin. This, perhaps, is the major shortcoming of the upper basin study; it did not adequately consider potential environmental damage to the aquatic ecosystem. The water resource is too important, both in its role in primary production and in its role as the natural communication link from the upstream watershed to the sea, to be inadequately studied.

As has been suggested, the original plans for the hydrologic development of the upper basin could possibly cause severe damage to several important fish species by making seasonal migration impossible and by disrupting their spawning cycles. Furthermore, the stream regulation envisioned in the plan could substantially reduce the primary production of the downstream wetlands and, as a consequence, eliminate important species from the drainage system by reducing food supply at critical stages of their life cycle. Specifically overlooked is a law obligating the installation of fish ladders on any dam under national jurisdiction (GOA, 1933). This oversight would not have happened had a limnologist or a fisheries biologist been included in the technical team and had there been opportunity for substantive interaction between this expert and those who designed the structures.

Figure 10. Revised work plan for the Upper Basin of the Bermejo River Water Resources Planning Investigation

Similarly, use of an epidemiologist is of paramount importance where increased disease incidence is a possibility, as is the case in the majority of developing countries. The Accord specifically asks for an analysis of sanitary problems related to the water resource but does not explicitly discuss the need for epidemeological studies in planning water resource use in the upper basin; the work plan itself does not mention, nor did the study treat, health problems. An environmentalist on the reconnaissance team probably would have assured the treatment of health problems related to water development. Close cooperation between an epidemeologist and a sociologist/anthropologist would have allowed the evaluation of the consequences of both on-going and increased migration in terms of potential health problems and increased health service and disease control measures.

The use of an ecologist was not considered, although the work plan mentioned general ecology. Thus the dynamics of the basin ecosystems were not considered, and little thought was given to describing critical aspects of subsystems either in the upper basin or downstream through the Bermejo, Paraguay, Paraná, and Plata river systems. If an ecologist with the help of a systems analyst had been utilized early in the natural resources survey to define the life zones in the project sites and other critical areas downstream in order to construct a prefeasibility stage conceptual model of these life zones (ecosystems), the major areas and processes could have been identified and described.

The Accord mentions an evaluation of recreational resources and demand, but this aspect did not appear to be treated in the resource evaluation nor were potential recreational projects evaluated. Several areas of the upper basin as well as the future reservoirs themselves offer recreation and tourist potential. Although, at this time, demand for these resources is quite low, they can become quickly overloaded if their use is not planned.

Changes in the terms of reference for those disciplines that were utilized could have been made. The sanitary engineer, for example, should have spent some time on an evaluation of the capacity of the basin's water resources for self-renewal in terms of industrial, urban, and agricultural contamination. This aspect of a water resource is a service of the natural system that can profitably be used, but easily overused if not adequately planned. Someone specializing in wild land management rather than watershed management would have undertaken tasks similar to those of the watershed management specialist but would have had a broader view - something needed at the early planning stages. The objectives assigned to the forester and plant ecologist could have been accomplished in much less time at this level of planning and their work could have been used more profitably by the rest of the planning team.

• Regional diagnosis and guidelines for development action

A regional diagnosis was made of: 1) the use potential of the upper basin's water resource, 2) the positive and negative factors for development, and 3) the water resource demands. From the results of this diagnosis, a preliminary global water balance was developed for the upper basin and the three subareas: Quebrada de Humahuaca, Development Pole, and El Ramal. No evaluation was made of the water demand to maintain the services of the natural systems in the upper basin or downstream.

The regional diagnosis was followed by a general characterization of the potential for hydroelectric energy production and available volumes for irrigation of the major upper basin river systems. The underground water resource, particularly in the San Francisco area, and its present and potential use were also investigated. Concurrently, a general analysis was made of the soil resource to locate potential agriculture areas and to locate areas now under cultivation which could have improved production if irrigated.

At the same time, guidelines for development action were given to the planning mission by the Government. These required resolution of the energy deficit in the region; industrialization of the mining sector; development of additional industry; and increased agricultural productivity.

Except for control of erosion, sedimentation, and flooding, there was virtually no mention of environmental concerns in the regional diagnosis and guidelines sections of the upper basin planning methodology. Whether or not these would be environmentally sound would depend on the potential impact downstream of the projects themselves and these may, indeed, be negative. Consideration of the temporal and total demands made on the water resource; first, by the services offered by the natural system and; second, for maintenance of the natural ecosystem could have avoided these problems. The guidelines for development action did not consider environmental protection, environmental planning, or the generation of alternatives.

• Definition of objectives and priorities; establishment of selection criteria; identification of projects; and economic analysis of local and regional demand

The Government defined the objectives and priorities in the hydroelectric energy, irrigation, and industrial and municipal water supply areas as well as in the control of erosion, sedimentation, and flooding, and established the criteria for the selection of projects. These criteria dealt with the resolution of the energy shortage, further development of the region, more complete use of the agriculture and livestock potential in addition to providing opportunities for training and for greater, more equitable, income distribution.

Identification and formulation of specific projects followed a global evaluation of the water resource, including the identification and predesign of water projects, irrigation schemes, groundwater exploitation, and an economic analysis of regional and local demand for hydrologic resources for energy, irrigation, industrial, and domestic purposes. Again, no mention was made of the potential utilization of natural systems services for such things as flood control and waste disposal; nor was environmental protection mentioned as an objective or a priority. The selection criteria included nothing on environmental quality, environmental health, or environmental protection. Several potential projects, such as recreational development, fisheries, and non-structural alternatives for irrigation and control of erosion and sedimentation, were not completely identified.

• Project evaluation

Hydroelectric projects were evaluated on the basis of their ability to supply energy for the needs of the region and, secondarily, on those benefits accruing to irrigation, industrial and municipal water supply, and sediment control. Parameters used in evaluating irrigation projects were the efficiency of the project, the period of time necessary to make the project operational, and the potential agriculture production of priority crops, such as vegetables, tomatoes, citrus, alfalfa, sorghum, soybean, sugar cane, cotton, and tobacco.

National, regional, and local authorities were consulted and the preprojects made compatible with national and regional objectives. A preselection of alternative development schemes was made and individual projects evaluated. From this process the national and binational programs and projects were selected, a schedule of investments was decided upon, and an administrative structure suggested. Subsequently, scopes of work for the feasibility investigations were developed along with suggestions for a number of complementary studies.

Benefits from all projects were calculated on the basis of: potable and industrial water supply, irrigation, utilization of return water, generation of electric energy, and sediment control. Costs for these projects included only direct costs and costs of operation and maintenance. There appears to have been no consultation with the public, other than perhaps through local and regional representatives, to get its view on the value of the proposed projects. No display of other quantitative and qualitative impacts was given. Fifteen of the 26 projects evaluated are given in Table 4.

Criteria for identification, formulation, and selection of individual projects and programs for the hydrologic development of the upper basin were overwhelmingly economic, while concern for potential environmental impact had almost no influence. There was no substantive environment impact evaluation of this or alternative plans for meeting the stated objectives under the stated criteria. The display of the evaluation was inadequate in terms of environmental quality criteria although it did go somewhat beyond the use of a benefit/cost ratio. Since so little explicit concern was given to the environment, even those impacts that could be costed out monetarily were not treated.

• **Administrative structure**

According to the plan, each country would have a National Bermejo River Basin Commission that would have the following functions: execution of the plan, either by itself or by delegation to other public institutions or through private contracts; general coordination of national and regional development programs which would treat the renewable natural resources of the basin; administration of the plan; promotion of the basin's development; and advising the Executive Office of the nations in their work with a proposed International Commission.

The great number and diversity of local, regional, and national organizations interested in the use of the water and other resources in the basin suggest that the administrative functions necessary for the development of the upper basin should have been centralized.

• **Scopes of work for the feasibility studies**

The plan for development of the water resources of the Upper Bermejo River Basin outlined the scopes of work for the feasibility studies of projects proposed for the area of the growth pole. In terms of the Pilot Study, these consisted primarily of construction of dams at Mojotoro and Vilte, implementation of irrigation systems at El Acheral, and construction of the aquaduct to Guemes, and dealt with feasibility level studies in topography, hydrology, soil mechanics, and edaphology. In addition, several basic investigations were proposed to gather additional data on climatology, hydrology, geology, seismology, and demographics.

Other concerns of a feasibility nature were given as a check list:

- Socio-economic effects of the individual projects and of the projects as a group.

- Potable water demand.

Table 4. Project evaluation and summary. Upper Basin of the Bermejo River Water Resources Planning Investigation

Benefits, Thousand of US Dollars								
River	**Project**	**Cost**	**Generation of electricity**	**Irrigation**	**Sediment control**	**Industrial and potable water**	**Total**	**Benefit/cost**
Tarija	Cambari	43,220	67,560	7,860	30,680		106,100	2.45
Tarija	Astilleros	148,460	48,760	10,100	30,680		89,540	0.60
Bermejo	Las Pavas	59,300	55,800	9,600	28,600		94,000	1.59
Bermejo	Arrazayal	59,840	76,300	10,200	28,600		115,100	1.92
Pescado	Pescado II	180,040	52,300	7,480	10,700		70,480	0.39
Iruya	El Portillo	54,370	55,950	3,920			59,870	1.10
Pescado	Pescado I	112,330	40,300	7,200	10,700		58,200	0.52
Blanco	Vado Hondo	194,130	66,410	7,120			73,530	0.38
Bermejo	Z. del Tigre	307,420	184,840	53,800	157,000		395,640	1.29
Colorado	Santa Rosa	18,138		20,200			20,200	1.11
Los Alisos	Los Alisos	14,380		4,720		530	5,250	0.36
Perico-Grande	Las Maderas	189,900		33,930		68,900	102,830	0.54
Mojotoro	Mojotoro	73,330	23,980	29,630	16,300	31,600	101,510	1.38
Levayén	Vilte[1]	13,670		15,190	16,300		31,490	2.30
S. Francisco	Yuto	112,570	38,410	64,100	31,270		133,780	1.19

[1] Based on a theoretical evaluation since the useful life of Vilte without Mojotoro is less than 30 years.

Industrial water demand, including an analysis of the situation, park siteing, and a theoretical evaluation of demand.

- Irrigation and rural planning.

- Tourism and recreation (site characteristics, demand, planning).

- Stream regulation (sediment and flood control, including river characteristics, size of suspended sediments, bed load, effect of dams on sediment transport, flood control, and downstream effects resulting from control of sediments and erosion).

- Mathematical models.

- Conceptualization of hydraulic works.

- Selection of the basic projects (dams, aquaducts, power centers, bridges and roads, lateral dikes, foundation consolidation, design, construction program).

- Irrigation projects.

- Economic evaluation (social evaluation; procedures and indices; opportunity costs; sequence, period; determination of benefits of irrigation, potable and industrial water supply, sediment control, flood control; recreation and tourism; investment costs; operation and maintenance costs).

- Financial evaluation.

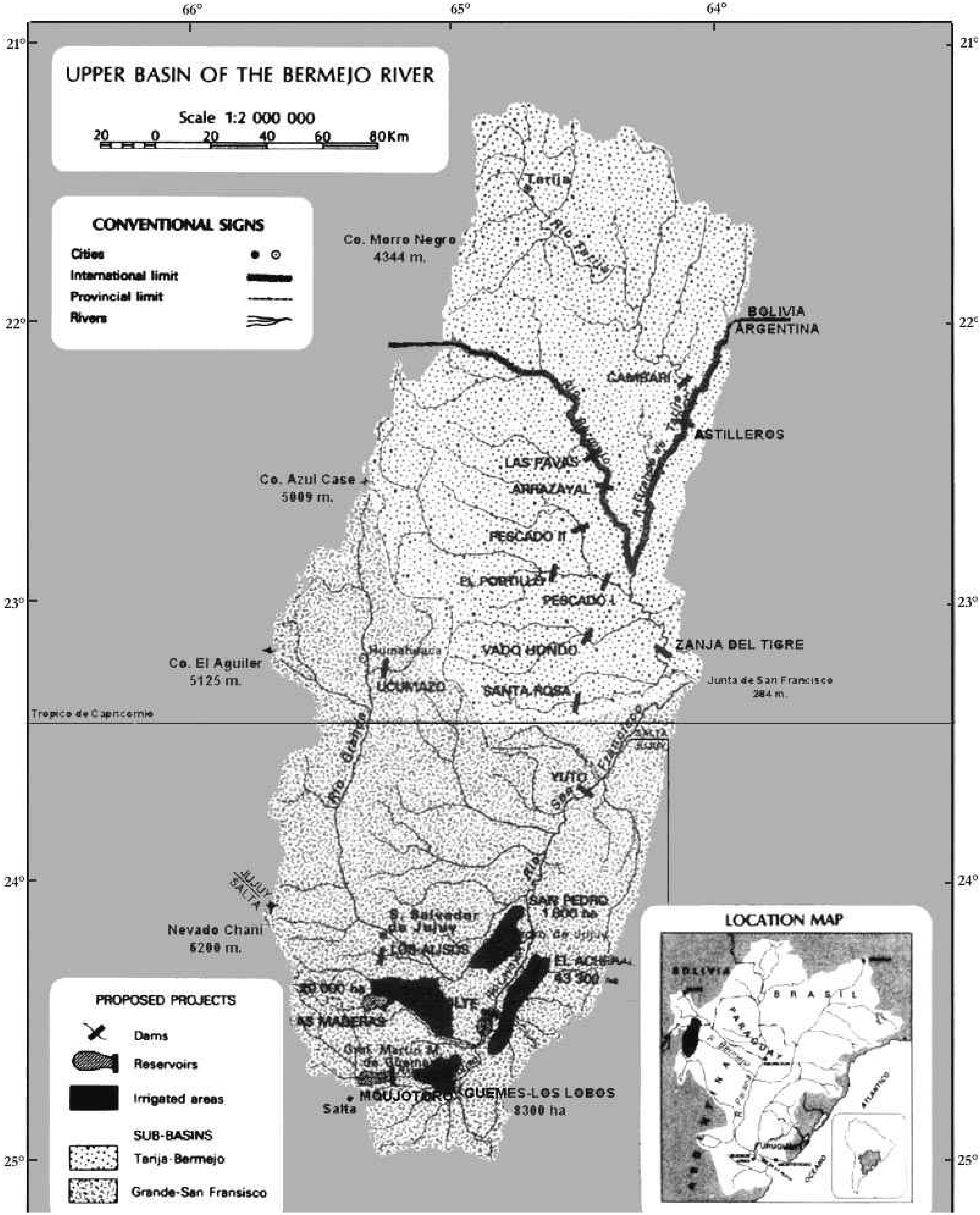
- Administrative organization; legal and institutional aspects.

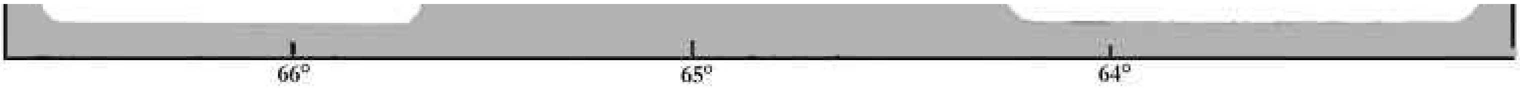
In addition to the terms of reference of concern in the feasibility study, complimentary studies and specific recommendations to allow a better understanding of the natural environment within which the projects would be undertaken were presented. These consisted of recommendations for additional studies in cartography, meteorology, hydrology, hydrogeology, geology and soils, land conservation and use, and forest and pastures.

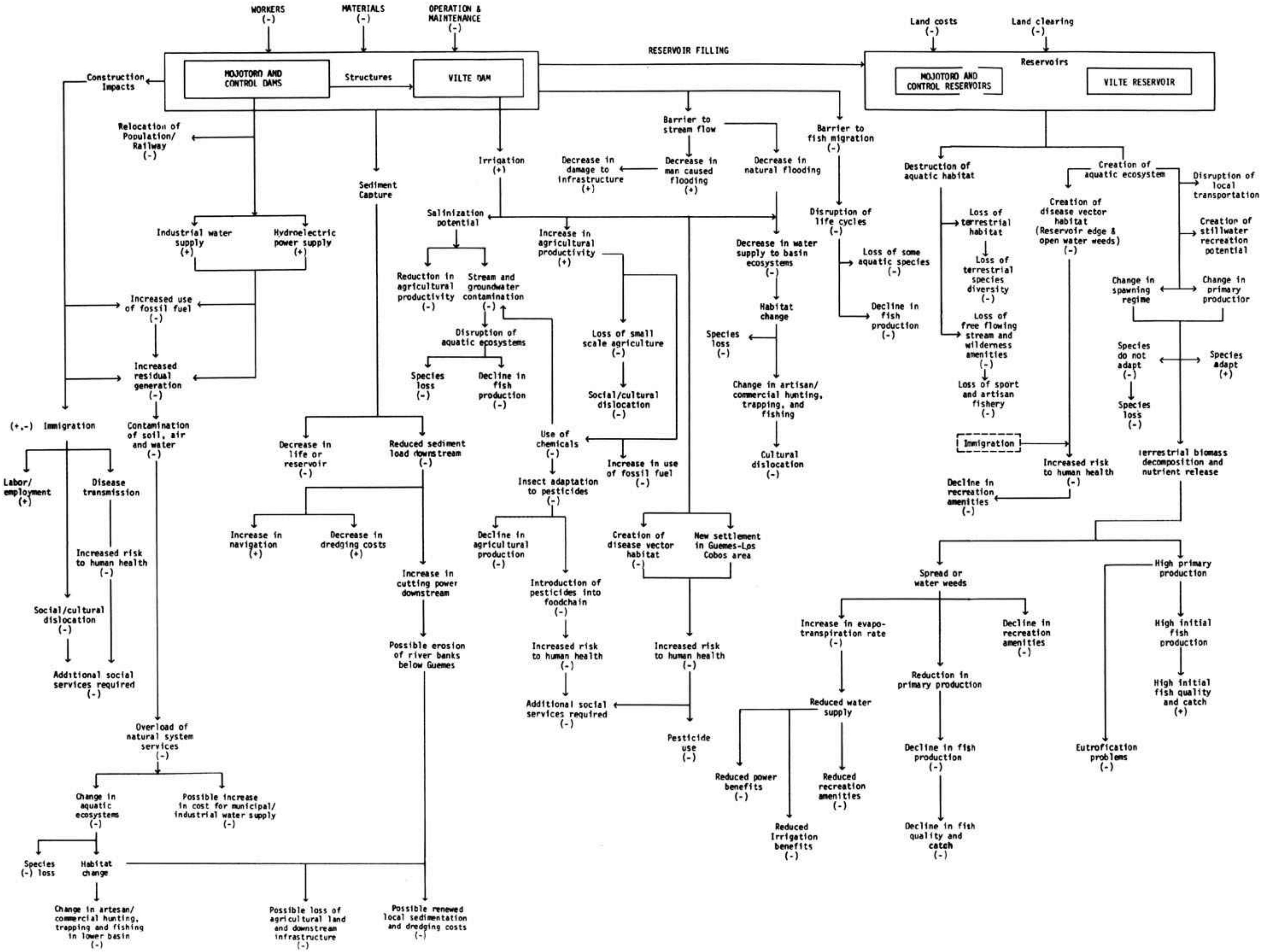
Of particular interest were the suggestions to make detailed studies in representative watersheds to characterize and model the hydrologic cycle in the region and to utilize smaller experimental watersheds to evaluate the effects of irrigation, deforestation, and overgrazing on the hydrologic cycle. In hydrology, studies were suggested to compute the sediment discharge; in hydrogeology, to evaluate potential groundwater contamination problems; in soils, to find methods of reclaiming saline soils; in land management and conservation, to select pilot areas for further study; and in forestry and range management, to begin control of exploitation and to locate areas requiring protection.

The outline of the scopes of work for feasibility studies was wide-ranging but did not treat environmental concern in detail. For example, further study of the problem of migration was not mentioned, and studies of potable and industrial water demand did not include water quality nor the treatment and dispersion of residuals. Problems relating to health and to the biological resources of the river system either in the area of study or downstream were not covered in the scope of work or in any of the recommended studies.

Although the recommendations did provide for studies of the effects of the plan on downstream sedimentation and flooding, as well as for studies to implement upstream erosion control measures - thereby potentially rectifying many of the environmental omissions at the reconnaissance and prefeasibility planning stages - the danger is that they will come too late in the process to bring about major changes in the plan without substantially increasing costs and, perhaps, decreasing benefits exists.


UPPER BASIN OF THE BERMEJO RIVER
Scale 1:2 000 000
20 0 20 40 60 80Km
CONVENTIONAL SIGNS
Cities
International limit
Provincial limit
Rivers
PROPOSED PROJECTS
Dams
Reservoirs
Irrigated areas
SUB-BASINS
Tarija-Bermejo
Grande-San Fransisco
LOCATION MAP
BOLIVIA
BRASIL
PARAGUAY
Tarija
Co. Morro Negro
4344 m.
Rio Tarija
BOLIVIA
ARGENTINA
CAMBARI
ASTILLEROS
LAS PAVAS
ARRAZAYAL
Co. Azul Case
5009 m.
PESCADO II
EL PORTILLO
PESCADO I
ZANJA DEL TIGRE
VADO HONDO
Co. El Aguiler
5125 m.
UCUMAZO
SANTA ROSA
Junta de San Francisco
284 m.
Tropico de Capricornio
SALTA
JUJUY
Rio Grande
YUTO
San Francisco
JUJUY
SALTA
Nevado Chani
6200 m.
SAN PEDRO
1 600 ha
S. Salvador de Jujuy
LOS ALISOS
EL ACHERAL
43 300 ha
20 000 ha
LAS MADERAS
Gral. Martin M. de Guemes
Salta
MOJOTORO
GUEMES-LOS LOBOS
8300 ha
66°
65°
64°
21°
22°
23°
24°
25°


66°
65°
64°

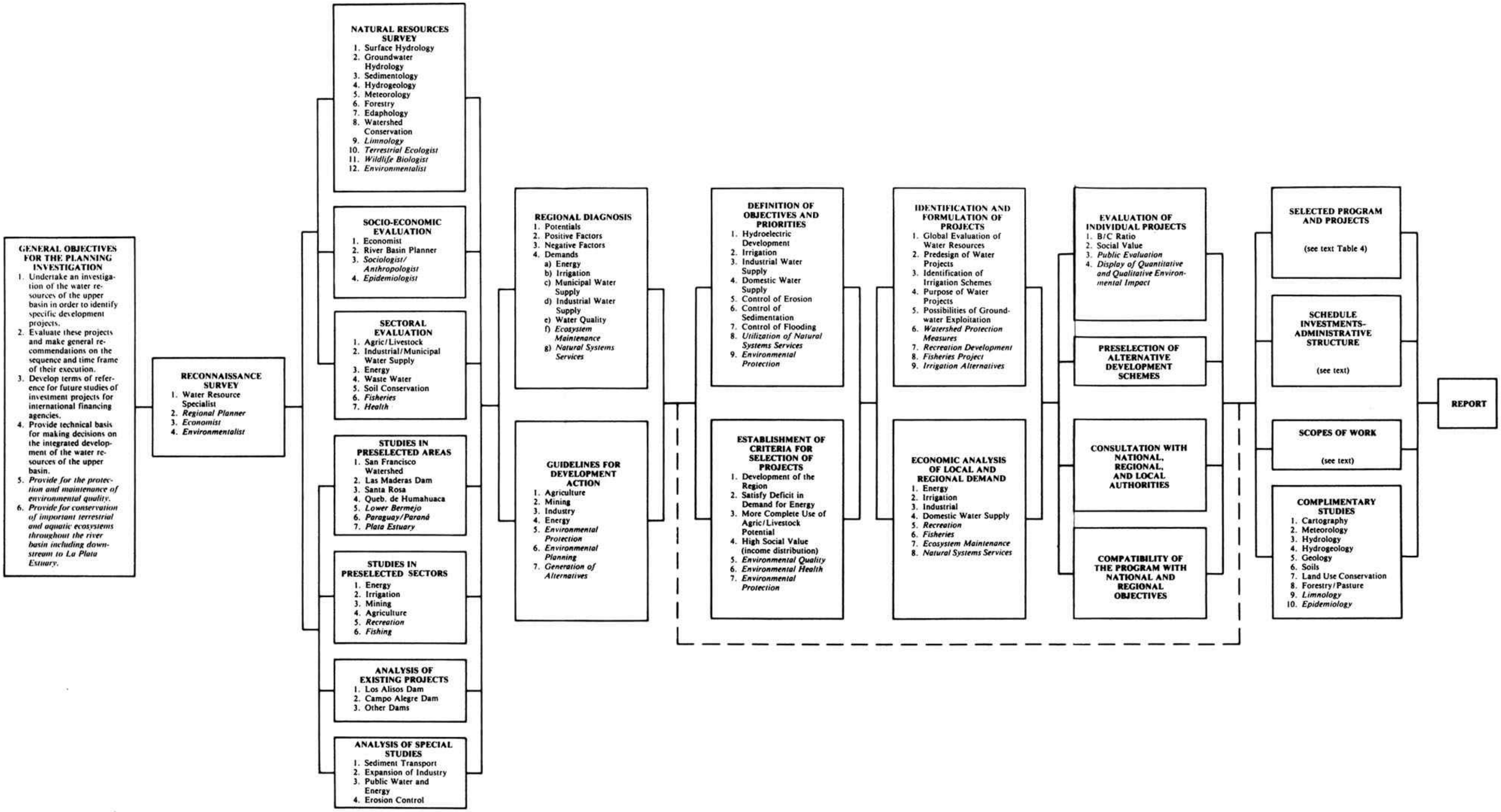

WORKERS (-)
MATERIALS (-)
OPERATION & MAINTENANCE (-)
Land costs (-)
Land clearing (-)
RESERVOIR FILLING
MOJOTORO AND CONTROL DAMS
Structures
VILTE DAM
Reservoirs
MOJOTORO AND CONTROL RESERVOIRS
VILTE RESERVOIR
Construction Impacts
Relocation of Population/ Railway (-)
Sediment Capture
Irrigation (+)
Barrier to stream flow
Barrier to fish migration (-)
Decrease in damage to infrastructure (+)
Decrease in man caused flooding (+)
Decrease in natural flooding
Disruption of life cycles (-)
Loss of some aquatic species (-)
Decline in fish production (-)
Destruction of aquatic habitat
Creation of aquatic ecosystem
Disruption of local transportation
Salinization potential
Industrial water supply (+)
Hydroelectric power supply (+)
Increase in agricultural productivity (+)
Decrease in water supply to basin ecosystems (-)
Reduction in agricultural productivity (-)
Stream and groundwater contamination (-)
Increased use of fossil fuel (-)
Disruption of aquatic ecosystems
Species loss (-)
Decline in fish production (-)
Loss of small scale agriculture (-)
Social/cultural dislocation (-)
Habitat change
Species loss (-)
Change in artisan/ commercial hunting, trapping, and fishing
Cultural dislocation (-)
Loss of terrestrial habitat
Loss of terrestrial species diversity (-)
Loss of free flowing stream and wilderness amenities (-)
Loss of sport and artisan fishery (-)
Creation of disease vector habitat (Reservoir edge & open water weeds) (-)
Creation of stillwater recreation potential
Change in spawning regime
Change in primary productior
Species do not adapt (-)
Species adapt (+)
Species loss (-)
Immigration
Increased risk to human health (-)
Decline in recreation amenities (-)
Terrestrial biomass decomposition and nutrient release
Increased residual generation (-)
Contamination of soil, air and water (-)
(+,-) Immigration
Labor/ employment (+)
Disease transmission
Decrease in life or reservoir (-)
Reduced sediment load downstream (-)
Use of chemicals (-)
Insect adaptation to pesticides (-)
Increase in use of fossil fuel (-)
Increase in navigation (+)
Decrease in dredging costs (+)
Decline in agricultural production (-)
Creation of disease vector habitat (-)
New settlement in Guemes-Los Cobos area
Increased risk to human health (-)
Increase in cutting power downstream
Introduction of pesticides into foodchain (-)
Spread or water weeds
High primary production
Social/cultural dislocation (-)
Possible erosion of river banks below Guemes
Increased risk to human health (-)
Increased risk to human health (-)
Increase in evapo-transpiration rate (-)
Decline in recreation amenities (-)
High initial fish production
Additional social services required (-)
Additional social services required (-)
Pesticide use (-)
Reduced water supply
Reduction in primary production
High initial fish quality and catch (+)
Overload of natural system services (-)
Decline in fish production (-)
Eutrofication problems (-)
Reduced power benefits (-)
Reduced recreation amenities (-)
Change in aquatic ecosystems (-)
Possible increase in cost for municipal/ industrial water supply (-)
Reduced Irrigation benefits (-)
Decline in fish quality and catch (-)
Species (-) loss
Habitat change
Change in artesan/ commercial hunting, trapping and fishing in lower basin (-)
Possible loss of agricultural land and downstream infrastructure (-)
Possible renewed local sedimentation and dredging costs (-)

Appendix A - Project participants

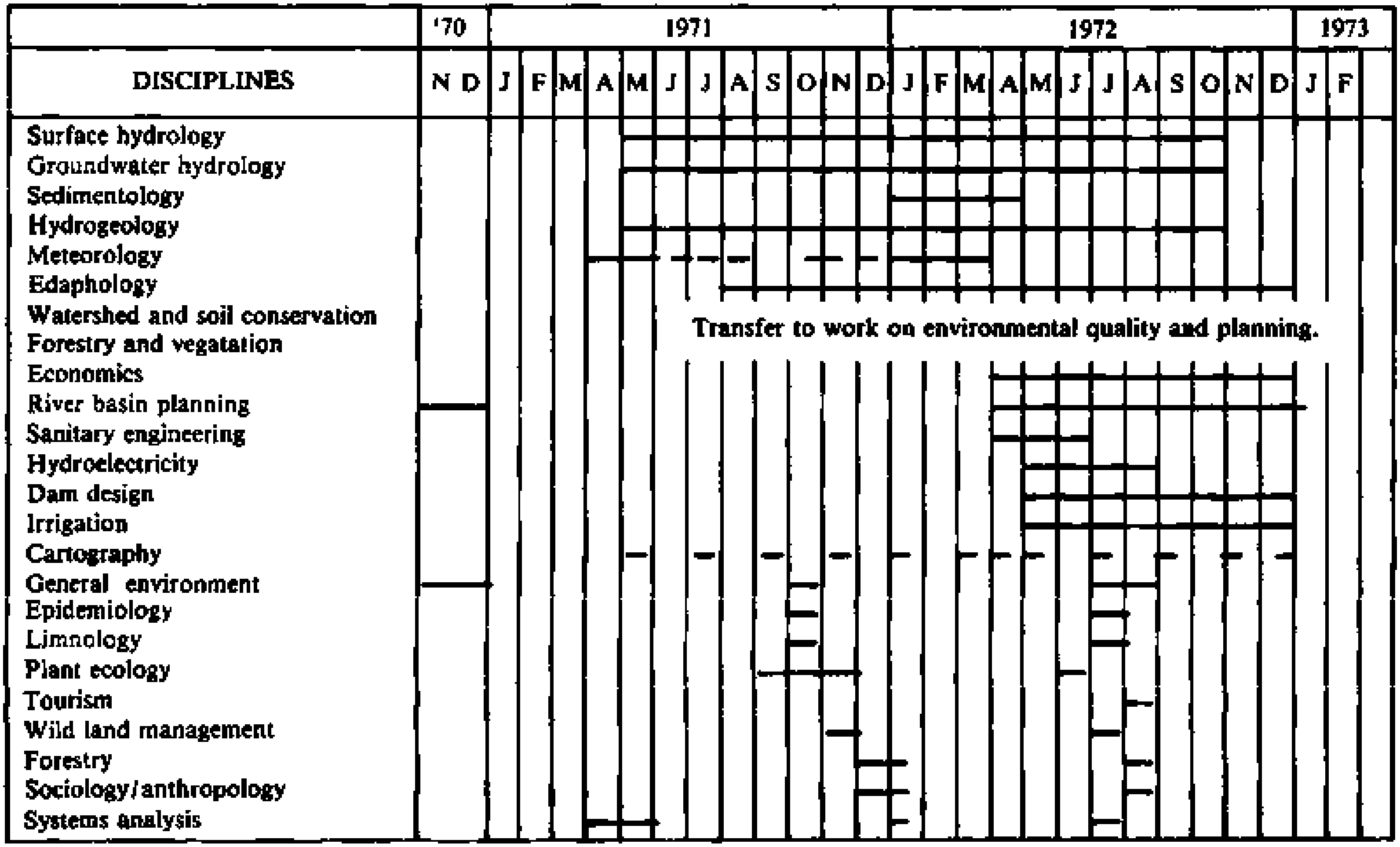
Agency Directors	
Rodgers, K.P.	Pérez, H. (deceased)
Program of Regional Development	Institute of Science and Water Technology (INCyTH)
Cordeiro, N.V.	
Geographic Group II	
Program of Regional Development	
Council of Directors	
Rodger, K.P.	Casañas, R. INCyTH
Project Coordinators	
International:	National:
Cutinella, A.	Diano, A. Schroeder, C.

Technical Group		
Astica, J.	Urban Planning	OAS
Bartoni, C.	Sanitary Engineering	USA
Blanco, J.	Economics	OAS
Boffano, M.	Hydrology	Argentina
Cigliano, E.	Anthropology	Argentina
Crespo, J.	Wildlife Biology	Argentina
Davis, R. K.	Economics	USA
Fake, M.	Ecology	Argentina
Forni, F.	Sociology	Argentina
Freeman, P.	Natural Resource Planning	USA
Fuentes-Godo, P.	Edaphology	Argentina
Gallopin, G.	Systems Analysis	Argentina
Gazia, N.	Ecology	Argentina
Gómez, I.	Ecology	Argentina
Hall, B.	Economics	Canada
Kleiman, P.	Water Resources Planning	Chile (OAS)
Knetsch, J.	Economics	Canada

Kozarik, J.	Forestry	Argentina
Lopez, R.	Limnology	Argentina
Maddock, T.	Fluviomorphology	USA
Merino, S.	Physical Planning	Argentina
Milton, J.	Ecology	USA
Morello, B.	Sanitary Engineering	Argentina
Neri, A.	Epidemiology	Argentina
Pantano, O.	Tourism	OAS
Saunier, R.	Environmental Protection	USA (OAS)
Serrentino, C.	River Basin Planning	Uruguay
Sioli, H.	Limnology	Germany
Valls, M.	Law	Argentina
Vargas, W.	Meteorology	Argentina
Viladrich, A.	Water Resources Planning	Argentina


GENERAL OBJECTIVES FOR THE PLANNING INVESTIGATION
1. Undertake an investigation of the water resources of the upper basin in order to identify specific development projects.
2. Evaluate these projects and make general recommendations on the sequence and time frame of their execution.
3. Develop terms of reference for future studies of investment projects for international financing agencies.
4. Provide technical basis for making decisions on the integrated development of the water resources of the upper basin.
5. Provide for the protection and maintenance of environmental quality.
6. Provide for conservation of important terrestrial and aquatic ecosystems throughout the river basin including downstream to La Plata Estuary.
RECONNAISSANCE SURVEY
1. Water Resource Specialist
2. Regional Planner
3. Economist
4. Environmentalist
NATURAL RESOURCES SURVEY
1. Surface Hydrology
2. Groundwater Hydrology
3. Sedimentology
4. Hydrogeology
5. Meteorology
6. Forestry
7. Edaphology
8. Watershed Conservation
9. Limnology
10. Terrestrial Ecologist
11. Wildlife Biologist
12. Environmentalist
SOCIO-ECONOMIC EVALUATION
1. Economist
2. River Basin Planner
3. Sociologist/ Anthropologist
4. Epidemiologist
SECTORAL EVALUATION
1. Agric/Livestock
2. Industrial/Municipal Water Supply
3. Energy
4. Waste Water
5. Soil Conservation
6. Fisheries
7. Health
STUDIES IN PRESELECTED AREAS
1. San Francisco Watershed
2. Las Maderas Dam
3. Santa Rosa
4. Queb. de Humahuaca
5. Lower Bermejo
6. Paraguay/Paraná
7. Plata Estuary
STUDIES IN PRESELECTED SECTORS
1. Energy
2. Irrigation
3. Mining
4. Agriculture
5. Recreation
6. Fishing
ANALYSIS OF EXISTING PROJECTS
1. Los Alisos Dam
2. Campo Alegre Dam
3. Other Dams
ANALYSIS OF SPECIAL STUDIES
1. Sediment Transport
2. Expansion of Industry
3. Public Water and Energy
4. Erosion Control
REGIONAL DIAGNOSIS
1. Potentials
2. Positive Factors
3. Negative Factors
4. Demands
a) Energy
b) Irrigation
c) Municipal Water Supply
d) Industrial Water Supply
e) Water Quality
f) Ecosystem Maintenance
g) Natural Systems Services
GUIDELINES FOR DEVELOPMENT ACTION
1. Agriculture
2. Mining
3. Industry
4. Energy
5. Environmental Protection
6. Environmental Planning
7. Generation of Alternatives
DEFINITION OF OBJECTIVES AND PRIORITIES
1. Hydroelectric Development
2. Irrigation
3. Industrial Water Supply
4. Domestic Water Supply
5. Control of Erosion
6. Control of Sedimentation
7. Control of Flooding
8. Utilization of Natural Systems Services
9. Environmental Protection
ESTABLISHMENT OF CRITERIA FOR SELECTION OF PROJECTS
1. Development of the Region
2. Satisfy Deficit in Demand for Energy
3. More Complete Use of Agric/Livestock Potential
4. High Social Value (income distribution)
5. Environmental Quality
6. Environmental Health
7. Environmental Protection
IDENTIFICATION AND FORMULATION OF PROJECTS
1. Global Evaluation of Water Resources
2. Predesign of Water Projects
3. Identification of Irrigation Schemes
4. Purpose of Water Projects
5. Possibilities of Groundwater Exploitation
6. Watershed Protection Measures
7. Recreation Development
8. Fisheries Project
9. Irrigation Alternatives
ECONOMIC ANALYSIS OF LOCAL AND REGIONAL DEMAND
1. Energy
2. Irrigation
3. Industrial
4. Domestic Water Supply
5. Recreation
6. Fisheries
7. Ecosystem Maintenance
8. Natural Systems Services
EVALUATION OF INDIVIDUAL PROJECTS
1. B/C Ratio
2. Social Value
3. Public Evaluation
4. Display of Quantitative and Qualitative Environmental Impact
PRESELECTION OF ALTERNATIVE DEVELOPMENT SCHEMES
CONSULTATION WITH NATIONAL, REGIONAL, AND LOCAL AUTHORITIES
COMPATIBILITY OF THE PROGRAM WITH NATIONAL AND REGIONAL OBJECTIVES
SELECTED PROGRAM AND PROJECTS
(see text Table 4)
SCHEDULE INVESTMENTS-ADMINISTRATIVE STRUCTURE
(see text)
SCOPES OF WORK
(see text)
COMPLIMENTARY STUDIES
1. Cartography
2. Meteorology
3. Hydrology
4. Hydrogeology
5. Geology
6. Soils
7. Land Use Conservation
8. Forestry/Pasture
9. Limnology
10. Epidemiology
REPORT

DISCIPLINES	Man/Months
Surface hydrology	18
Groundwater hydrology	18
Sedimentology	4
Hydrogeology	18
Meteorology	5
Edaphology	17
Watershed and soil conservation	10
Forestry and vegetation	11
Economics	9
River basin planning	9
Sanitary engineering	3
Hydroelectricity	4
Dam design	8
Irrigation	8
Cartography	?
	142


'70
1971
1972
1973
DISCIPLINES
N D J F M A M J J A S O N D J F M A M J J A S O N D J F
Surface hydrology
Groundwater hydrology
Sedimentology
Hydrogeology
Meteorology
Edaphology
Watershed and soil conservation
Forestry and vegatation
Economics
River basin planning
Sanitary engineering
Hydroelectricity
Dam design
Irrigation
Cartography
General environment
Epidemiology
Limnology
Plant ecology
Tourism
Wild land management
Forestry
Sociology/anthropology
Systems analysis
Transfer to work on environmental quality and planning.

Appendix B - Summary review of selected environmental impact assessment methods

Despite environmental impact assessments' relatively short history, a concensus of the need for minimal information regarding a) impact identification, b) predictions, c) interpretation, d) tradeoff determinations and preferences, and e) communication (Munn, 1975). However, most schemes generally have proved to be less than satisfactory in collecting, interpreting, and displaying the required information.

A majority of assessment methods have centered on or have emphasized one of four general strategies: a) checklists, b) matrices, c) networks, and d) map overlays. In each, the focus of the method is on identification of potential impacts; weighting the relative values of these impacts has received only secondary emphasis.

The checklist is common to many of the methods and makes use of a catalogue of impacts that might be expected from different activities. By itself, this is valuable but it says little about the extent or relative importance of the impacts. An example of the checklist is that developed by Batelle (see Dee *et al*, 1973) which divides potential impacts into four major categories: a) ecology, b) environmental pollution, c) esthetics, and d) human interest. These are subdivided into 18 components and 78 parameters. Although the method emphasizes quantitative impact, the methodology for assigning weights to the various impact parameters and converting them to a common base (environmental quality units) through specific graphs and value functions is a bit unwieldly. Other checklist methodologies include that of Adkins and Burke (1971) for evaluating social, economic, and environmental impacts of highway routing and construction, and the "Georgia methodology" which incorporates 56 environmental components specific to the evaluation of highway project alternatives (Institute of Ecology, 1971).

Matrices combine a list of possible impacts with different project activities that might be associated with or bring about such consequences. The intent is to be more explicit in discerning the specific actions that impact on specific environmental characteristics. Matrices go beyond a simple listing to deal, at least in an initial way, with cause and effect relationships.

The now classic approach of Leopold *et al.* (1971) utilizes the matrix approach to identify 100 project activities and 88 environmental characteristics or conditions which may be impacted. As presented by Leopold, heavy emphasis is placed on ecological and physical-chemical impacts whereas social and economic impacts and secondary impacts are not evaluated.

Network proposals attempt to deal more fully with cause and effect relationships. As in other methods, impacts are listed but indications of how these are brought about are presented by means of flow charts. Sorensen (1970) and Sorensen and Pepper (1973) use examples of this approach. Its advantage lies in its capabilities to trace pathways that allow identification of both primary and secondary impacts.

Map overlays, in the main, attempt to find areas of lesser conflict among resource uses and environmentally important values. This is accomplished by overlaying a series of maps which indicate various environmental characteristics, such as vegetation types, water courses, cultural and historic sites, and wildlife habitat. One of the pioneers in the development of this approach was McHarg (1968, 1969). Its advantage is that it can be used as a "first cut" method to identify alternative project sites for later, more detailed impact analysis. However, it is difficult to establish the relative importance of and interrelationships among resource uses.

In all of these methods, a major problem is how to assign values of significance to forecasted changes; things must be deemed of greater or lesser importance in accord with some scale and this, almost by definition, will vary with the evaluator. This, in turn, creates problems of comparability and reproducibility between and perhaps even within alternatives. Similarly, the impacts will normally be expressed in a variety of measurement units, and reaching a common numerary is a major problem. Consequently, the resultant indices are inherently arbitrary since they depend on the largely subjective weights used. Likewise, there are disadvantages in substituting a single number for an array of information that could more usefully resolve the conflicts (Lord and Warner, 1973). It is also abundantly clear that the current procedures and methods are not adequate to give a fair balancing of economic, technical, and environmental values in project planning nor do they exert an appropriate influence throughout the planning process. It is also evident that the current procedures can be burdensome and costly; that little clear focus is provided for data collection; and that often only vague criteria are given for comparison and weighting. While methods are still evolving, it now appears that, contrary to much of the current work in the area, the search should not be simply for a more intricate, ingenious, and longer list of the types of impacts that may be encountered as a result of initiation of a project. A checklist by itself is not sufficient to do more than provide the enumeration of impacts and encourages simply the listing of the predicted demise of environmental resources. Although a useful first step, it does nothing to ensure that such enumerations are explicitly taken into account in the evaluation of a project's desirability and, unfortunately, it very often encourages consignment to virtual obscurity.

Despite these problems, experience has indicated that environmental values do receive more explicit and proper attention when an environmental impact evaluation is made.

From this short review of environmental impact assessment methods, several conclusions on methodology can be made.

Useful features:

- Methods can discriminate minimal information needs.

- They provide comprehensive lists of kinds of impacts and potential consequences.

- They may elicit reaction and articulation of values from most affected parties, including the public.

Problematic features:

- They assume the existence of good data base - thus they do not suggest data collection or field survey methods.

- They assume that the proposed action does not adequately take into account the environment impacts.

- They do not develop information for use in economic analysis.

- They make an artificial distinction between socio-economic costs and benefits and changes in environmental conditions.

- They do not adequately show linkages.

It is clear that the various methods in existence must be closely scrutinized and adapted if they are to be effectively used elsewhere in the world. Also, and perhaps more importantly, it is clear that the impact assessment concept as currently practiced is not entirely suited for adaptation 10 early stages of river basin planning.

Appendix C - Methods for analyzing interactions within a system

Methods for analyzing interactions within a system include flow diagrams, matrices, and models.

• Flow diagrams

Figure 5 is one of the simpler diagrams and illustrates cause/effect relationships. Although useful as a first approximation, it does not explicitly consider the processes involved, and it defines a particular action in only one way. The consequences of a variation in the design of a dam or some other action can be taken into account only by constructing another, different cause/effect diagram. In other words, the diagram permits only one output option, a decrease in fish production, to be considered.

Figure 11 is a flow diagram based on the same situation as that in Figure 5. Each block indicates a process, the arrows indicate input or output variables, and the hexagon indicates an intervention. Note that the large box contains several more elementary boxes, each with its own inputs and outputs. In order to predict the effect of the dam on an output variable, such as the production of fish or a change in the state of stream erosion, it is necessary to consider a group of intermediate variables and processes. Thus Figure 11 is more general than Figure 5 because it permits representation of alternative effects in the same diagram. For example, modification in the dam structure or additions of nutrients to the river through the return of irrigation water may finally result in an increase rather than a decrease in fish production.

An alternative way to represent the same system is given in Figure 12. However, the arrows now represent processes or transformations and the ovals represent the variables. Note that this is the opposite representation of the flow diagram in Figure 11.

Finally, Figure 13 shows a simplified version of the same situation but the relationships are "monotonous." That is, the effect of one variable on another is always in the same direction. Thus the plus sign (+) between the variables "Nutrient level in the river" and "Primary production in river and estuary" indicates that, if the addition of nutrients is increased, the primary production is also increased and, if the addition is decreased, the primary production is likewise decreased. The minus sign (-) at the variable "Downstream sediment load" and "Level of river erosion" implies that, if the sediments increase, the erosion decreases and *vice versa.* Use of this type of diagram allows representation of the transfer of the negative or positive effects of the input variables to the output variables.

Figure 11. Flow diagram showing the effects of a dam on fish production and stream erosion

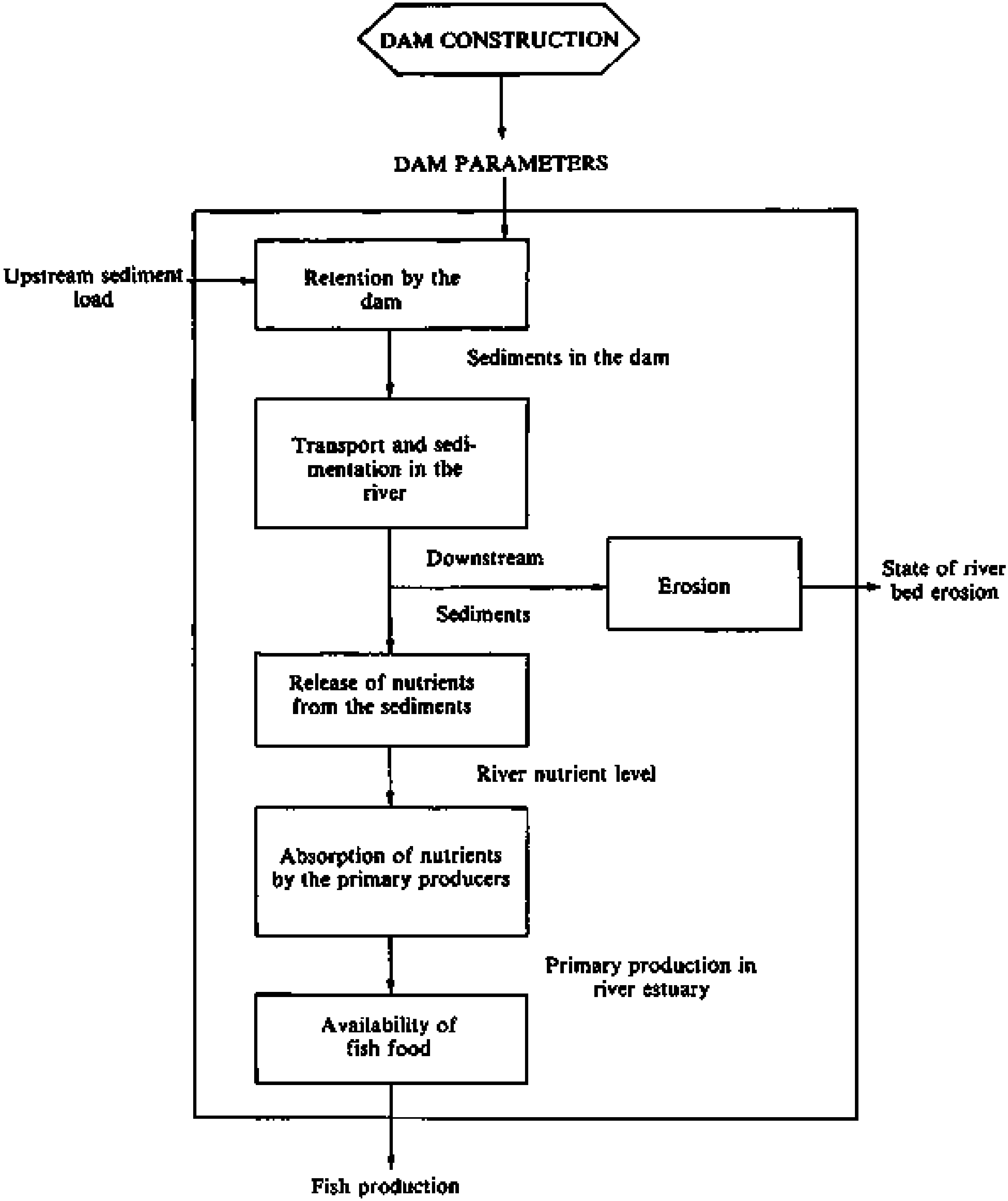


Figure 12. Flow diagram showing the effects of a dam on fish production and stream erosion

The disadvantage of this type of focus is that the relationship may not be "monotonous." At times the effect of one variable on another may change depending on the size of the variable. For example, an increase in primary production can increase the fish production but, at certain levels, an "excess" of primary production intensifies the process of eutrofication which may, in turn, provoke a decrease in fish production.

• Matrices

An alternative way of representing flow diagrams is with a matrix. For example, the matrix in Figure 14 represents the diagram in Figure 11 and indicates with a number one (1) the existence of interactions between horizontal and vertical coordinates, but says nothing of the types of interactions. The matrix in Figure 15 is similar to that of Figure 14 but, in addition, it indicates the types of processes by which the horizontal variable transforms the vertical variable. For example, PP (Primary Production) influences FP (Fish Production) through f (availability of fish food). Figure 16 is a matrix representing the flow diagram in Figure 13 where the signs in the matrix cells indicate the directions of interactions between variables.

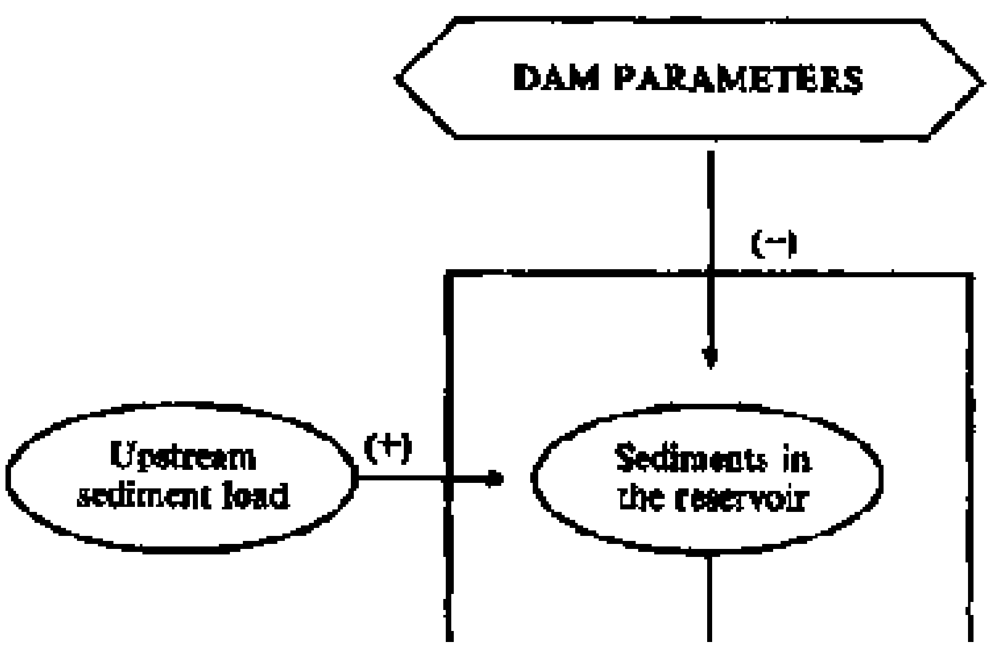
The mechanism for transferring inputs to outputs for each individual block can vary depending on the subject, the availability of information, and the required precision. As a simple hypothetical example consider the last block in Figure 11 which represents the supply of food for the fish population, a process connecting primary production with fish population. The transformation could be defined in several ways at different orders of complexity and precision.

a) A simple qualitative description where the required inputs are an increase or decrease in primary production and the outputs generated are an increase or decrease in fish production is presented in Figure 17.

- The fish population increases to an undetermined degree if primary production increases; and

- The fish population decreases to an undetermined degree if primary production decreases.

Figure 13. Flow diagram showing the effects of a dam on fish production where the effects are monotonous



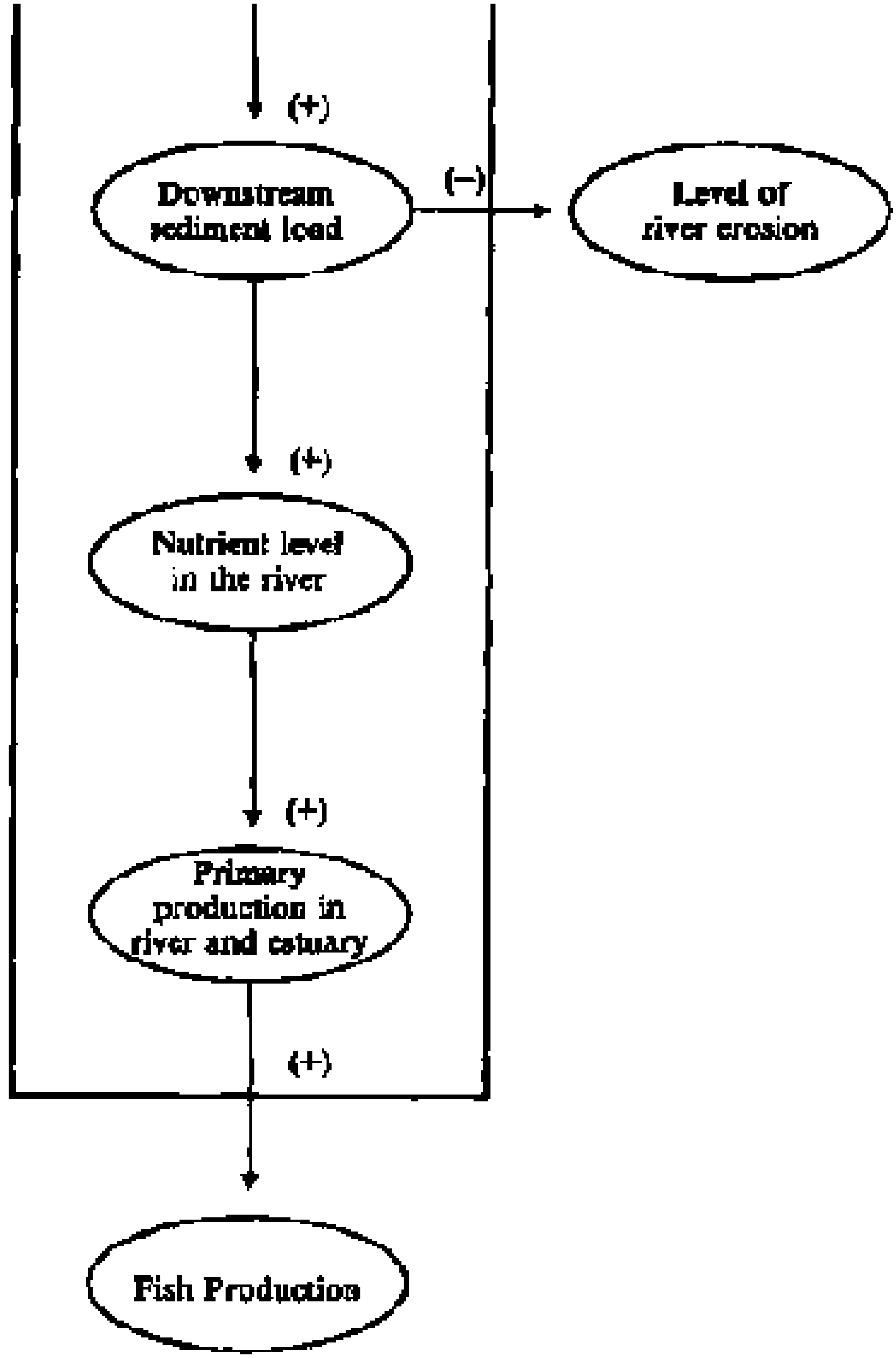


Figure 14. Matrix representing the relationships in Figure 11

	DP	US	RS	DS	RE	NL	PP	FP
DP			I					
US			I					
RS				I				
DS					I	I		
RE								
NL							I	

PP								I
FP								

I = Interaction
DP = Dam parameters
US = Upstream sediments
RS = Reservoir sediments
DS = Downstream sediments
RE = Level of river erosion
NL = Level of nutrients in the river
PP = Primary production in the river and estuary
FP = Fish population

DP = Dam parameters
US = Upstream sediments
RS = Reservoir sediments
DS = Downstream sediments
RE = Level of river erosion
NL = Level of nutrients in the river
PP = Primary production in the river and estuary
FP = Fish population

Figure 15. Matrix representing the processes involved in the effects of a dam on fish production

	DP	**US**	**RS**	**DS**	**RE**	**NL**	**PP**	**FP**
DP			a					
US			a					
RS				b				
DS					c	d		
RE								
NL							e	
PP								f
FP								

DP = Dam parameters
US = Upstream sediments
RS = Reservoir sediments
DS = Downstream sediments
RE = Level of river erosion
NL = Level of nutrients in the river
PP = Primary production in the river and estuary
FP = Fish population

a = Sedimentation in the reservoir
b = Transport and sedimentation in river

c = Erosion
d = Liberation of nutrients from sediments
e = Use of nutrients by primary producers
f = Availability of fish food

Figure 16. Matrix showing the direction of interactions involved in the effects of a dam on fish production

	DP	US	RS	DS	RE	NL	PP	FP
DP			-					
US			+					
RS				+				
DS					-	+		
RE								
NL							+	
PP								+
FP								

+ = Positive effect
- = Negative effect

DP = Dam parameters
US = Upstream sediments
RS = Reservoir sediments
DS = Downstream sediments
RE = Level of river erosion
NL = Level of nutrients in the river
PP = Primary production in the river and estuary
FP = Fish population

b) A semiquantitative description where it is understood that there are certain levels of primary production beyond which fish production changes its behavior, is given in Figure 17. For example, if primary production (PP) is at a maximum level (U max), fish population (FP) rapidly increases because of an optimum food level; if primary production is less than a minimum required level (U min), the fish population dies of hunger. If primary production is equal to a value for equilibrium (U o), the fish population does not vary in size; if production is between U o and U max, the fish population slowly increases; if production is between U o and U min, the fish production slowly decreased. A much more precise, and more complex, method is the mathematical model.

• **Quantitative Mathematical Description.**

The rate of variation in the fish population is an arithmetic function of the availability of food (PP) and the size of the fish population (FP) and can be defined by the integral equation:

$$FP(t) = \int_0^t (dFP/dt)^{dt} = \int_0^t [aFP(1 - \exp(-bPP/FP) - kFP]^{dt}$$

The first term describes the increase in the fish population as a direct proportion of the existing population and is related exponentially with the quantity of food per fish (PP/FP). The second term (k FP) describes the decrease in fish proportionate to the existing population having normal mortality. The symbols a, b, k are constants that must be estimated in each particular case.

Figure 17. Matrices showing simple qualitative (a) and semiquantitative (b) descriptions of input/output relationships of the effects of a dam on fish production

(a)

INPUT (PP) Primary Production	OUTPUT (FP) Fish Population
Increase	Increase
Decrease	Decrease

(b)

INPUT (PP) Primary Production	OUTPUT (FP) Fish Population
U max	Large increase
U max U o	Small increase
U o	No change
U o U min	Small decrease
U min	Loss of species

This description is the most precise of the three since, for each numerical value of primary production, one can obtain a numerical value for fish production. Naturally, it does not make sense to represent this description in a tabular form as in Figure 17 since there exists an infinite number of pairs of values for inputs and outputs.

A mathematical description can be much more complex, that is, if the numerous factors that influence the growth of each fish population are considered. This, of course, requires much more information on the population structure of the fish and on the primary producers.

These representations are only three examples of the ways that the internal mechanisms that relate input and outputs of a subsystem can be dealt with. If all of the factors could be represented correctly with mathematical equations, one could easily construct a mathematical model of the total system which would permit predictions to be made with a relatively high precision.

Appendix D - Methodology for the evaluation and display of environmental impact

The stage of the planning investigation being undertaken will fix the detail and degree of information needed for the evaluation. Early stages will require only compilation of data and information already available or easily obtainable, and many of the items discussed below will not be sufficiently known to be treated. Later stages will need more intensive research and should be specific to the problems being treated and the detail required for their resolution.

I. Economic development account

Formulation and evaluation of development plans are based on the demand projections of goods and services for some future period. The needs for water and land resources are then related to these projections. Beneficial and adverse effects of each strategy are then determined by comparing the conditions expected with and without the plan. From the viewpoint of their contribution to economic development, the beneficial effects of development activities - such as the control of flood, erosion, sedimentation, and drainage - on the output of goods and services are increases in land productivity or reductions in cost of its use. These benefits essentially release resources for the production of goods and services elsewhere. They affect land resources as follows:

- Prevention or reduction of flooding arising from stream overflow, overland water flow, high lake stages, high tides, and prevention of damage from inadequate drainage;

- Prevention or reduction of soil erosion, including sheet erosion, gullying, landslips and landslides, floorplain scouring, stream bank cutting, shore or beach erosion, and sedimentation; and

- Prevention or limitation of certain specified land resource uses.

Three major types of benefits occur from including these activities in a plan: an increase in productivity without a functional change in land use; a shift to more intensive land use; and a shift to a less intensive but more protective use. In each case, the general method of calculating benefits is applicable. This usually establishes the limit of an individual's willingness to pay for a plan that results in an increase in productivity or a reduction in the cost of using land resources. The following should be considered:

a) An increase in productivity where analyses with and without implementation of the plan indicate that current and future uses of given resources are the same and where it is more profitable to continue using a land resource than to relocate at the next most efficient site.

b) A change in land use covers two situations:

- A landowner benefits from a change in land use as a result of plan implementation. Net income change to the land user is the difference in net income from that land use without the plan compared to the net income received if the location were improved as a result of the plan.

- Enterprises using a given resource would be unable to use that resource with implementation of the plan. Beneficial effects are evaluated by using the net income change for the land use precluded with and without plan implementation plus the net income change for the enterprise that would be allowed to use land with and without plan implementation.

c) Protection from damage. In cases where it is impossible to directly calculate benefits through changes in net income, an estimate of actual or prospective damages without the plan can be used to approximate the net income change. Where productivity stays the same with and without the plan, benefit will equal the reduction in total damages. Where land use is intensified, benefits will be equal to the damages these land uses would sustain without protection.

Another environmental activity that may be evaluated economically is recreation. For the most part, outdoor recreation is produced publicly and distributed in the absence of a viable market mechanism. Under this condition, the increase in recreation provided by a plan may be valued on the basis of simulated willingness to pay. A number of approaches are available:

a) Relating travel cost to distance. Using the variable costs of travel as a measure of willingness to pay for recreation, a relationship can be established between price and per capita attendance at recreational sites and areas. This relationship indicates the demand for recreation at alternative prices. Separate demand curves may be constructed to reflect each kind of recreational use, whether day-use travel, camping-use travel, or other. If a fee is charged, the cost would then be equal to that fee plus travel cost.

b) Simulated prices per recreation day. Two classes of outdoor recreation days are used and estimates of total recreation days for both categories can be developed. The general class, the more usual activities of swimming, picnicking, boating, and most warm water fishing, constitute the majority of water-related activities. Generally, fewer alternatives are available and higher total costs are incurred in the special class of hunting and fishing activities and the monetary values applicable to fish and wildlife recreation will ordinarily be larger than are those for other types of recreation.

River basin plans may include specific measures to enhance fish and wildlife resources and associated activities for commercial uses well as for recreational use. Benefits from commercial fishing, hunting, and trapping consist of the total value of an increase in the volume or quality of the products expected to be marketed minus the cost of obtaining the fish or game. This increase is determined by comparing values of future production and harvest with and without the plan.

Increases in output resulting from external economies may also result from a plan. Technological external economies are the beneficial effects on individuals, groups, or industries that may or may not benefit from the direct output of the project.

a) Final consumer goods. Provision of additional recreational opportunities and fish and wildlife enhancement may enable suppliers of sporting goods and recreational equipment and services to increase their sales and net income.

b) Intermediate producer goods. Utilization of intermediate goods and services by direct users may enable them to expand their output. Increased levels of output by direct users may, in turn, enable economically related firms to improve the efficiency of their operation and/or expand their output and, as a result, increase their net income.

c) Cost adjustments. A special case of benefits from cost adjustments arises when a plan creates an opportunity to use resources that would be unused or inadequately used in the absence of the plan. These resources include natural resources as well as labor and fixed capital.

II. Environmental quality evaluation

Although some of the environmental effects of river basin development may be evaluated economically, they generally are characterized by their nonmarket, noneconomic nature. Both beneficial and adverse effects should be treated throughout the area of the plan's influence. The geographic areas to be considered in the evaluation will vary according to the environmental feature of interest and how it relates to the project or program being developed. It should include the areas to be occupied by the project program and its areas of influence, including areas downstream of the mouth of the basin.

Adverse environmental quality effects are those that result from actions leading to the deterioration of those environmental characteristics that are desirable. Each major beneficial and adverse impact should be evaluated and displayed. This requires the use of specific criteria for describing the impact so that the various developmental alternatives may be compared. In all cases, the importance of the impact will depend upon the nature of the environmental feature being impacted and the nature of the impacting action. These may be evaluated according to quantity, quality, human influence, uniqueness, degradation, reversibility, and importance.

- *Quantity:* To the degree possible, each relevant environmental feature should be measured and displayed in terms of surface area, distance, volumes, and/or numbers of individuals or sites.

- *Quality:* The quality of relevant environmental features may be subjectively described by assigning numbers on the scale wherein they are compared with similar features or conditions elsewhere. Each planning team should construct its own subjective scale according to prevailing conditions and level of detail required. One possibility is a scale where 0 is the worst example known, 2 is average, and 4 is the best example known; 1 and 3 would signify a comparatively low value and a comparatively high value respectively.

- *Human influence:* This factor subjectively evaluates the degree that people use or would use the relevant environmental feature; the degree that it is or would be available for continued use; the degree that it is, or would be, protected for use; the degree that it might be degraded by use; and the degree that it contributes to education, scientific knowledge, and human enjoyment. Human factors can also be evaluated on a scale which compares them to similar factors at other locations.

- *Uniqueness:* Some environmental features are significant because they are rare, unusual, or extraordinary regionally, nationally, or internationally. Degradation of such resources may deprive many people, both now and in the future, of the opportunity to use and/or enjoy unique environmental features. Consequently such features should be identified and evaluated in accordance with a subjective scale, such as the following:

1. Unique in the area being planned but occurs in abundance throughout other parts of the region.

2. Unique in the region but examples occur frequently elsewhere nationally and internationally.

3. Rare nationally and internationally but several examples occur within the region.

4. Very rare outside the planning setting with one or few examples occurring in the planning setting.

5. The only one of its kind or the only population of a species occurring anywhere.

- *Degradation:* The effect of the project or program on any unique environmental feature should be measured in relation to the degree of its degradation or destruction. The following is one possible scale:

0. No measurable effect on the feature.

1. Minor effect. A minor portion of the feature would be degraded or destroyed but would not significantly affect the feature within the area being planned.

2. Moderately effected. A portion of the feature would be degraded or destroyed, but an adequate portion would remain to preserve the feature at a reduced scale.

3. Severely effected. A major portion of the feature would be severely degraded or destroyed.

4. Feature would be totally destroyed.

- *Reversibility:* Reversibility of the impact on any unique environmental feature should be evaluated by considering: a) degree of uniqueness; b) degree of degradation expected when a plan is operational, and c) degree of reversibility of that degradation. The following scale may be used:

1. Any degree of uniqueness and degradation where the impact is reversible over the short-term (0-10 years).

2. Any degree of uniqueness and degradation where the impact is reversible over the long-term (11-20 years).

3. Any degree of uniqueness and degradation where the potentially impacted feature can be moved.

5. Features that would be severely and irreversibly degraded.

6. Rare features that would be severely and irreversibly degraded or destroyed.

- *Importance:* Specific attention should be given to those environmental features that are especially important and to those that require additional study or protection, also to those impacts that may be particularly dangerous.

• Environmental evaluation and display

Examples of the types of question that need to be asked to utilize the above evaluation factors are given for representative environmental categories.

• Economic category

At least two activities resulting from economic development should be mentioned for their impact on environmental quality. These are the use of fossil fuels and the generation of residuals.

a. *Fossil fuel consumption.* Given the increasing cost of fossil fuel energy and the scarcity of this resource, fossil fuels use should be evaluated.

1. Quantity: The amount of fossil fuel to be used; area within and outside the planning site to be modified for fossil fuel production, stockpiling, and transport.

2. Quality: The kinds of fossil fuels to be utilized; their quality and the kind and quantity of potential contaminants.

3. Human Influence: Accessibility and availability of fuel; legal, administrative, and security aspects of its production and use; effects on climate and air quality.

4. Importance: Production and use of fossil fuels may require a separate environmental evaluation.

b. *Residual generation:* If applicable, the production, disposition, and potential use of any residuals should receive an environmental evaluation for each project alternative.

1. Quantity: The amount in kilos, tons, parts per million, or other relevant measure; values should be indicated for each expected residual discharge; type and number of each source; quantity from each source. Include data on biological oxygen demand (BOD), suspended solids, temperatures, heavy metals, toxics, etc. for water discharge; quantities and kinds of air pollutants emitted (oxides of nitrogen, sulfurdioxide, trace elements, etc.); length of river or stream, area of water surface, air and/or soil surface to be affected by pollutant. Cumulative effects of all sources should be considered.

2. Quality: Potential effect of each pollutant on organisms, buildings, monuments, etc.; qualitative description of each discharge.

3. Human influence: Extent to which discharges have adverse effects on water, air, and soil quality; extent to which discharges have adverse effects on human living conditions; proximity of discharge to inhabited areas or areas of use (beaches, parks, etc.).

4. Degradation: Residual discharges can often be greatly reduced or eliminated completely. Possibilities for the use, recycling, or mitigation of the effects of these discharges should be discussed.

5. Importance: Many of the residuals discharged by industry are highly toxic to human beings and other life forms. These should be specifically mentioned. Additional investigations, such as a more specific environmental impact study, should be indicated.

• **Social category**

This category should receive a more detailed evaluation by a social scientist. However, certain specific aspects may be discussed in an environmental evaluation.

a. *Human health:* The general health status and specific disease and health problems of the population should be evaluated and displayed as to:

1. Quantity: Percent of the total population or population subgroups based on income, race, distribution, etc. having good, fair, or poor health; percent of population or actual numbers having specific diseases or health problems.

2. Quality: Severity of specific diseases or general health problems; survival rates; degree of debilitation.

3. Human influence: Susceptibility of the population to specific diseases; how close does or would the population live to health hazards or unhealthy conditions? How often would the population come in contact with disease vectors or conditions involved in the transmission of diseases or health problems?

b. *Population migration.* The impacts of and on population migration may be positive or negative and the short-term impacts may be different from the long-term impacts; these should be evaluated.

1. Quantity: Number of migrants by sex, nationality, race, social status, and age; length of stay if seasonal; cyclic distribution.

2. Quality: Skills involved and their value to the area being studied; impact on social services in area; health and economic status of immigrating population; desirability of continued migration.

3. Human influence: Degree of acceptance by, and of, local population, ease of migration; services, including health and educational facilities available; legal and administrative protection.

4. Importance: Health problems and impact on social services may require further study.

c. *Green space* has a function in human health, welfare, and public safety as well as providing transportation corridors and recreational opportunities.

1. Quantity: Size and location of areas designated as urban and non-urban parks; nature

trails; cultivated and uncultivated agricultural lands; flood plains; water surfaces; and rights-of-way for traffic and communication facilities.

2. Quality: The degree that land features can and do provide open space and green belts; the degree that water surfaces provide open space; diversity of the landscape; distribution patterns.

3. Human influence: Relationship to the population in terms of time and distance factors; public access; public amenities; physical, legal, and administrative protection.

d. *Air quality:* Impacts of projects on the chemical, physical, and biological aspects of air should be evaluated.

1. Quantity: Give type, number, and quantity of each air pollution source, identify major sources; include data on plant capacities and the quantities of each kind of pollutant emitted; approximate area in sq. km where air does and does not meet indicated or suggested standards.

2. Quality: Extent to which air quality degrades or enhances other environmental values; extent to which air is free from nuisance-causing materials or materials harmful to human health and to flora and fauna; extent to which thermal inversions are or could be a factor in air quality; extent to which development may alter climatic regime.

3. Human influence: Extent to which human use has an adverse effect on air quality. Where pollution occurs, the extent to which technology is available to meet actual or suggested air quality standards.

e. *Culture:* Development projects will have impacts on human cultures and life styles and these impacts should be evaluated.

1. Quantity: Population numbers and distribution of each culture and subculture; areas considered significant by tradition or religion even though not actually occupied, such as cemeteries or burial grounds, sacred areas, hunting, fishing, and gathering areas.

2. Quality: Extent to which members of a culture identify with that culture; its contribution to the life style of other cultures; the importance of the areas occupied or otherwise associated with the culture; the extent of cultural change that has intruded or has been imposed from outside.

3. Human influence: Geographical proximity of the culture to development projects; ability of the culture to retain its characteristics and unity; legal and administrative factors which inhibit or protect the cultures.

- **Archeologic/historic category.**

Given the isolated nature of archeological remains and their importance in reconstructing the past, and given the fact that historic events are not repeatable, this category should receive a uniqueness evaluation as well as a discussion on the mitigation of negative impacts.

1. Quantity: Total number of sites, structures, or structural remains in affected areas having historical/archeological interest, giving location and description; total number of sites where

significant events occurred; total number and description of trails, roads, farming areas, etc. that may have historic significances; total number of occupation sites; summary of scattered artifactual material; total number of sites displaying petroglyphs, pictographs, etc. with location and description; total number of burial or other funerary sites, or sites of apparent religious association.

2. Quality: Historical or archeological significance of these resources; condition and extent of deterioration or preservation of structures; record of past investigation or preservation of sites and structures; aesthetic setting.

3. Human influence: Relationship to the population; degree to which the resource is visited by the public or is elsewhere interpreted to present and future populations; degree of public access and amenities; existing or proposed facilities of visitation; legal and/or administrative protection; land tenure status; educational, scientific, and/or recreational value.

• **Natural resources category**

This category includes the renewable and non-renewable resources, such as water, soils, forest, fish, wildlife, air, and minerals, as well as the interacting components and processes of the ecosystems under study. Thus, evaluations should be made on entire ecosystems as well as on individual components and processes of these ecosystems. The definition and evaluation of ecosystems are facilitated by mapping the area's important life zones and by the use of conceptual models.

a) *Terrestrial and aquatic ecosystems:* Ecosystems can be classified as terrestrial or aquatic, and the ecosystem itself should be evaluated according to quantity, quality, human influence, uniqueness, and reversibility; critical areas or concerns should be flagged.

1. Quantity: Size of area covered by different ecosystems (tundra, forest, shrubland, deserts, grassland, lakes, reservoirs, streams, rivers, marshes, bogs, swamps, and estuaries as well as their shorelines and beaches), major or important subunits of these as they would naturally occur given the climate, soils, topography, and geologic substrate; size of, or percent of, each of these units and subunits that have been disturbed or that are held at a given successional stage because of man's influence; quantitative data on other important descriptive parameters, such as the area's cyclic contribution to precipitation and runoff. For aquatic ecosystems, the size of area covered by different ecosystems at both low and flood stage; amounts and seasonal variation in inflow and outflow of water; length of free flowing streams and rivers; depth and volume of water bodies; length of streams and rivers having intermittent and permanent flows; numbers of lakes and reservoirs; length of shore lines and beaches.

2. Quality: Degree that each ecosystem is in good condition and its dynamics tend to remain in a state of equilibrium; degree to which conditions contribute to maintenance of the more desirable successional stages; the value these systems have in support of the human quality of life. Water quality in terms of turbidity, debris, chemicals, odor, algae, temperature, and capability of supporting aquatic life; eutrofication; characteristics of stream bottoms and shorelines; specific actual or potential uses of water body; land features along and surrounding water body; productivity; impact of fluctuation on water body and adjacent lands; adequacy of water volume for sustaining populations of flora and fauna; importance

of the area to production of adequate supplies of desirable plants and animals; value of system in flood and erosion control; further evaluation of unique ecosystems.

3. Human influence: Existing physical, legal, and/or administrative protection and access; recreational, scientific, and educational value and use; value as national reserves or parks.

4. Importance: Further studies of those ecosystems that appear important or that are endangered.

b) *Flora:* This sub-category includes terrestrial, submerged, and emergent plants as individual species, as stands of individual species, and as communities of associated species.

1. Quantity: Approximate population numbers and distribution of species that are rare or in danger of extinction, or that have a potential economic or other value; species that may be considered noxious or pestilent; growth rates; rates of spread or population increase or decline; species or communities that provide habitat for fauna that have an economic value or that are potential disease carriers.

2. Quality: Degree that the plant communities are in good condition and tend to remain stable; diversity of species within a community; desirability of the types of plants that occur; degree that the area is free from pestilent or nuisance plant species.

3. Human influence: Degree of scientific, educational, or recreational value; amount, kind, and value of physical, legal, and/or administrative protection.

4. Uniqueness: Evaluation by community and species; include uniqueness of processes as well as species.

5. Reversibility: Possibilities of efforts at impact mitigation or amelioration.

6. Importance: Species or communities that are endangered; further studies required to protect or understand life histories of important species or of community functions.

c) *Fauna:* Both aquatic and terrestrial fauna may be discussed as subunits except where an individual species is of importance. Possible subunits are as follows: threatened species, large mammals, fur bearers, water fowl, other birds, reptiles and amphibians, fish, crustaceans, mollusks, insects, and others. In addition to individual wildlife species, the habitat of these species should be considered.

1. Quantity: Population numbers of individual species in each subunit and the area of habitat needed for their support; data on habitat-carrying capacity for each of the units; age distribution of more important species; seasonal variation in number of migratory species; number and location of breeding grounds and nesting sites.

2. Quality: Degree to which population is self-sustainable; degree to which population is sustainable and can adapt to individual and cumulative changes.

3. Human influence: Scientific, educational, and recreational value of each of the subunits; accessibility or visibility to the public for each subunit or species of importance; physical, legal, and administrative protection of each subunit or species of importance.

4. Uniqueness: Evaluation by subunit and important species; include uniqueness of habitat relationships as well as species.

5. Reversibility: Possible efforts of impact mitigation; physical relocation of population or breeding pairs.

6. Importance: What are the species or habitats that are endangered? What kind of additional studies are necessary?

d) *Edaphic:* This sub-category includes soils or protosoils and their applicability for the many agricultural, urban, industrial, and protective uses.

1. Quantity: Size of area of each soil type according to actual or potential use (farmland, range land, forest land, urban and industrial areas, etc.)

2. Quality: Susceptibility to erosion, landslides, salinization, laterization, or other problems; relative fertility; presence of toxic elements; stability.

3. Human influence: Degree to which land management practices can improve the usability of the land; physical, legal, and/or administrative protection.

4. Importance: Areas that are particularly hazardous for certain uses; additional studies that may be required should be described.

e) *Geologic/Topographic:* This sub-category covers areas of geologic importance as future mineral sources, areas of interest for studying or displaying earth's development, and areas for recreational purposes. It should include such things as fossil beds, potential ski slopes, caves, geothermal energy sources, areas having scenic values, and areas that are hazardous because of severe incline or susceptibility to landslides, mudflows, etc.

1. Quantity: Approximate volume of important mineral deposits, number of locations of fossil beds, exposed formations or land formations of special interest, (fumerols, geisers, hot springs, volcanic activity, faults, etc.)

2. Quality: Uniqueness of formations and processes in the area; condition of preservation; aesthetic setting; hazard potential; further evaluation of unique aspects.

3. Human influence: Relationship to population access; scientific, educational, and recreational values; legal, physical, and/or administrative protection.

4. Importance: Areas that are particularly hazardous, interesting, and/or require additional study.

f) *Water quality:* This category includes the chemical, physical, and biological aspects of fresh, brackish, and salt water with respect to its suitability for a particular use. Of highest value would be water of a quality better than that needed for expected uses. The effects of a project on water quality may extend well beyond the immediate project area. Therefore, the total area under evaluation should be carefully considered to measure the cumulative environmental effects of all proposed actions.

1. Quantity: Type and number of each waste water source; quantity of discharge from each source. As available, include data on BOD of discharge, suspended solids, temperature, metals, and other parameters. Length of rivers or streams not reaching established or suggested standards; length of rivers and streams, and area or volume of lakes and reservoirs that reach established or suggested standards; length of streams or rivers that are dry as a result of diversions; number and area of diffuse contamination sources, such as grazing and

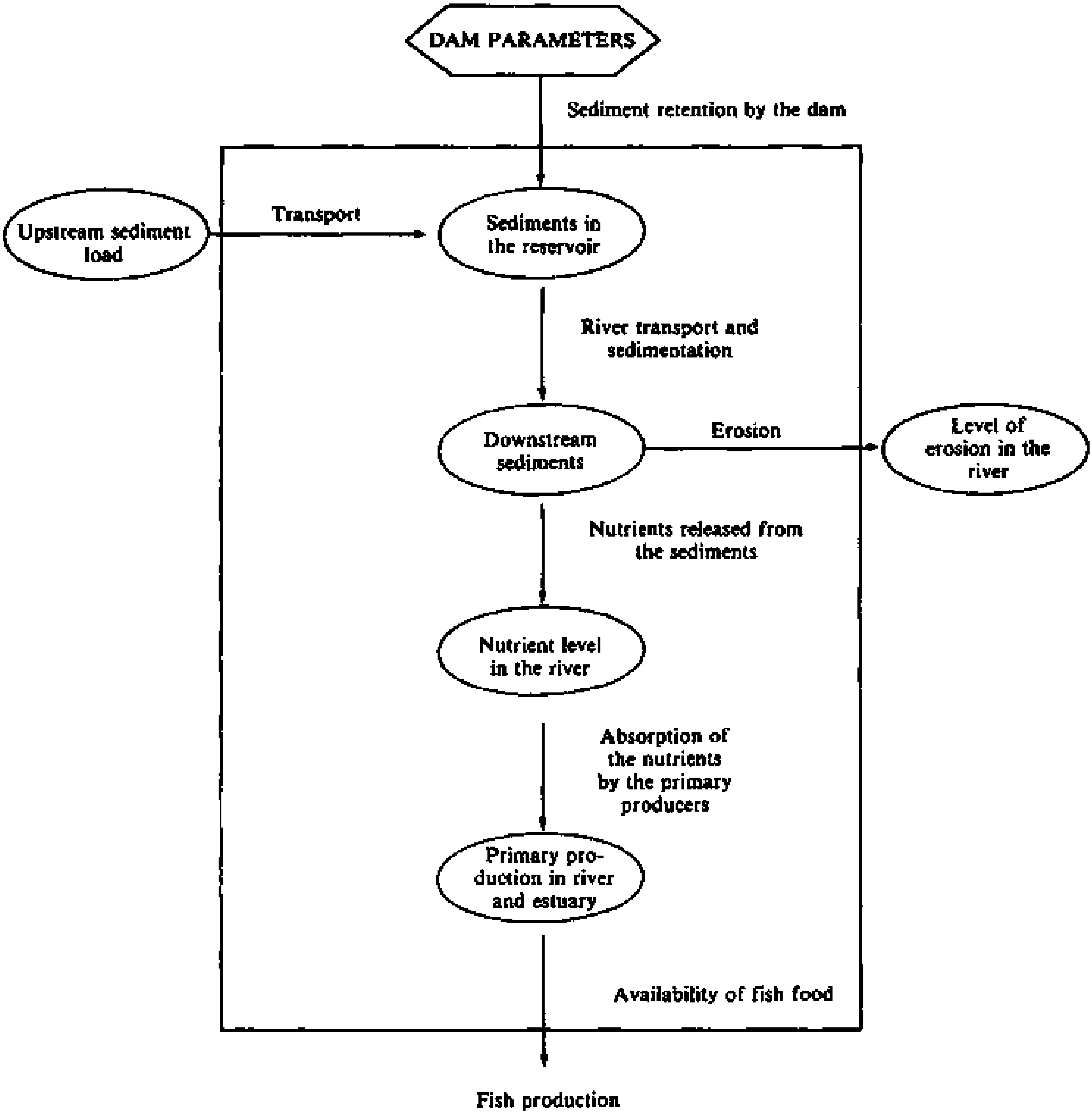
agricultural lands that may contribute to silt, pesticide, fertilizer pollution, or additional BOD loads.

2. Quality: Extent to which water supports undesirable aquatic organisms; extent to which water supports desirable organisms; extent to which water quality impairs or enhances desired uses, including aesthetics; extent to which water meets set or suggested standards; extent to which desired or existing uses, such as irrigation, municipal and industrial water supply, and recreation, are limited by water quality.

3. Human influence: Extent to which use has an adverse effect for which technology is available to meet the set or suggested water quality standards; extent to which water is available for beneficial uses, such as irrigation, water supply, etc. (consider over-appropriation, water laws, water compacts, etc.)

4. Importance: Toxic materials with potentially adverse impact on critical portions of aquatic ecosystems should be further investigated.

A simple table format indicating the various project alternatives across the top with specific descriptions of the environmental categories to be impacted, and the evaluators along the right hand side is applicable for display purposes of the above evaluations. Numeric and subjective evaluation summaries of these impacts may then be presented within the matrix.


DAM PARAMETERS
Sediment retention by the dam
Upstream sediment load
Transport
Sediments in the reservoir
River transport and sedimentation
Downstream sediments
Erosion
Level of erosion in the river
Nutrients released from the sediments
Nutrient level in the river
Absorption of the nutrients by the primary producers
Primary production in river and estuary
Availability of fish food
Fish production

Literature cited

Adkins, W. G. and Burke, D. Interim Report: Social, Economic, and Environmental Factors in Highway Decision-Making. Texas Transportation Institute, Texas A&M University, 1971.

Barbour, Edmund. Multi-Objective Water Resource Planning. Second World Congress on Water Resource Planning. International Water Resources Association, New Delhi, India, December 17, 1975.

Bardach, John E. "Some Ecological Implications of Mekong River Development Plans." The Careless Technology. Farver, M. T. and Milton, J. P., Editors. The Natural History Press, Garden City, N.Y., 1972.

Ciccetti, C. and Freeman, A. M. "Option Demand and Consumer Surplus: Further Comments." Quarterly Journal of Economics, Vol. LXXXV, No. 3, 1976.

Clawson, M. and Knetsch, J. "Outdoor Recreation Research: Some Concepts and Suggested Areas of Study." Natural Resources Journal, Vol. 3, No. 2, 1963.

Cooke, G. Dennis. The Cuyahoga River Watershed. Proceeding of a Symposium held at Kent State University, Kent, Ohio, November 1, 1968.

Dasmann, R. F., Milton, J. P., and Freeman, P. H. Ecological Principles for Economic Development, John Wiley, London, England, 1973.

Davis, Robert K. "The Value of Outdoor Recreation: An Economic Study of the Maine Woods." PhD thesis. Harvard University, 1963.

Dee, Norbert *et al.* "An Environmental Evaluation System for Water Resource Planning." Water Resource Research, Vol. 9, No. 3, 1973. Pp. 523-535.

Ditton, R. and Goodale, T., Editors, Environmental Impact Analysis: Philosophy and Methods. University of Wisconsin Sea Grant Program, University of Wisconsin, Madison, Wisconsin, 1973.

Eckholm, Erik, P. Losing Ground. Environmental Stress and World Food Prospects, W. W. Norton and Co., New York, N.Y., 1976.

Ehrenfeld, David W. "The Conservation of Non-Resources." American Scientist, Vol. 64: 648-56, 1976.

Farvar, M. T. and Milton, J. P., Editors, The Careless Technology: Ecology and International Development. The Natural History Press, Garden City, N.Y., 1974.

Fogel, Martin M. "Environmental Considerations in River Basin Planning and Decision-Making." Working paper No. 5 UNDP/UN. Interregional Seminar on River Basin and Interbasin Development, Budapest, Hungary, September 16-26, 1975.

Forbes, F. J. and Hodges, R. C. "New Approaches to Comprehensive Planning in Canada." Water Resources Bulletin, Vol. 7, No. 5, 1971.

Fox, Irving K. "Some Political Aspects of the Relations Between Large-Scale Interbasin Water Transfers and Environmental Quality." Environmental Quality and Water Development, Goldman, C. R., McEvoy, J. M., III, Richerson, P. J., Editors, W. H. Freeman and Co., San Francisco, Calif., 1973. Pp. 413-24.

Freeman, Peter. The Environmental Impact of a Large Tropical Reservoir: Guidelines for Policy and Planning, Smithsonian Institute, Washington, D.C., 1974.

George, Carl J. "The Role of the Aswan High Dam in Changing the Fisheries of the Southeastern Mediterranean." The Careless Technology. Farvar, M. T. and Milton, J. P., Editors, The Natural History Press, Garden City, N.Y., 1972.

Goldman, C. R., McEvoy, J. M., III, and Richerson, P. J., Editors, Environmental Quality and Water Development, W. H. Freeman and Co., San Francisco, Calif., 1973.

Goodman, D. "The Theory of Diversity-Stability Relationships in Ecology." Quart. Rev. Biol. 50: 237-66, 1975.

Gosselink, J. C., Odum, E. P., and Pope, R. M. "The Value of the Tidal Marsh." Bulletin LSU-SG-74-03, Center for Wetland Resources, Louisiana State University, Baton Rouge, La., 1974.

Government of Argentina. Decreto N° 558, Gobierno de Argentina, 7 de agosto de 1970.

Government of Argentina. Plan Nacional de Desarrollo y Seguridad, 1971-1975, Ley 19.039, Gobierno de Argentina, 14 de mayo de 1971.

Government of Argentina. Ley N° 11709, Gobierno de Argentina, 19 de septiembre de 1933.

Government of Perú. Ley General de Aguas. Decreto Ley N° 17752, 1969.

Government of Venezuela. Ley Orgánica del Ambiente. Congreso de la República. Gaceta Oficial. N° 31.004. Caracas: Miércoles 16 de junio de 1976.

Hay, John. "Salt and Salinity on the Upper Rio Grande." The Careless Technology. Farvar, M. T. and Milton, J. P., Editors, The Natural History Press, Garden City, N.Y., 1972.

Institute of Ecology. "Optimum Pathway Matrix Analysis Approach to the Environmental Decision-Making Process." Test Case: Relative Impact of Proposed Highway Alternatives. Institute of Ecology, University of Georgia, Athens, Georgia, 1971.

Knetsch, Jack. "Outdoor Recreation and Water Resources Planning." Amer. Geophysical Union, Water Resources Monograph, No. 3, 1974.

Knetsch, J. and Fleming, W. "Resource Development Alternatives: An Evaluation Strategy." Unpublished document, Simon Frazer University, Vancouver, B.C, 1975.

Krutilla, John V. "Conservation Reconsidered." The American Economic Review, September 1967.

Krutilla, J. and Fisher, A. C. The Economics of Natural Environments. Johns Hopkins University Press, Baltimore, Maryland, 1975.

Leopold, L. B., Clarke, F. E., Hanshaw, B. B., and Balsley, J. R. "A Procedure for Evaluating Environmental Impact." Geological Survey Circular 645, U.S. Government Printing Office, Washington, D.C., 1971.

Lord, William and Wasner, Maurice L. "Aggregates and Externalities: Information Needs for Public Natural Resource Decision-Making." Natural Resources Journal, Vol. 13, No. 1, 1973. Pp. 106-17.

Matthews, H. Freemen, Jr. International River Problems: Three Examples. Senior Seminar in Foreign Policy. U.S. Department of State, Washington, D.C., 1974.

May, R. M. Stability and Complexity in Model Ecosystems. Princeton University Press, 1973.

McHarg, I. A Comprehensive Highway Route-Selection Method. Highway Research Record No. 246, 1968. Pp. 1-15.

McHarg, I. Design With Nature. Natural History Press, Garden City, N.Y., 1969.

Ministerio del Ambiente y de los Recursos Naturales Renovables, Políticas, Organización, y Funciones. Ediciones Amon. C. A. Caracas, Venezuela, 1977.

Munn, R. E., Editor, "Environmental Impact Assessment: Principles and Procedures." SCOPE Report 5, Toronto, Canada, 1975.

OAS. Acuerdo de Asistencia Técnica entre el Gobierno de la República Argentina y la Secretaria General de la Organización de los Estados Americanos para la Ejecución de un Estudio de los Recursos Hídricos de la Cuenca del Río Bermejo y Programación para el Desarrollo. OEA./Ser. D/V 18-70, 1970.

OAS. Cuenca del Río de la Plata. Estudio para su planificación y Desarrollo. República Argentina-República de Bolivia I - Alta Cuenca del Río Bermejo. Estudio de los Recursos Hídricos. Secretaría General de la Organización de los Estados Americanos. Washington, D.C., 1974.

OAS. Cuenca del Río de la Plata. Estudio para su planificación y Desarrollo. Cuenca del Río Bermejo II. Cuenca Inferior. Secretaría General de la Organización de los Estados Americanos, Washington, D.C., 1977.

Odum, Eugene P. Ecology. Modern Biology Series. Holt, Rinehart and Winston, New York, N.Y., 1963.

Odum, Eugene P. "Energy, Ecosystem Development, and Environmental Risk." The Jour of Risk and Insurance, Vol. XLIII, No. 1, 1976.

Odum, Howard T. "Use of Energy Diagrams for Environmental Impact Statements: Tools for Coastal Management." Proceedings of Conference, Marine Technology Society, Washington, D.C., February 14 and 15, 1972. Pp. 197-213.

Ordóñez, Absalon. Proyecto de Manual de Objetivos y Alcances de Trabajo para Distintos Niveles de Estudio de Desarrollo Económico de las Cuencas Hidrográficas. UPADI. Comité de Desarrollo de Cuencas Hidrográficas, 1969.

Schramm, Gunter and Burt, Robert E. An Analysis of Federal Water Resource Planning and Evaluation Procedures. School of Natural Resources, The University of Michigan, Ann Arbor, Michigan, 1970.

Scudder, Thayer. "Ecological Bottlenecks and the Development of the Kariba Lake Basin." The Careless Technology. Farvar, M. T. and Milton, J. P., Editors. The Natural History Press, Garden City, N.Y., 1972.

Smith, V. K. "The Effect of Technological Change on Different Uses of Environmental Resources in Natural Environments." Studies in Theoretical and Applied Analysis. Krutilla, J., Editor. Johns Hopkins University Press, Baltimore, Maryland, 1972.

Sorenson, J. A Framework for Identification and Control of Resource Degradation and Conflict in the Multiple Use of the Coastal Zone. University of California, Berkeley, Calif., 1970.

Sorenson, J. and Pepper, J. E. Procedures for Regional Clearinghouse Reviews of Environmental Impact Statements: Report to the Association of Bay Area Governments, 1973.

Sweet, David C. "The River Basin as a Socio-Economic Region." Cooke, G. Dennis, Editor. The Cuyahoga River Watershed. Proceedings of a symposium held at Kent State University, Kent, Ohio, November 1, 1968.

United Nations. Integrated River Basin Development, New York, N.Y., 1970.

United Nations. "Water Resources Project Planning." Economic Commission for Asia and the Far East. Water Resources Series No. 41, 1972.

United Nations. "The Environmental Aspects of Water Resources Development and Management With Suggestions for Action." Food and Agriculture Organization of the United Nations. U.N. Conference on the Environment, Stockholm, Sweden, 1972.

United Nations. "The Demand for Water: Procedures and Methodologies for Projecting Water Demands in the Context of Regional and National Planning." Department of Economic and Social Affairs, Natural Resources Water Series No. 3, 1976.

U.S. Bureau of Reclamation. Guidelines for Implementing Principles and Standards of Water Resources. USDI. Washington, D.C., 1972.

U.S. Congress. Congress and the Nation's Environment. Environmental and Natural Resources Affairs of the 93rd Congress. U.S. Government Printing Office, Washington, D.C., April 1975.

U.S. Senate. Policies, Standards, and Procedures in the Formulation, Evaluation, and Review of Plans for Use and Development of Water and Related Land Resources, Document No. 97. U.S. Government Printing Office, Washington, D.C., 1962.

U.S. Water Resources Council. Water and Related Land Resources. Establishment of Principles and Standards for Planning. Federal Register, Vol. 38, No. 174, Part III, Monday, September 10, 1973.

Walters, Carl. An Interdisciplinary Approach to Development of Watershed Simulation Models. Technological Forecasting and Social Changes. 6: 299-323, 1974.

Warner, M. L., Moore, J. L., Chatterjee, S., Cooper, D.C., Ifeadi, C., Lawhon, W. T., and Reimers, R. S. An Assessment Methodology for the Environment Impact of Water Resource Projects. Office of Research and Development, U.S. Environmental Protection Agency. Washington, D.C. EPA-60015-74-016, 1974.

Weisbrod, B. A. "Collective Consumption Services of Individual Consumption Goods." Qtrly Jour of Economics, Vol. LXXVIII, No. 3, 1964.

Wymore, A. Wayne. Systems Engineering Methodology for Interdisciplinary Teams. John Wiley and Sons, New York, N.Y., 1976.

The Organization of American States

As specified in its Charter, the Organization of American States (OAS) has the following essential purposes: to strengthen the peace and security of the Hemisphere; to prevent possible causes of difficulties and to ensure the pacific settlement of disputes that may arise among the member states; to provide for common action on the part of those states in the event of aggression; to seek the solution of political, juridical, and economic problems that may arise among them; and to promote, by cooperative action, their economic, social, and cultural development.

The OAS is the oldest regional society of nations in the world, dating back to the First International Conference of American States, which was held in Washington, D.C., in 1890. Within the United Nations it is a regional agency. Its Charter was signed in Bogota in 1948 and amended by the Protocol of Buenos Aires, which entered into force in 1970. Today the OAS is made up of twenty-eight member states. The General Secretariat of the Organization, its central and permanent organ, is situated in the city of Washington, D.C.

MEMBER STATES: **Argentina, Barbados, Bolivia, Brazil, Chile, Colombia, Commonwealth of Dominica, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Grenada, Guatemala, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, St. Lucia, Suriname, Trinidad and Tobago, United States, Uruguay, Venezuela.**

Abstract

During the period 1970-1975, the Program of Regional Development of the Organization of American States and the Government of Argentina conducted regional development studies of the Bermejo River Basin in Northern Argentina and, in 1976 developed a methodology of river basin planning to consider the environmental ramifications of development using the Rio Bermejo investigation as a case study. This paper presents that methodology. It includes comments on the relationship between environment, development and river basin planning (Chapter 1) and recommends (Chapter 2) that an environmental quality objective be included in the planning exercise; that environmental concerns receive explicit consideration; that the dynamics and interactions affecting the system be considered; that interdisciplinary teams be involved; that the planning effort be closely coordinated with other planning entities having interest in the area; that the public, in some form, participate; that alternatives be formulated and that these include some that do not foreclose other potential development options; that the adverse and beneficial inputs of the proposed alternatives be assigned economic values where possible; and, that they be displayed for the use of the decision maker.

Chapter 3 suggests that environmental concerns are best taken care of thru integrated planning and outlines a methodology for river basin planning based on systems analysis.

Chapter 4 presents a model for the evaluation and display of environmental impacts which may be used at early planning stages. Chapters 5 and 6 compare the methodology used in the Rio Bermejo

investigations to that suggested by the pilot study.

Resumen

Durante el período 1970-1975, el Programa de Desarrollo Regional de la Organización de los Estados Americanos y el Gobierno de Argentina condujeron estudios de desarrollo regional de la cuenca del río Bermejo, en el norte de Argentina, y en 1976 desarrollaron una metodología para la planificación de cuencas hidrográficas con el fin de considerar las consecuencias ambientales de desarrollo utilizando las investigaciones del río Bermejo como un estudio de caso. Dicha metodología se presenta en este volumen. Incluye comentarios sobre las relaciones entre el medio ambiente, el desarrollo y la planificación de cuencas hidrográficas (Capítulo 1), y recomienda (Capitulo 2) que en la planificación se incluyan objetivos de calidad ambiental; que las consideraciones ambientales reciban un tratamiento bien explícito; que sean consideradas la dinámica y las interacciones que afectan al sistema; que constituyan equipos interdisciplinarios; que el esfuerzo de planificación esté estrechamente coordinado con otras entidades de planificación que tengan interés en el área; que el pueblo participe en alguna forma; que se formulen alternativas que no limiten las diversas opciones potenciales de desarrollo; que a los insumos adversos y beneficiosos de las alternativas propuestas le sean asignados, cuando sea posible, valores económicos, y que sean claramente expuestos para que pueda utilizarlos el encargado de tomar decisiones.

El Capitulo 3 sugiere que las consideraciones ambientales se tomen en cuenta a través de la planificación integrada y hace el bosquejo de una metodología para la planificación de cuencas hidrográficas basada en el análisis de sistemas.

El Capitulo 4 presenta un modelo para la evaluación y explicación de los impactos ambientales que pueden utilizarse al principio de la planificación, mientras que los Capítulos 5 y 6 comparan la metodología utilizada en las investigaciones realizadas en la cuenca del río Bermejo con la que fue sugerida en este estudio piloto.

Résumé

Au cours de la période 1970-1975, le Programme de Développement Régional de l'Organisation des Etats Américains et le Gouvernement de l'Argentine réalisèrent des études de développement régional du Bassin du Fleuve Bermejo situé au nord de l'Argentine; par la suite, en 1976 ils développèrent une méthologie d'études des bassins versants, laquelle considère les impacts du développement sur l'environnement, utilisant pour ce faire l'investigation sur le Fleuve Bermejo comme une étude pilote. Cette méthodologie est présentée dans ce document. Le Chapitre 1 renferme des commentaires sur les relations entre environnement, développement et planification de bassins versants; le Chapitre 2 propose les recommandations suivantes: la qualité de l'environnement doit être inclue comme objectif dans la préparation du plan; les effets sur l'environnement doivent être considérés de façon explicite; les forces et relations affectant l'écosystème doivent être prises en compte; des équipes interdisciplinaires doivent être constituées; l'effort de planification doit être étroitement coordonné avec les autres organismes de planification s'intéressant à la région et le public doit pouvoir y participer d'une façon ou d'une autre; des alternatives doivent être formulées et présentées de telle manière qu'elles n'excluent pas d'autres options possibles de développement; dans la mesure du possible une valeur économique doit être attribuée aux composantes positives et négatives des différentes alternatives proposées, et ceci doit être présenté clairement à ceux qui auront à prendre les décisions. Le Chapitre 3 suggère une planification intégrée comme moyen possible de prendre en compte les considérations relatives à l'environnement et fait le

sommaire d'une méthodologie de planification des bassins versants basée sur l'analyse de systèmes. Le Chapitre 4 propose un modèle qui puisse montrer et évaluer les impacts sur l'environnement et soit utilisable tout au début de la phase de planification. Les Chapitres 5 et 6 comparent la méthodologie utilisée au cours des investigations sur le Fleuve Bermejo avec celle suggérée par l'étude pilote.

Resumo

Durante o período 1970-75, o Programa de Desenvolvimento Regional da Organização dos Estados Americanos e o Governo da Argentina conduziram estudos de desenvolvimento regional da bacia do rio Bermejo, no Norte da Argentina e, em 1976 desenvolveram uma metodologia para o planejamento de bacias hidrográficas com a finalidade de considerar as consequências ambientais do desenvolvimento utilizando as investigações do rio Bermejo como um modelo. A referida metodología se apresenta neste volumen. Inclue comentários sobre as relações entre o meio-ambiente, o desenvolvimento e o planejamento de bacias hidrográficas (Capitulo 1) e recomenda (Capitulo 2) que no exercício da planificação se incluam objetivos de qualidade ambiental; que as considerações ambientais recebam um tratamento bem explicito; que sejam consideradas a dinâmica e as interaçòes que afetam o sistema; que se constituam equipes interdisciplinárias; que o esforço de planificação esteja estreitamente coordenado com outras entidades de planejamento que tenham interesse na área; que a população participe em alguma forma; que se formulem alternativas que não limitem as diversas opções potenciais de desenvolvimento; que aos insumos adversos e beneficiosos das alternativas propostas lhe sejam asignados, quando seja possível, valores económicos e que os mesmos sejam descriminados para que possa utilizá-los o encarregados da toma de decisões.

O Capitulo 3 sugere que as considerações ambientais se tomem em conta através da planificação integrada e esboça uma metodologia para a planificação de bacias hidrográficas baseada em análise de sistemas.

O Capitulo 4 apresenta um modelo para a avaliação e descriminação dos impactos ambientais que podem utilizar-se ao inicio do processo de planificação, enquanto os Capítulos 5 e 6 comparam a metodologia utilizada nas investigações realizadas na Bacia do rio Bermejo com a que é sugerida neste estudo piloto.
