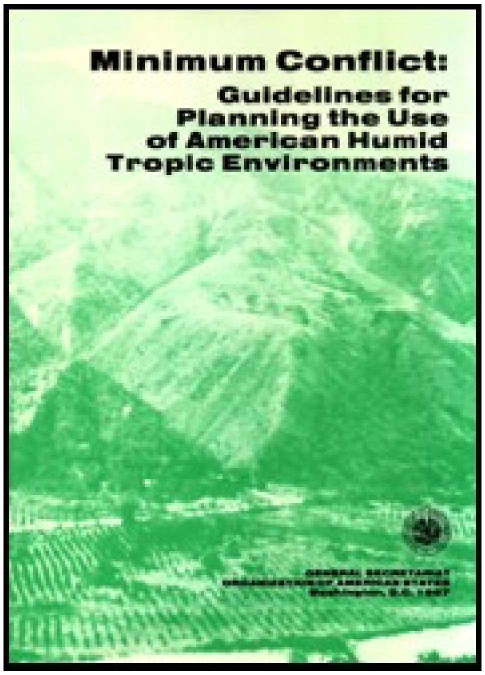
Minimum Conflict: Guidelines for Planning the Use of American Humid Tropic Environments



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Preface

MINIMUM CONFLICT: GUIDELINES FOR PLANNING THE USE OF AMERICAN HUMID TROPIC ENVIRONMENTS

Minimum Conflict: Guidelines for Planning the Use of American Humid Tropic Environments represents the Phase I report of the OAS/UNEP/Government of Peru sponsored project: "Case Study of Environmental Management: Integrated Development of An Area in the Humid Tropics - The Selva Central of Peru." To a large degree this effort is a follow-up of the OAS/UNEP/Government of Argentina study of the Upper Bermejo River Basin of Argentina in 1975-1977 which sought to develop a planning methodology for river basins in semiarid areas. The results of this early study were published in 1978 as a small book, *Environmental Quality and River Basin Development: A Model for Integrated Analysis and Planning.* Both of these studies have their basis in Resolution 61 of the 1972 United Nations Conference on the Human Environment Action Plan, which requests that research be undertaken to design practical planning methodologies for distinct categories of development activity in specific individual biomes and which would include "concern for the environment" as an integral part of development planning.

This follow-up study began at a crucial moment in Latin American history. A number of other countries were considering major development of their own tropical areas. Mineral and petroleum exploration, combined with mounting economic and social pressures, were creating waves of spontaneous migration, while conservation groups worldwide were publicizing the plight of the tropics and their inhabitants. Premature descriptions of the tropics as uninhabited and "rich" were leading to uncontrolled migration to areas with a long history of failed and failing projects. Development planners were caught short, since the vast majority of planning experience had been in temperate and arid areas, while the environmentalists had barely begun to understand the astonishing diversity of the rainforest species. But what made 1980 a good time to undertake such a study, was that by now "environment" and "development" were no longer mutually exclusive terms.

For after nearly 15 years of conflict, environmentalists and the development community show signs of coming together. When the environmental movement began, it was somewhat fragmented into sectoral interests, prone to hasty analyses and confrontational pronouncements. But this movement has changed substantially. It is now more coherent in its goals and more understanding of the pressures on the Third World.

At the same time, the international development community made efforts to improve its "environmental" behavior, and a number of its members signed in 1980 the "Declaration of Environmental Principles and Procedures Relating to Economic Development." The development community had finally learned that no matter where a project was to be undertaken, other plans and projects already existed, other interests were involved, and all of these needed to be considered.

More and more, both groups realized that neither the technology of development nor the technology of environmental concern were easy to transfer from the developed temperate areas to the "underdeveloped" tropics.

Environmental impact assessments were expensive, and relevant information was too often unavailable. The mechanisms of governance in tropical areas proved difficult to adapt to a system of decision making that includes public participation and open competition between interest groups, and even when specific problems were fully and fairly stated, they were easy neither to understand nor to solve. Realizing their mutual dilemma, developers and environmentalists began to study concepts such as "basic human needs," "appropriate technology," and "appropriate styles of development," which have helped them to work together. Rarely now does one hear of the need to conserve, or of the need to develop, without hearing that specific conservation efforts are necessary for long-term equitable development.

Despite the changes on both sides, however, some human beings still suffer the degradation of their environments because other human environments have been improved; the commons are still not managed to provide for the common good, and the number of the disenchanted and the disenfranchised continues to grow. In this light, the development work of the Government of Peru in the Central Selva in the last few years has been refreshingly successful in bringing new solutions to old problems. Thus, this study will draw on Peru's experiences to formulate guidelines for development planning in the humid tropics, and will try to do it in a ground-breaking way: for example, we discuss the concepts and methods of environmental management, but the words "environment" and "environmental" are seldom used; and horror stories are conspicuously absent. Rather, we acknowledge that attempts to develop the humid tropics will be made and concentrate on the proper use of their ecosystems instead of belaboring their abuse. We acknowledge the existence of "sectors" and "sectoral interests" and, because of this, we treat the quality of specific, identifiable human environments as opposed to the quality of "the environment." Instead of "environmental impact," the report speaks of the identification and resolution of conflict between those many activities which make up the development process, and makes no ethical judgement as to which of those activities might be correct. And, though the title talks of "minimum conflict," the study recognizes that some conflict is healthy: it seeks only to reduce the number of *unnecessary* conflicts that planning so often inadvertently creates. The result is a set of guidelines to set the stage for a level of environmental management that could lead to full, long lasting and equitably distributed use of the nearly infinite resources of the American humid tropics.

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Acknowledgements

This document is based on the Phase I report of the project "A Case Study of Environmental Management: Integrated Area Development in the Humid Tropics, the Central Selva of Peru" which was funded by the OAS, UNEP and the Government of Peru. Chapters 1,2 and 16 were written by Richard Saunier who also acted as general editor. Chapters 3 to 15, in large part, are edited sectoral reports from several specialists who comprised the study team; many of the ideas in Chapter 16 also belong to them.

The study team consisted of Carlos Ponce who prepared the legal and intitutional discussions; Marc Dourojeanni who described the ecosystems of the humid tropics and Central Selva, discussed their conservation and wrote the major portion of the wildlife chapter; Hugo Lumbreras prepared the report on health in the humid tropics and provided information on the native wildlife species used in medical research.

Hector Martínez's participation covered the history of human settlements in the Central Selva. Jorge Malleux, Douglas Pool, and Manuel Ruiz respectively discussed tropical forestry, agriculture, and ranching. Gonzalo de las Salas contributed to the chapter on tropical forestry, and Fernando Carbajal helped with the chapter on human settlements.

Christian Berger wrote the report on tropical fisheries resources; Pedro Lavi, with help from Marta Bittner prepared the report on petroleum and mining resources; Rolando Flores developed the chapter on transportation infrastructure and Javier Verastegui produced the section on energy resources. Antonio Tatit Holtz wrote the portion on water resources and Joshua Dickinson prepared the Appendix on regional conceptual modelling as well as the national and regional conceptual models in Figures 16-1 and 16-2. Janice Delaney wrote the Executive Summary and her editorial work on the rest of the document made it much more readible.

As in any effort of this nature, a large number of individuals were involved throughout - logistics, editing, typing, reviewing, proof-reading, translating, and in providing support in numerous other ways. Teresa Angulo, Salvador Archondo, Stephen Bender, Marta Bittner, Jorge Blanco, Janice Bramson, Patricio Chellew, Newton Cordeiro, Rafael Diaz, Ed Farnworth, Gabriel Gross, Arthur Heyman, Gloria Martinez, Richard Meganck, Elba Molina, Monica Muller, Lilian Renique, Julio Reyes, Richard Sims, Boris Utria, and David Wood figure prominently among these. The Institute Nacional de Planificación of Peru and the Oficina Nacional de Evaluación de Recursos Naturales of Peru helped in the original proposal and field logistics. UNEP staff members in Nairobi, Mexico City, and Washington D.C., though unnamed, are appreciated for their work as well.

Executive summary

The "environmental movement" and the international development community commonly have been at odds over the use of the world's humid tropical lands and their resources. This book is about the obstacles to and consequences of exploiting one such area in the rainforest of Peru and presents guidelines drawn from that experience which should help minimize the conflict inherent in any development activity. It is based on the view that environmentalism represents neither a sector nor a special interest; rather it is a way of looking at the activities of development to assure that their costs and benefits are equitably distributed. It also understands that our world is made up of an infinite number of environments, not one, and that therefore the question of *whose* environment becomes the paramount one in any discussion of what is to become of a land, a country, a river, an enterprise, a people.

Underlying the meaning and ultimate effect of this study are the premises that development in its social, economic and cultural dimensions is the process of improving human life quality and that this process involves manipulation of the complex, interrelated natural and man-made structure and function of human environments.

Economic pressures on developing countries in Africa, Asia and South America make it imperative that they eschew overdependence on imported goods and services and try to feed and house their people using the nation's own resources. It is natural that such countries should look to their rainforests as areas of unlimited potential for food, fiber, energy, mineral wealth and land to be occupied. But once there they are faced with the enormous complexity of the forest ecosystems and the minimal available information about the relationships among the earth, air, water, flora and fauna. They are reminded also that though sparsely settled, the humid tropics are seldom "empty."

This study has defined "environmentally sound development" as a process having the improvement of human life quality as its objective. It is a process of active manipulation of ecosystem structure and function in order to appropriate the goods and services offered by the ecosystem in question - a process that almost always changes the mix between natural and economic goods and services. That is, cities rely almost exclusively on economic goods and services, while in frontier areas like the rainforest of Peru natural goods and services play a relatively greater role. Environmentally sound development minimizes the conflict inherent in the shift towards economic goods and services and the increase in human activity; it maximizes mutual support between the required activities and distributes their costs and benefits throughout the affected populations.

In order to enable planners in the humid tropics to carry out their mission, understand the region, foresee possible conflicts among competing sectors and linked ecosystems, and forestall these conflicts by informed planning and adjustment, the OAS, UNEP and the Government of Peru initiated a detailed study of a single region of the Peruvian humid tropics in which development had been underway. This document provides an exhaustive treatment of the region and a method of conflict identification and resolution in the early stages of development planning. Each chapter has a single subject (water, agriculture, wildlife, etc.) but a multiple purpose. Experts in each field were asked first to describe the present state of the resources and sectoral activity in the region, discuss the goods and services upon which sectoral activity was, or could be based; and then identify and suggest solutions to any conflicts that exist or might arise between that sector and others with which it must interact.

The first part of this book (Chapters One through Three) discusses the context of the study, the conceptual bases supporting the sectoral analyses and the legal basis for human activity in the study area. Chapters Four through Seven identify the vast and complicated natural resources and processes of the Central Selva, looking at its major ecosystems with particular emphasis on soils, vegetation, water resources and wildlife. Chapter Eight gives the history of human occupation of the Central Selva, and the remaining chapters recount the activities of human beings there:farming, ranching, forestry, fishing, mining, road building and the search for alternative sources of energy from the forest - the activities, in other words, by which man changes the ecosystems which surround and support him. Chapter 16 presents guidelines, recommendations and observations for planning development in the American humid tropics.

The contents of this report are designed to assist policy makers and practitioners of development who participate in planning the use of humid tropic environments. Since the report is based on sectoral analyses written by representatives of the more relevant and important development sectors, those who undertake sectoral planning will find something here for them. Further, the concepts and conclusions should provide a basis for discussions within the organizations and interest groups that have come to be called "environmental," and should find ready use as reference material in courses or training centers dealing with environmental management.

Perhaps the most important parts of this report, however, are the sections which suggest to planners how to go about gathering information in information scarce areas, identifying the potential conflicts, and working together to minimize the impact of these conflicts while the planning stage is still going on. This will, of course, greatly facilitate the actual implementation of the development project, and, through understanding of each sector's needs, mitigate the "negative environmental impact" such projects inevitably generate.

Planners are told first to develop a regional model, and are offered a system for regional modelling based on the Central Selva experience. Next, an inventory of goods and services is necessary: this report offers a list of the more widely used natural goods and services in a tropical forest, but cautions that planners must make up their own lists based on interviews with the people who live, use, or have an interest in the ecosystems under study. Finally, a companion inventory of natural hazards will help planners predict how earthquakes, flooding, erosion and other natural events and processes might threaten the project at hand.

Among the guidelines to identify and remove potential conflicts during the planning stage are:

- use an environmental management advisor;

- coordinate to reduce potential conflicts (exchange ideas and information with other members of the planning team);

- review the regional conceptual model;

- analyze goods and services (and assign them to individual sectors);

- use an activity matrix to see how activities in one sector will influence, positively or negatively, activities in another; and

- distinguish between real and apparent conflicts.

Specific guidelines for the sectors are given, as well as directions for agriculture, forestry and livestock management. The report also deals with the thorny problems of spontaneous migration and how to honor cultural traditions and long-established patterns of land use.

Throughout this report the writers have used a common vocabulary, purged, as far as possible, of emotional words and phrases indicating the superiority of one sectoral interest over another. "Environment" itself was used only where it could be said to describe a specific environment; the word "ecology" did not replace "environment" or "ecosystem." "Delicate" and "fragile" are not allowed to describe ecosystems, because more often than not their common usage is to justify the position of a sector or interest group and says little of value about ecosystem structure and function.

The methods presented here do not discuss economic valuation of goods and services despite its being an important contribution towards better development decisions. Rather, the methods recognize that much of what has value from frontier areas has not been and may never be quantitatively valued. Important conflicts arising from changes in the mix of goods and services created by development activities, however, will occur, and it is the early identification and resolution of these conflicts that this document treats.

Chapter 1 - Introduction

"Planning" has been a part of human society from the time that human beings first made organized attempts to improve their quality of life. Today, planning methods are frequently modified to comply with changing perceptions of the human condition. Recent topics among professionals refer to the fluctuating cost and availability of fossil fuels and the concomitant interest in finding sources of renewable energy; the economic value of "women's work" in the development process; the priority to be given to satisfying basic human needs; the presence and role of native populations, the practice of public participation in planning, the concern for slowing population growth, and, of course, including "the environment" in development planning.

The more specific and clearly defined topics listed above have little difficulty in becoming a part of classical planning methods. Others on the list are not added so easily. One of the more difficult of these is "the environment" and it becomes even more so when one considers "environment and development of the humid tropics" - the subject of this report. The problem stems from two well-known factors: lack of information and experience concerning the tropics; and, the uncontrollable pressures for their development.

It may seem odd that there is a lack of information on the tropics given the outpouring of environmental writings of the last 20 years. But if one compares the ratio of scientists per unit area in the tropics with the same ratio in temperate areas, the reason becomes clear: there is one "environmental scientist" for every 20 sq. km in California and one for every 20,000 sq. km in the Amazon Basin - an area considerably more complex and less known to both scientists and planners.

Published works by those who have an interest in the tropics can be divided into four general categories:

1. Material that predicts the failure of certain kinds of development based on what little we know of the tropics, and which then suggests caution in undertaking such development (Gómez Pompa *et al*, 1972; Denevan, 1973; Goodland and Irwin, 1975);

2. Material that describes development failure and suggests recommendations which might lead to success elsewhere (Nelson, 1973; Smith, 1981; Hecht, 1981);

3. Material that broadly summarizes existing data and which draws conclusions on how to proceed - usually in the area of research (Farnworth and Golly, 1973; IUCN, 1975; UNESCO, 1978; NAS, 1982), but also in the area of development alternatives (Fearnside, 1979; Goodland, 1980);

4. Material published on individual or group research within specific disciplines. Many of these will be cited in the sectoral chapters. Examples, however, are Sioli, 1968; Sánchez *et al*, 1981; Fittkaw and Klinge, 1973; and Brown, 1980.

Unfortunately, most of this research information is unavailable to planners in the tropics and much of it, if available, is unusable in its present form, because recommendations and suggestions based on it have essentially been made by the "environmental" scientists with little input from the development community. The problem is that the questions asked by the two groups are different. Scientists are generally more interested in answers to why and how. Development planners need answers to when, where and how much.

To the alarm of many, socioeconomic pressures are pushing for rapid development of the humid tropics. Primary among the figures which cause alarm are those for deforestation rates, high estimates of genetic erosion, and the loss of human cultures. (See especially Sommer, 1976; Raven, 1976; Myers, 1980; Ekholm, 1982; and Cultural Survival Inc. 1982.) Tropical deforestation estimates of 7.3 million hectares (FAO, 1982) to 20.0 million hectares per year are often cited. Much of the loss in the genetic resource is attributed to deforestation in the tropics where two-thirds of all species are to be found (USAID, 1981).

These concerns, combined with the paucity of data, have led many authors to argue for a slowing of development until the ecosystems involved are better understood. Unfortunately, the speed of tropical development is so rapid and unplanned that development effort there will be slowed only by its own failure. Those who are concerned with development in the region, be it as critics or as practitioners, must realize this. And together, they must design new strategies for the development process.

Such strategies would include a set of practical guidelines to adapt the development planning process to the urgency of the situation in the humid tropics. These must be based on concepts of environmental management that consider the many interests extant in the humid tropics, and be based on knowledge already available, depending to a lesser degree on what we hope to learn in the future. Further, the guidelines must be understood and accepted by the development sectors. This means that they themselves must be involved in guideline formulation. It is the formulation of such a set of guidelines and recommendations that the present study attempts; before it can begin, however, a paragraph is necessary concerning the often repeated statement, "There is no conflict between environment and development."

Hidden by the verbal shorthand that accompanies such a statement is often an element of truth. There is also an element of error. First, one can say that concern for the quality of environments and efforts at development encompass the same general objectives, since both attempt to improve someone's environment. On the other hand, there is always the potential for conflict between any two activities that attempt to use the same ecosystems for different purposes. What is clear is that both the environmental movement and the development sectors base their activities on a common premise - that human beings deserve more than they are getting. Although neither group should claim ethical superiority over the other, the activities of each can be debated. Two facts concerning the environmental movement, and two questions which the development sectors must answer, provide the context for that debate.

The facts concern first, the one common theme and, second, the diversity of interests in the environmental movement. The theme is that of "the environment as one" elaborated by the late Barbara Ward (1966). We live in one interconnected and interdependent world - a complex place full of cause and effect relationships, feed-back, and thresholds where the activities of one individual or group influence the life of another and often come back to haunt those who initiated the actions. Science has chosen to call this interdependence "holocoenosis" and Commoner (1971) has called it the first law of ecology: "everything is connected to everything else."

Where Ward and Commoner described the *theme* of the environmental movement, the late Dr. René Dubos described the *concerns* of the movement (1972,1981). He preferred to speak of "environments" and wrote of the richness of individual and cultural differences. He recognized that the efforts made by men to improve their surroundings reflected their different desires and needs. The environmental movement, made up as it is of such disparate groups as those who protect wilderness and those who cultivate gardens, is proof of the correctness of his observation.

Today there are some 5,000 non-governmental organizations registered with the Environmental Liaison Center in Nairobi - each with its own concern. The major reason for their identification with "the environment" is that they had been overlooked by a development process being led by other interest groups that were often more powerful economically and politically. The blossoming of the movement came when a critical mass of the "overlooked" was reached in the 1960s. This led to the 1972 Stockholm Conference on the Human Environment, where the problems of the developed countries were discussed as being "environmental" and those of the Third World as being "developmental." However, the concerns of the countries of the Third World were similarly "environmental," for "environmental concerns" are always the sectoral interests of individuals, groups and societies which may or may not coincide with those of other individuals, groups and societies who share those same environments.

As a consequence of these observations, two sets of questions arise that only the development sectors can answer. The first is akin to the questions of traditional economics: "What resources of environments do development sectors manipulate to improve quality of life?," "How are they to be manipulated?" and "Who should decide?"

The second set of questions - "How should the development sectors respond to the holistic nature of environments?" and "How can a specific development effort avoid interfering with the development efforts of other sectors or interest groups?" - also requires an answer. A positive response to these questions is "environmental management" - the subject of the next chapter.

Methods of the study

The area used as the case study was the Central Selva of Peru (Map 1) and there are several reasons why this region makes an appropriate study area:

- the concerns of the Government of Peru to integrate fully its extensive territories in the humid tropics into the life and economy of the rest of the country; to pay attention to the needs of native peoples only recently being subjected to the rapid change and pace of the 20th Century; and to undertake development efforts that respect the dangers inherent in substantially altering complex ecosystems whose structure and function are largely unknown;

- the long history of both successful and unsuccessful settlement efforts in the area (Nelson, 1973; Martínez, 1981) and reconnaissance level natural resource investigations (ONERN, 1981; 1982), which offer a wide range of material for evaluation; and,

- the substantial amount of information made available through the work of the World Bank, the Inter-American Development Bank, USAID and other bilateral aid agencies in the area under the coordination of the Central Selva Special Projects Office.

Although the Central Selva was to "represent" all the humid tropics, the authors are under no illusion that the humid tropics can be adequately represented by any one sample; efforts were made simply to place the study area in the overall context of the humid tropics. The work of the authors was to describe the nature of the interest of each sector; identify the components and processes of the Central Selva ecosystems which were of interest to that sector and to identify any natural hazards that could restrict potential development activities; identify which activities of other sectors were related in both positive and negative ways to the activities of their sector; discuss these relationships with specialists representing other sectors and, together, arrive at solutions to any conflicts and discuss any aspects of interactions which may be mutually supportive. Based on these discussions the authors were to provide guidelines, recommendations or observations relative to planning the use of the American humid tropics.

MAP 1-1 - PERU - LOCATION OF CENTRAL SELVA

Throughout the study, use of a common vocabulary was encouraged. One product is the glossary presented at the end of this report. In addition, a number of words, phrases and/or concepts felt to be inadequate or problematic in discussions of environment and development were prohibited. For example "environmental" could not be used except in the term "environmental management" or where it was accompanied by a description of a specific environment. As a consequence, phrases such as "environmental considerations," "environmental deterioration," "environmental effects," "environmental costs," "environmental impacts" and "environmental preservation" are only used where the characteristics being deteriorated, affected, impacted or preserved are identified as belonging to a specific sector or interest group. Likewise, the word "ecology" is used only in agreement with its definition - essentially the study of relationships. Such phrases as "ecologic equilibrium," "ecologic preservation," "ecologic management" and "ecologic aptitude" are not used; nor is the word "ecology" used to replace the words "environment" or "ecosystem." "Delicate" and "fragile" are not allowed in describing ecosystems because more often than not their common usage is to justify the position of a sector or interest group and say little of value about ecosystem structure and function. Thus, communication was based on efforts to be specific in discussion and to limit the use of words that attempt to indicate intellectual and/or ethical superiority of one sector over another.

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Chapter 2 - Concepts of environmental management

Underlying the meaning and ultimate effect of this study are two unarguable premises: development in its social, economic and cultural dimensions is the process of improving human life quality; and the process of development involves manipulation of the complex, interrelated natural and man-made components and processes of human environments. In this chapter we shall develop concepts based on these premises, which will lead to an understandable and workable definition of "environmentally sound development"; we will do this by an examination of the terms: "human quality of life"; "human environments"; "systems goods, services and hazards"; and, "environmental management."

Human quality of life

Quality of life discussions have usually centered on the subject of "basic human needs" (Streeton and Burki, 1978; McHale and McHale, 1977) and the moral choices to be made among those needs in development activities (Goulet, 1971).

Human life quality depends on the physical and psychological health or welfare of an individual or a society. Health and welfare in turn, depend on the degree to which a person's or a society's respective environments satisfy their needs.

Needs vary substantially by culture, age, sex, season, climate, education and income. Some must be satisfied before others are felt. It is often difficult to distinguish between "needs" and "wants" and lack of information and understanding often undo efforts to improve one's quality of life. If the allotment of resources required to satisfy any of their perceived needs is not sufficient or, though sufficient is placed in jeopardy, that society will believe that its quality of life is threatened and will fight to save or restore it.

Human environment

The Encyclopedia of Environmental Sciences defines Environment as "the aggregate of all external conditions and influences affecting life and development of an organism" (Platt, 1971) but a definition of the "human environment" must go further. A human environment is more than external, for internal and external are relative concepts and an individual is a significant component of his own environment. This study therefore regards the human environment as *"the aggregate of all conditions and influences affecting the behaviour and development of humans as individuals and as societies"*. "Conditions and influences" vary over time and space and, though often shared, are perceived and experienced differently by each individual or society (Saarinen, 1969).

Each environment is a system which overlaps, influences, and is influenced by other systems. They resemble ecosystems (or are at least significant parts of ecosystems) in that they are units of space where biotic and physical components and processes interact to develop patterns of energy and material flow and cycling. In human environments these components and processes - called structure and function by scientists (Odum, 1962) - are not restricted to those that are from "nature." Indeed, they include those that are social, economic and political (Smith, 1972) or cultural (Boyden, 1976). By extension, they include machines, institutions, language, and art, as well as nutrient cycling, photosynthesis, respiration and food chains, since all are conduits for the flow and storage of energy (Odum and Odum, 1976).

A reductionist approach to environmental complexity, though useful in a great many ways, cannot resolve environment/development conflicts. We do participate in a world where everything is related to everything else. Though some of the components and processes involved are more important than others, there is no easy way for any one person or interest group to decide for the others which are the important ones (Dasgupta, 1976).

Thus, considering the many levels of organization, our world is made up of a large number of environments - not one. One of those environments, of course, is the "biosphere," but that is only *one more* environment and not the environment. The global environment is important. However, there are countless other environments that are just as problematic, more easily understood, and treatable and very much nearer at hand than the global environment. Because there are numerous environments, the phrase "protect the environment" is not a useful term unless we know whose environment is to be protected.

The question "whose environment" is always relevant. Because sectoral activities use, improve, or conserve what comes to us from an environment, decisions based on these sectoral interests are the cause of what have been called "environmental problems." These problems are created by efforts to improve quality of life in one environment at the expense of reduced quality of life in another. "The environment," therefore, is not a special set of unique interests to be treated separately from "development."

Natural resources and the concept of goods, services and hazards

Nature is the original patrimony of humanity and is the source of goods and services as well as of the space in which society develops and evolves.

The concept of goods, services and hazards opens and extends the concept of natural resources and links the concepts of environmental quality and life quality, since a quality environment is one that provides the necessary goods and services to satisfy life quality needs and which mitigates the severity of an encounter with a hazardous event.[1]

> [1]. *Environmental quality in some writings refers to "ambient environmental quality" i.e. the "state of air, water, land, and human artifacts"* (*Hufschmidt et al*, 1983, p.2). However, as used here, it is the relative capability of an environment to satisfy the needs and wants of an individual or society.

When the natural characteristics of ecosystem structure and function are of interest to any one, they are classified as natural goods and services. Natural goods are generally equivalent to natural resources except that they have been further defined and identified by specific sectors as being useful for development. Thus, within the natural resource "forest," the natural goods may be woody fiber for lumber, pulpwood, or posts; medicinal plants; edible fruits, and chemical substances among others. Natural services are derived from the natural characteristics of ecosystem structure and function and include the flow of energy and materials; nutrient storage, distribution and cycling; provision of wildlife habitat; germplasm storage and evolution; biomass production; and flood control.

The term "goods and services" historically carries an economic connotation. Economic goods and services are, of course, the results of labour and the expenditure of capital to refine and convert natural resources to useful products, and to design and provide activities of public utility such as health, security, communication and goverment services.

Several years ago, the concept of "natural goods and services" was introduced. These have been defined as those goods and services that are provided by natural environments (Gosselink *et al*, 1973; Ehrenfeld, 1976; Lugo and Brinson, 1979) and, in economic literature, include, but are not confined to, "amenity resources."

In many ways, no *fundamental* distinction can be made between natural and economic goods and services. Both types are derived from the structure and processes of ecosystems. Both types support human life quality. Individual examples of each kind have value dependent upon their utility and scarcity. Price and market participation do not make a difference despite the fact that early efforts to place a market price on natural systems - and the goods and services they provide - met with stiff resistance on the part of some economists (Shabman and Batie, 1978). There is now little, if any, debate as to whether natural goods and services have value nor whether the concept fits economic theory.

Indeed, the major difference between them seems to be that economic goods and services have been thoroughly discussed and studied while natural goods and services have not. To correct this inequity, today economists are beginning to grapple with ways to place a value on non-priced natural goods and services (Krutilla and Fisher, 1975; Hufschmidt *et al*, 1983).[2] Those which remain non-priced but no less valuable will have their identifiable constituencies who will demand due process in development planning in much the same way as the value of work in the household and the real worth of protection by police and firemen are receiving increasing attention because housewives and police officers demand it.

> [2]. *It is not the purpose of this study to provide methods of economic valuation. Rather it is to help lay an acceptable conceptual foundation for "environmentally sound development." Analysis of the market pricing system and other methods of economic analysis are and will continue to be, formidable tools in development planning and decision making. Our purpose*

> *here is to define where and in what context those decisions will have to be made. As we will see in the following sections, that context is often one of competing and reinforcing sectoral activities.*

Natural goods and services have a value according to the following categories:

1. They may have economic, social or cultural value and are therefore considered to be important to current development activities. The economic elements (those that are priced and participate in the monetary market) are well understood. The barter system is less understood but no less important in many development contexts - particularly in frontier areas such as the Central Selva. Though not necessarily quantifiable, the social and cultural components can also be valuable in other ways. Human culture and life styles contribute to the diversity and richness of a population. Both recent immigrants and native peoples use an area's natural goods and services as food, folk remedies, instruments in religious ceremonies, and to provide historical perspective. Though not ordinarily considered in development planning, the social and cultural components may carry an importance far beyond anything known by an outsider.

2. They may have a scientific value and are therefore of importance to future development. Natural goods and services of this type are of interest to those who search for new technologies and new information for development purposes. Much of the effort to protect endangered species, representative ecosystems, germplasm reserves, and wildlands for research and monitoring fall into this category.

3. They may control ecosystem functioning and are therefore important to a sustainable flow of a good or service. Thus, activities which lead to the conservation, protection and use of those natural goods and services required to maintain ecosystem atributes of value are also important development activities. Included are the natural goods and services of erosion and flood control, climate regulation, and chemical buffering. Their conservation or protection are legitimate and valuable *development* activities.

In addition to providing natural goods and services, human environments also present a gamut of natural hazards which have a great influence on how successful development efforts may be. These phenomena are also the result of ecosystem structure and function. Earthquakes and hurricanes are a part of energy and material flow in the global ecosystem. Though they are hazards to development they may be responsible for a significant number of natural goods and services. For example, hurricanes which distribute large amounts of energy built up in tropical latitudes to the temperate latitudes are also responsible for the survival of valuable mangrove systems (Lugo, 1978); natural flooding and ocean currents are responsible for massive flows and cycling of nutrients (Hartline, 1980); lightning fixes unusable nitrogen to useful forms; bees sting but they have a value beyond calculation in the pollination of flowering plants and in food production for human beings (Pimentel *et al*, 1980).

Indeed, *the process of development is made up of those activities that lead to the use, improvement, or conservation of goods and services in order to maintain and improve life quality*. "Negative environmental impact," on the other hand, is the opposite of development. That is, it is *the destruction, impoverishment, misuse or non-use of goods and services whether the result of human activity or of natural hazardous events.*

Environmental management

The objective of environmental management is improved human life quality. It involves the mobilization of resources and the use of government to administer the use of both natural and economic goods and services. It is based on the principles of ecology. It uses systems analysis and conflict resolution to distribute the costs and benefits of development activities throughout the affected populations and seeks to protect the activities of development from natural hazards. Conflict identification is one of the more important tasks in environmental management planning and the resolution of conflicts is a fundamental part of what makes up "environmentally sound development."

In the complex and interdependent world that we have been given, environmental management is required because the activities of development in one sector affect in both positive and negative ways the quality of life in others. Indeed, if one asks of any "environmental impact" the questions "who caused it?" and "who felt it?," sector/sector relationships are identified. For example, a hydroelectric dam which reduces nutrient levels in the water and thus destroys downstream fisheries is sector 410 causing problems for sector 130 of the UN List of Economic Activities (UN, 1969). By the same token, cutting down trees to produce grazing land for cattle may cause sedimentation in a reservoir, and is a problem between sectors 111 and 420. And, if a hotel sends its wastes out to sea only to have them return to its beaches, a conflict is caused within sector 632. It needs to be said in addition that such "problems" are, in reality, conflicts between two activities. That is to say, the problem is not only caused by promoting ranching over fisheries since a decision in favor of fisheries will cause a problem for ranching as well. It is the *conflict* that requires solution.

Such a concept of "environmental impact" may be seen to have left out "the environment;" a very large black box exists between cause and effect if one is only interested in those sectoral activities which cause a problem and those which receive the problem. There are two basic reasons, however, why this is not a major concern here. First, the guidelines to be produced are guidelines for planning development at the earliest possible stage of the process. Time, funding, and expertise at this level do not allow in-depth study of that black box. Second, the guidelines are for planners in the humid tropics - a biome known for its lack of available information. That is, the black box covering the humid tropics is a very large one and efforts to reduce its size in any significant way - though certainly necessary and welcomed by planners - should not be undertaken by planners. The needs of development planning should help orient research in information-scarce areas. But, in the context of specific development planning projects, neither science nor planning will be advanced much by expenditures of large amounts of planning time and funds for research.

Conflicts between natural hazards and development activities also exist and result from a confrontation between hazardous natural events and human activity. So-called "natural disasters" occur because we have not paid sufficient attention to natural hazardous phenomena. Indeed, the term "natural disaster" is misleading for this reason: it places the blame on nature when, in fact, the blame belongs to those who decided that projects be implemented under circumstances that jeopardize the very objectives that the development activities were designed to meet.

The techniques of conflict resolution are well known and are comparatively successful given man's continued existence on earth for several thousands of years under very complex conditions. If they had not worked there would be no life as we know it today. Conflicts make up the matrix in which we live; it is a world of uncertainties compounded by a shortage of technical information, a large variety of values, interests and judgements, and overlapping environments.

Most writers on the subject of conflict resolution, however, say that conflict can be positive as well as negative (Boulding and Kahn, 1962; Coser, 1956; Deutsch, 1973). For example, conflict tends to maintain valid group boundaries and needed group structure and provides incentives for the formation of alliances to combat an exploitive elite.

Planning, especially intersectoral planning, has a tremendous advantage over efforts in real life to resolve conflicts because, in many ways, planning is a game; and, to play the game one must cooperate. Within this context, individuals on a planning team have a shared commitment to rules and procedures which can be controlled. The various parties (sector specialists) operate with a similar rationale, can be easily encouraged to focus on criteria rather than on positions and, each can insist that evaluation criteria be objective. The result is an opportunity to invent options for conflict resolution that provide for mutual gain.

Many activities designed to use, improve, conserve, and protect goods and services for development purposes support other development activities. Development projects requiring the conservation of ecosystems for purposes of wildlife management also conserve the soil stabilization function of vegetation and, as a result, downstream reservoirs receive less sediment. Development policies that restrict construction in areas of natural flooding create recreation possibilities and green space near urban areas and lessen dependence on expensive flood control structures. Enlightened systems engineering turns industrial wastes into residuals that provide raw material for other development projects (Bower, 1977).

Environmentally sound development

Discussions that treat environment and development revolve around the point of "environmentally sound development." Despite this, the term has seldom been defined and it is left to the reader to gather from the discussion just what it might be. In large part, such discussions seem to suggest that development is "environmentally sound" if it is "sustainable," if it does not "disturb the ecological balance," if it "causes no environmental degradation," if it does not "surpass the carrying capacity of the natural system," and if it "avoids the loss of long term natural productivity." Even the most cursory analysis, however, will show that such criteria are untenable; no development project - including conservation - can meet all of these restrictions.

First, there is a problem of meeting the objectives of development. Development objectives that do not treat life quality - even if "environmentally sound" - make no sense because no one will benefit. Second, there is a problem of level of aggregation. Which natural system are we talking about? The construction of any man-made structure will disturb, even erase, natural systems at a certain level. Third is a question of decision. Is long-term natural productivity essential when a choice must be made between wood fiber and protein? Fourth, there is a question of adequacy. Is the carrying capacity of a natural system relevant when it can be significantly increased through the application of even the simplest technology? Fifth, there are problems of clarity and specificity. Environmental "degradation" and "ecological balance" mean different things to different people. Is a project "environmentally sound," for example if "balance" is maintained but a species is lost, or added, because of that project?

To evade such problems this study has defined "environmentally sound development" as a process having the improvement of human life quality as its objective. It is a process of active manipulation of ecosystem structure and function in order to appropriate the goods and services offered by the ecosystem in question. It minimizes the conflict inherent in the appropriation of those goods and services, it maximizes mutual support between the required activities and distributes their costs and benefits throughout the affected populations. The chapters which follow are based on this understanding of environmentally sound development.

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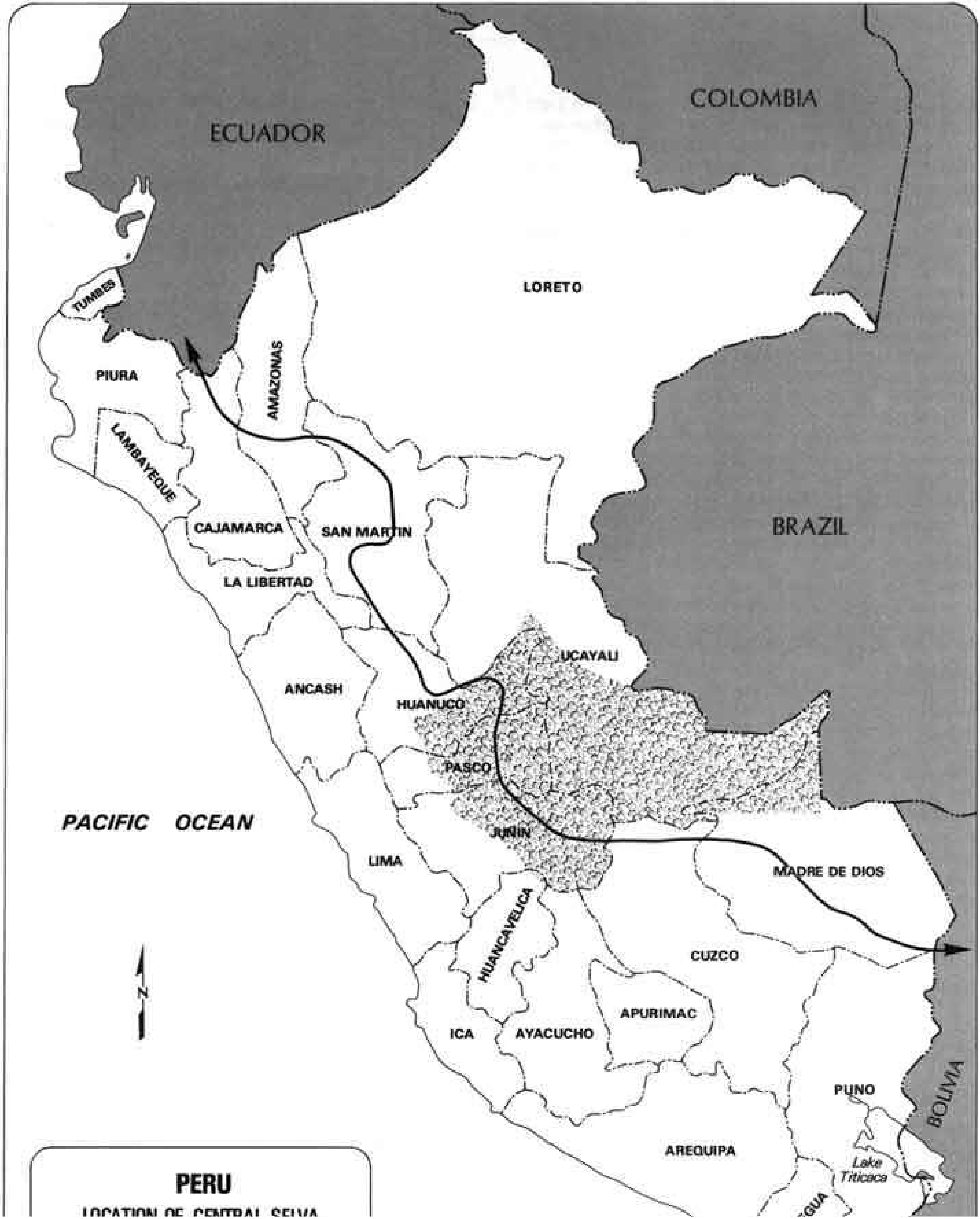
COLOMBIA
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PACIFIC OCEAN
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LIMA
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HUANCAVELICA
CUZCO
N
APURIMAC
ICA
AYACUCHO
BOLIVIA
PUNO
AREQUIPA
Lake Titicaca
PERU
LOCATION OF CENTRAL SELVA


LOCATION OF CENTRAL SELVA
Marginal highway
TACNA
CHILE

Chapter 3 - Legal, governmental, and institutional authority in the Central Selva of Peru

Peru's 1979 Constitution establishes that both renewable and non-renewable natural resources are national patrimony. The law further states that everyone has both the right to live in a healthy environment suitable for a fulfilling life, and the corresponding obligation to "conserve the environment." It also specifies that the State evaluate and preserve natural resources and encourage their wise management while controlling environmental contamination, and to this end, the law sets forth regulations governing natural resource and energy resource use by both the public and private sectors.

This chapter will describe Peru's natural resource legislation and the government bodies which administer it. Focusing on the Central Selva, it will demonstrate how laws and institutions often inhabit territories of poorly defined authority, thus retarding the goals of "minimum conflict" among the users and caretakers of the rain forest. Using the Pichis-Palcazu "Special Project" as an example of intra-governmental cooperation, it will suggest ways that such problems can be overcome.

Principal natural resource legislation

The General Water Law states that all water in Peru is State property, the use of which must be in the social interest and serve the country's development. The State formulates policy governing its use and preservation. Thus the executive branch regulates water use and can reserve waters; organize development of a region, watershed, or valley; declare protected areas and states of emergency; transfer water from one watershed to another; and substitute supply sources. The Ministry of Agriculture has primary jurisdiction over waters, except for medicinal mineral waters which are administered by the Ministry of Health. The Superior Water Council considers intersectoral affairs and preferences for water use.

Government policy under this law emphasizes preservation and encourages integrated watershed and irrigation district development plans to prevent deterioration and loss of water, flora, fauna, and soil. Water use easements may be used for construction and operation of hydraulic works and for shoreline and riverbank protection and natural resource conservation. Priorities for water use, after every citizen's basic entitlement for drinking and cooking has been met, are livestock, agriculture, energy, and industry.

The Forest and Wildlife Law declares that forest resources are in the public domain. All flora and fauna except for aquatic species are covered by the law, which further states that forest lands may not be used for agriculture and livestock production.

Forests are classified as natural or cultivated. Two natural forest management categories are included: national forests, and forests of free access. Both types are declared suitable for permanent production of wood, other forest products, and wildlife; national forests can only be exploited for industrial and commercial purposes by the State. Forests of free access can be used by any authorized person.

Natural protected forests are established to conserve soil and water. Four different conservation categories include the following: *National Parks* for the protection of natural associations of flora and wildlife and attractive landscapes; *National Reserves* to protect and propagate wildlife of national interest; *National Sanctuaries* for protection of plant and animal species' communities, as well as natural formations of scientific and aesthetic interest; and *Historic Sanctuaries* to preserve the natural settings of significant historical events. The law also authorizes *Communal Reserves* to conserve wildlife that serve as traditional human food sources and *Game Preserves* for sport hunting.

Under the *General Fishery Law* the State is responsible for administering marine resources and continental water resources, particularly with regard to industrial fishing. This law has given rise to several regulations that touch on fishing seasons and restrictions in the Selva and throughout the country. In applying this law the authorities have focused on harvesting, paying little or no attention to conservation.

The Agrarian Reform Law has attempted to transform the agrarian structure into a system of more equal property distribution, guaranteeing rural social justice. It considers a rural settlement to be a group of farmers organized into an agriculture unit, and prohibits the partition of rural land holdings into parcels smaller than the size of a family farm unit. Agrarian law adjudicates land to the communities under the condition that it cannot be transferred to the public domain except when it is incorporated into cooperatives or agricultural societies of social interest. The community recovers the ownership of abandoned parcels and of parcels not being directly exploited by community members, subject to payment for necessary land improvements.

Also administered under this law is uncultivated or unproductive "wasteland" which can be awarded as concessions, rented, or sold for irrigation and other purposes that coincide with development and zoning plans. Lands not considered wastelands include terrain being planted in trees, hillsides planted for grazing, urban lands, and lands put to household and industrial use.

Native tribes and rural populations in the Selva and Ceja de Selva (Mountainous or high jungle area) are the principal beneficiaries of the *Forest Agrarian Promotion and Native Communities Law of 1974,* which enabled approximately 900 communities made up of 56 ethnic groups in Peruvian Amazonia to own the lands they had historically occupied. Under the law the State guarantees the native communities ownership of property; draws up land ownership registries and awards property titles; and gives natives the right to exploit the forest production potential of their territory, as long as land use taws are obeyed.

Native communities located within national parks may remain without holding title to the land if park objectives are not violated. When the natives are sedentary, the areas where they are settled are considered theirs to use for agriculture, ranching, gathering, hunting, and fishing. Likewise, all of the land where seasonal migrations occur is considered native land, and additional land is adjudicated to native communities who need it.

Private lands located within communal areas conceded after the Constitution of January 18,1920 are to be incorporated into the native communities. If community members decide not to admit them, however, they will be compensated. National public agencies will give priority to native communities: for example, licenses granted for using areas adjacent to native community property are granted preferentially to natives, as are contracts for forest exploitation and reforestation.

The 1974 Law distinguishes the following land use categories: lands suitable for agriculture, lands suitable for livestock, and lands suitable for forestry. Legal rights of way for almost every purpose, bridges, roads, pipelines, telecommunication and power lines, and irrigation and drainage works can be established.

Farms smaller than 20 hectares cannot be divided legally for any purpose. Lots of 10 or more hectares that are not being used for agriculture or livestock can never be divided into parcels smaller than 10 hectares for agriculture and 200 hectares for livestock raising. The units are adjudicated according to the availability of land, the quality of resources, and the requirements of the areas' populations, although farmers who were settled no less than one year from the date of the present law's implementation have first preference to obtain the land they were working. National parks, national reserves, national and historical sanctuaries, national and protected forests, and areas needed for the extraction of metals and hydrocarbons may not be adjudicated.

Rural Settlement Projects are multisectoral efforts established by the 1974 Law designed to establish or consolidate populations. Agriculture and livestock lands in rural settlement projects are adjudicated in favor of native communities, peasant communities, agrarian cooperatives, agricultural social interest societies, worker-owned corporations, and qualified individuals. Plots suitable for cultivation up to 150 hectares and lands suitable for livestock up to 300 hectares are adjudicated to natural persons in rural settlement projects. Lands suitable for cultivation and lands suitable for agriculture up to 6,000 hectares in low-priority areas in rural settlement projects are adjudicated in favor of cooperatives. When plots larger than 500 hectares are requested for livestock activity, their exploitation and investment plans must be approved by the Ministry of Agriculture.

All agriculture and livestock lands under this law should maintain the original forest cover on 15 and 30 percent of their area, respectively. Riverbanks, ravines, and steep slopes are to be left in plant cover. Wood from forest clearing must be used. Land owners have the first opportunity to harvest wood found on their parcels.

The Agrarian Promotion and Development Law of 1978 was to increase agrarian productivity, promote expanded agrarian activity, encourage employment opportunities, promote the construction of agroindustrial plants, improve rural commerce, strengthen research, support rural investment and economic expansion, and encourage the development of farmer organizations. Among the complementary dispositions are those that modify articles of the 1974 Native Communities Law. For example, in the Ceja de Selva and Selva regions, the Ministry of Agriculture can award land suitable for agriculture and livestock production. When deemed a national priority, national forests can be exploited for industrial and commercial purposes by corporations that are State-run or have State participation.

The General Industrial Law refers to the activities of manufacturers. The State is to promote construction and operation of industrial complexes in the Selva and other frontier zones, giving priority to cooperatives.

The General Mining Law establishes that all mineral resources, including geothermal ones, belong to the state. Its intent is to promote the exploitation of mineral and geothermal resources, protect small and medium-scale mining, and promote large-scale mining. Prospecting is free in most national territory, except where prior mining rights are established, in National Reserves, and where Special State Rights are in effect. Prospecting is also prohibited on public use property, fenced-off and cultivated land, and urban and future urban land. Under some circumstances owners of mining rights can solicit authorization to establish easements on third-party lands and can solicit the expropriation of property dedicated to other economic purposes.

International treaties with other countries are a State responsibility in accordance with Article 101 of the Peruvian Constitution. When a treaty and a law conflict, the treaty takes precedence. While many treaties regarding natural resources exist, Table 3-1 presents treaties relevant to resources of the Selva region.

Table 3-1
INTERNATIONAL Treaties [a]

- Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere (1940), ratified by Peru in November, 1946.
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), signed by Peru, December 30, 1974; approved by the Government through Decree Law 21080 and ratified June 18,1975.
- Accord for Floral and Faunal Conservation in the Amazon Territories of the Republic of Peru and the Federal Republic of Brazil, signed in Lima, November 7,1975.
- Accord for Floral and Faunal Conservation in the Amazon Territories of the Republic of Colombia and the Peruvian Republic, signed in Lima, March 30,1979.
(Both Accords have been signed by all Parties.)
- Treaty for Amazonian Cooperation, signed June 3,1978. In this treaty, signed by the countries of the Amazon Basin, basic rules are established for the integrated management of natural resources, relying on viable alternatives for managing binational and multinational projects, all taking into account the integral conservation of the watershed.

[a.] Concerning renewable resources in Peru.

Institutional authority

The *Research Institute of Peruvian Amazonia* is responsible for inventory, research, evaluation, and control of Amazonian resources. Although the agency has become severely limited over the years because of the rise of other institutions, it must be involved in any planning that looks toward institutional organization in Peruvian Amazonia.

Departmental Development Corporations

Departmental development corporations are decentralized public agencies responsible for encouraging rational exploitation of the natural resources of each department, preserving flora and fauna, and preventing pollution; promoting the processing of natural resources, rural development, agriculture, livestock production, agro-industry, mining, and fishing; promoting business, industries, and cooperatives in cooperation with municipalities; maintaining basic services and infrastructure not the responsibility of the municipalities or federal government; and encouraging recreation, tourism, and festivals.

Local Governments

Local governments correspond to municipalities, which can be Provincial or District Councils. Provincial and District Councils have economic and administrative autonomy to plan the development of their jurisdictions, vote on and approve their own budgets, regulate collective transportation and traffic; and organize, regulate, and administer local public services.

Regional Governments

A constitutional mandate delineates the regions and establishes their governing bodies. These will enjoy economic and administrative autonomy and consider matters of health, housing, public works, roads, agriculture, mining, industry, commerce, energy, and security.

Agriculture Sector Institutions

Ministry of Agriculture: The jurisdiction of the Ministry of Agriculture consists of lands suitable for agriculture, grazing, and forest production; "wastelands"; river beds, channels, and margins; waters of rivers, lakes, and aquifers; forest resources, flora and wildlife, the commerce of agricultural products and by-products, agrarian services and agricultural technical assistance. The ministry formulates and directs policy in the agrarian sector, and plans, implements, supervises, and evaluates the sector's regulations.

The federal government's work is conducted by the General Departments of the Ministry of Agriculture. These are: *Water, Soil, and Irrigation; Agriculture and Livestock*, which covers agricultural and livestock production, health inspection, registering and regulation;

Agro-industry and Commerce, which promotes activities related to the agricultural, livestock and food industries; *Forestry and Wildlife*, which works for the conservation and wise use of forest resources and wild flora and fauna, the processing and commerce of these products, and the classification of land according to its best use. *Agrarian Reform and Rural Settlement*, which manages the reorganization of the agrarian sector and supervises land use, tenancy, and ownership and guides the activities related to peasant and native communities.

The Agrarian Sector Organic Law has created four decentralized public agencies under federal government control:

The *National Institute for Agricultural Frontier Expansion* (INAF) extends agricultural activity through implementing irrigation projects and rehabilitating land, including land in the Selva and the Ceja de Selva; the *National Institute for Agriculture and Livestock Research and Promotion* (INIPA) carries out research, extension, and agricultural and livestock promotion and encourages rural marketing of agricultural and livestock products; the *National Forest and Wildlife Institute* (INFOR) carries out research, extension, and promotion of agroindustrial, forest, and wildlife products and it implements special projects concerning the conservation and wise use of forest and wildlife resources; and the *National Agro-Industry Development Institute* (INDA) carries out agroindustrial research and promotion.

Unfortunately, serious conflicts have arisen between the agencies in the Ministry of Agriculture (General Departments) and the decentralized public agencies (Institutes) making it necessary to reorganize these departments so that each agency has clear jurisdiction over its own area of activity.

Special Projects

In the last decade a number of autonomous decentralized public agencies called *Special Projects* have been established in Peru.[1] The political, economic and social importance of the special projects is found within the national and regional objectives of the Government for the Amazon region of Peru. These objectives are to:

> [1]. On June 28,1983, the Peruvian Government created the National Institute of Development (INADE) which is to manage and coordinate the activities of the Special Projects Offices.

> 1. increase production and productivity through widening the agriculture frontier and through the rational exploitation of the region's natural resources;
>
> 2. plan settlement in the territory which channels the migratory flows within the region as well as in the rest of the country by means of the "marginal highway";
>
> 3. increase the employment and income levels of the region; and
>
> 4. conserve the natural resources and maintain the ecosystems in the region.

Four large-scale special projects in the Selva Region are organized as technical-administrative units designed to assist integrated development. Their jurisdictions are the most important Selva valleys along the route of the Marginal Highway. Three are described briefly below; as promised, the fourth - the Pichis-Palcazu Special Project - will be examined in depth as a microcosm of the goods and evils of governmental authority in the Central Selva.

The Huallaga Central and Bajo Mayo Special Project covers the northern sector of the Peruvian Selva Alta Region. The total project area is 864,000 hectares with a population of 179,800, of which 59 percent is urban. Twenty-five percent of the population is economically active; 62 percent of these work in agriculture, silviculture, and hunting; 14 percent in the service sector, 5 percent in manufacturing, 4 percent in commerce, and 15 percent in other activities.

The main objectives of the project are to assure an adequate internal traffic of agricultural products and commerce with the coast and mountains, through the improvement and construction of local roads and the maintenance of principal roads; and to attempt a low-cost development model that could be repeated in other parts of the high forest area.

The Jaen-San Ignacio-Bagua Integral Development Project is located in the high forest of the northern part of the country. The total project area is 3,966,122 hectares, of which 746,000 hectares are estimated to be suitable for agriculture and livestock development, including 120,000 hectares already being exploited. Population of this area is estimated at 488,336 people. By expanding the amount of land under cultivation by 250,000 hectares, approximately 10,000 new families are to be settled in the region.

The project consists of a regional development plan and of integrated programs in two micro-regions. It is concerned with the expansion of agricultural land and the occupation of the country's frontier areas, and is expected to carry out research, improve road and energy infrastructure, and organize urban and rural settlements. The project will also incorporate productive frontier areas into the country's economy, integrate them into regional and national development, and organize present and future settlements in order to end spontaneous migration and natural resource degradation.

The Madre de Dios Integral Development Project encompasses the 7,840,300 hectares and 28,216 inhabitants of Madre de Dios Department. The general objectives of this project are to increase the amount of land under cultivation and manage forest resources, and to occupy "uninhabited" territory through the formulation and implementation of an integrated regional development plan and small regional programs.

Presently being developed are the Tahuamanu rural settlement, rubber tree cultivation, gold mining, petroleum extraction, and forest production. In addition, the project is supporting activities in Manu National Park.

The Pichis-Palcazu Special Project which operates entirely in the Central Selva is the primary focus of this case study. Two ministerial resolutions outline the area of the project. The first delineated the area of the project to be the lands drained by the Pichis, Palcazu, and Pachitea Rivers and served by the San Alejandro-Puerto Bermudez stretch of the Marginal Highway. The second increased the geographic area of the Pichis-Palcazu Special Project to include the Villa Rica, Oxapampa, Chontabamba, Huancabamba, and Pozuzo districts in Oxapampa Province; and a Supreme Decree incorporated 74,200 hectares within the Von Humboldt National Forest (Huanuco and Ucayali Departments). Consequently, the Pichis-Palcazu Special Project focuses on an area that includes the Marginal Highway axis (Map 1-1; Map 16-1).

The project objectives are to increase the amount of land under cultivation and thus increase national and regional production; improve living standards, employment, and income distribution; occupy national territory; conserve natural resources; preserve the rights of native communities and settled colonists; exploit forest resources with appropriate technology; provide basic necessities to the population; promote a civil order and preserve native ethno-cultural values; organize settlements appropriate to the valley; stimulate and control natural resource exploitation using appropriate technology; and organize public administration, coordinating sectors and governments. (Table 3-2 presents the laws and regulations affecting this project.)

Table 3-2
LAWS AND REGULATIONS PERTAINING TO THE CENTRAL SELVA PROJECT

The Selva Development and Native Community Law, DL 22175
The Regulation of the Native Community Law, DS 003-79-AA
The Forest and Wildlife Law, DL 21147
The Conservation Units Regulation, DS 160-77-AG
The Forest Product Harvesting and Processing Regulation, DS161-77-AG
The Flora and Fauna Conservation Regulation, DS 158-77-AG
The Agrarian Promotion and Development Law, DL 2
The Regulation of the Agrarian Promotion and Development Law, DS147-81-AG
The Selva Region Tax-free Zone Declaration Law, Law 15600
The Expansion of the Selva Region Tax-free Zone, DL 22179
The Agriculture Sector Organic Law, DL 021

DL = Law Decree
DS = Supreme Decree

The project's strategy to meet those objectives was to occupy "uninhabited" land. Thus, it developed regulations and began a land ownership survey and land titling effort. The strategy was implemented through the creation of centers of rural development (CDR), where a steady rapid population growth is expected until 1990, after which growth rates will practically stop in the Pichis and Palcazu valleys, and be moderate in the Pachitea valley (Table 3-3 presents the land area in the Pichis, Palcazu, and Pachitea valleys and indicates the amount of land to be settled by the year 2010).

The urban population of 50,000 inhabitants, 25 percent of the total, would be distributed accordingly:

First Order:	Ciudad Constitución	20,000 inhabitants
Second Order:	Puerto Bermúdez	8,000 inhabitants
	Puerto Inca	8,000 inhabitants
	Iscozacín	8,000 inhabitants
Third Order:	Six settlements, each with 1,000 inhabitants	6,000 inhabitants
	Total	50,000 inhabitants

The chief economic activities of the urban center include wood processing, meat and milk production, agro-industry, commerce, transportation, banking, public administration, secondary and technical education, health services, construction, lodging, and tourism. Other identified projects are access roads, resource evaluation, an ownership survey and land titling effort, production and population services, infrastructure development, and executive administration.

The organization of the Special Project includes an administrative unit which assists in technical matters and in designing and implementing programs; a Promotion Administrative unit that proposes projects and their implementation; Project and Public Works Administrative units; and Rural Development Centers and Subcenters. The project has five different subprojects, the sizes of which differ markedly, with each requiring different numbers and kinds of specialists, according to population densities, road networks, population distribution, and land use capability (Tables 3-4; 3-5.)

External funding sources were sought for each valley so that no overlap would occur. The Agency for International Development (AID) loaned US$18 million and donated US$4 million, which combined with national counterpart funds provided US$30 million for the Palcazu Valley. The Inter-American Development Bank (IDB) contributed US$22 million in special operating funds to the Pichis Valley Development Feasibility Study and US$24 million of ordinary capital. Peru invested US$40 million in national counterpart funds. A Von Humboldt National Forest development subproject will require financing for 74,000 hectares of land suited for forest production.

Other sources of funds include Canadian Forestry Development Credit, which donated $1.7 million (Canadian) for forest product harvesting, and the World Bank-FAO which may provide a loan of US$64 million to a Satipo-Chanchamayo development project. In 1982 the Federal Republic of Germany donated 1,045,000 marks for baseline studies that would permit the loan of an additional 20 million marks (10 million for rural development and 10 million for roads). Also in 1982, through an agreement with the Belgian Technical Cooperation, 70 million Belgian francs were obtained for agriculture, silviculture, and grazing projects in the Von Humboldt National Forest. It is contemplated that these funds will help establish a research center and a forestry training program in the Pachitea valley.

Economic activity of the Pichis-Palcazu Special Project will be based on rational and controlled forest exploitation, through integrated agriculture-silviculture-grazing systems. Whether the project emphasizes agriculture and livestock or forest production will depend on the soil and climate. Other rural activities will include processing and marketing, harvesting and production. The project will direct settlement of lands by providing infrastructure and services to pioneering settlements and by controlling land use. To this end, the project area has been divided into 20 micro-regions to help plan settlements and orient production appropriate to each micro-region's physiography, soil, accessibility, and climate. The area of each micro-region varies between 30,000 and 80,000 hectares.

Table 3-3
LANDS TO BE SETTLED BY THE YEAR 2010

	Pichis-Palcazu		Pachitea[a]		Total	
	(ha)	%	(ha)	%	(ha)	%
Total Potential Area	242,500[b]	100	356,200[c]	100	598,800	100
Area Presently Settled	112,000	46	50,000	15	162,000	27
Additional Area to Be Settled by Year 2010	130,500	54	187,500	52	318,000	53
Total Land to Be Settled by Year 2010	242,500	100	237,500	67	480,000	80

a. Includes the Pichis-Palcazu Special Project area in the Von Humboldt National Forest.
b. Forest Production Potential Study. National Agrarian University 1981.
c. Estimated population and rural density.

Table 3-4
PERSONNEL DISTRIBUTION IN THE PICHIS-PALCAZU SPECIAL PROJECT

Occupation of Professionals	Projects					
	Pachitea	Pichis	Palcazu	Satipo Chanchamayo	Oxapampa	Total
Foresters	8	2	1	6	3	20
Agronomists	1	8	8	15	8	40

Animal Scientists	1		2		2	5
Civil Engineers				1		1
Architects		1				1
Lawyers		2	1	2	2	7
Economists		2	1			3
Social Workers		1	2			3
Veterinarians					3	3
Accountants		2	1		1	4
Sociologists		3				3
Anthropologists		1		3		4
Administration						
personnel	4					4
Doctors		2	1			3
Biologists					2	2
Total Professionals	14	24	17	27	21	103

Table 3-5
SOIL SUITABILITY IN THE PICHIS, PALCAZU, AND PACHITEA VALLEYS

	Land Area	Area Studied	Suitability for Clean Cultivation		Suitability for Permanent Cultivation		Suitability for Grazing		Suitability for Forest Production		Protected Lands	
			ha	%	ha	%	ha	%	ha	%	ha	%
Pichis	894,750	280,026	6,121	2	29,118	10	18,053	7	112,060	40	114,674	41
Palcazu	418,750	189,206	7,200	4	13,653	7	12,671	7	43,796	23	11,886	59
Pachitea	385,000	356,268	112,862	32	22,216	6	118,652	33	102,358	29	-	-
Bosque Nacional Von Humboldt	76,400	76,400	-	-	13,112	17	-	-	58,663	77	4,625	6

Particular attention will be paid to semi-intensive dairy farming using indoor facilities, and to permanent and semi-permanent cultivation. Forest production will concentrate on rational exploitation of climax forests and their gradual incorporation into agricultural and livestock activities.

Special attention will also be paid to finding solutions for the socio-cultural problems affecting native communities. The Pachitea valley, the Codo de Pozuzo sector, and the Von Humboldt National Forest Sector are only sparsely populated in view of their potential for supporting human activity. These areas show particular promise for intensive and permanent cultivation and forest production.

The Pichis-Palcazu Special Project, with assistance from the Peruvian Agrarian Bank, will develop regulations for credit operations previously financed by IDB. In the Pichis valley the beneficiaries will be individual producers (land-owners and commune members) and native communities with legal title to the land. Private individuals and native communities will be eligible for individual loans to be used for agricultural, livestock, and forest production; harvesting, planting, rehabilitation and maintenance of permanent and semi-permanent crops; purchase of machinery, tools, and vehicles; acquisition of breeding stock and work animals; and working capital.

The project will consider important variables. Land will be classified according to its best use, and production will be based on technical criteria. Market studies will determine supply and demand for each product, enabling the project to recommend to colonists the most profitable products to cultivate. The project will give technical assistance and credit in materials to potential investors, with financial credit channeled through the Agrarian Bank. The project will construct storehouses, but will not participate directly in marketing the region's products. The project guarantees the construction of the roads described in the Road Plan to encourage commerce in the region, and it may assume the responsibility for transporting products in the first year. It will provide market and price information and promote private associations of the producers and industrialists who set commerce standards.

Urban development is another part of the Pichis-Palcazu Special Project. Constitución is planned to be the Central Selva's largest urban center along the Marginal Highway and the primary focal point for future industry and services. Constitución is expected to overcome such Amazonian problems as the precariousness and isolation of pioneering settlements, land tenancy conflicts, distance to markets and disorganized village growth. Development of this Center will include four steps projected to last 20 years. The first step, the project phase (3 years), is to begin with a pioneering settlement of 200 inhabitants along the road and will provide a school, medical center, airstrip, and river port on the Palcazu River, an agriculture experiment station, police station, and project administrative offices that will attend to the needs of the road workers and their families.

During the second phase (2 years) infrastructure sufficient for small commercial establishments will be provided to 1,700 inhabitants. In the third phase (5 years) the settlement will be reinforced by industrial and commercial activities that will focus on the region's production. At the end of this phase, it is estimated that 5,000 people will be occupying 200 hectares. During the last phase (10 years) the town's production, social, and administrative activities will be strengthened. At the end of this phase, a population of 20,000 people on 575 hectares is expected.

Enforcement problems

While the decentralized public agencies of the Special Projects represent law and governmental authority at their most efficient and successful, such is not the general state of affairs in the country. One reason for this is that Peru, like other Latin American countries, uses general laws and specific regulations relating to those laws. In several instances, laws have not been applied because regulations do not exist; in others they have not been applied and await regulations even though the laws are sufficiently specific to be enforced.

This legislative practice has given rise to an unhealthy proliferation of rules at various levels. In some cases, it becomes so extreme that one regulation requires additional interpretation and regulations, which of course complicates and obstructs the administration of laws originally intended to help citizens achieve their objectives.

Natural resource management is likewise adversely affected. It has to be recognized that the proliferation of regulations at all levels is not only the result of legal policy, but also the result of bureaucracies considering legislation to be an end in itself, not the means with which resource management and other activities can be carried out. This abundance of laws, regulations, and other measures is notorious for creating undesirable interference in accomplishing the objectives of natural resource management.

Peru has enormous mining potential, and the spirit and letter of the law consider it such a high priority that conflicts with other resource users and activities are often created. For example, mineral prospecting is not excluded in forest management areas nor does the law establish effective mechanisms for mine waste control. Pollution of water from mine waste is localized, but it seriously affects important human populations (La Oroya and Huancayo, among others),

Deficiencies in hydrocarbon legislation create significant conflicts between hydrocarbon extraction and the management of renewable natural resources. It is understandable that petroleum exploration and exploitation should receive major support, as with the exploration occurring in the Pacaya Samiria National Reserve in the Department of Loreto and approval of petroleum exploration in part of Manu National Park, even though it violates regulations treating this category of protected areas. However, while some restrictions have been included in petroleum exploration contracts, in practice these regulations are unenforceable because of chronic underfinancing for guards and inspectors.

According to current forest legislation, "protected inviolate," as applied to such protected areas as national parks and national sanctuaries, is defined as "maintaining flora, wildlife, landscapes, and geologic formations in their natural state." This concept, so clearly expressed in legal regulations, is too often capriciously interpreted by such conflicting sectors as mining and energy.

Another example of conflict caused by natural resource legislation is controversy concerning changes in land use. The Forest and Wildlife Law, of clear conservationist rather than preservationist orientation, and the Land Classification Regulation both restrict irresponsible and unjustified exploitation of protected and other forest lands. They establish, however, mechanisms by which these lands can be justifiably exploited. Nevertheless, institutional policies contradict these two laws. For example, although it is not officially accepted, the new agrarian promotion legislation encourages changes in land use. The current practice of credit institutions, specifically the Agrarian Bank, is to award loans to migrants who present "ownership certificates" despite the fact that they occupy lands unsuitable for agriculture and livestock in the Selva and Ceja de Selva. Conflicts are further aggravated by road construction that does not consider soil use capacity.

In many cases, applying national legislation to the Selva causes natural resources to deteriorate and social conflicts and economic problems to develop. Many legal and natural resource specialists realize this, but bureaucratic practice is difficult to change. Also, the centralist and "colonial" point of view is maintained in some legislation. For this reason, the applicability of national laws in Amazonia is being studied to determine when and how such regulations can be effective in local and regional conditions. The Peruvian Constitution of 1979 opens the possibility for the special treatment of natural resource management in Amazonia, saying "The State encourages development of Amazonia. It will consent to special endeavors when required" (Article 120). It is crucial that technicians and planners coordinate the legal measures to be applied in Amazonia that will gradually end contradictory practices.

Often legislation is interpreted differently by different sectors. A regulation may be clear and explicit, but jealous institutions distort it nonetheless. The Ministry of Agriculture and the Ministry of Fisheries have such differences, for example. The Forest and Wildlife Law considers all wildlife that "reproduce" on dry land to be under the jurisdiction of the Ministry of Agriculture. However, the Fisheries Ministry interprets this concept differently; consequently, the two ministries do not agree on which of them has jurisdiction over such animals as giant otters and river turtles. The Fisheries Ministry broadly interprets "reproduction" as referring to more than the actual location where birth takes place and eggs are laid. Thus, when considering these animals, both ministries apply different regulations which are almost always contradictory.

Implementing the Forest and Wildlife Law and the Industry Law has also led to long-standing conflicts. The harvester of forest products is constantly under pressure from local authorities representing these two ministries. The industrial sector believes that, even in rural areas, primary processing of forest products in sawmills falls under its administrative jurisdiction, while the Forest District believes it to be within the jurisdiction of the agrarian sector, a position that seems to be supported by strict interpretation of the legislation.

The Agrarian Development and Native Community Law of the Ceja de Selva and Selva (Decree Law 22175), although established to promote the welfare of Amazonia's first inhabitants, is little heeded by other legislation, so its influence is diminished. Measures are included in the law that discourage the natives from wisely using their natural resources and continuing ancestral sustained-yield land use practices.

Sometimes the state's administrative structure borders on anarchy. During the Agrarian Public Sector reorganization of April, 1981, which divided up the management of a significant portion of the Selva's living resources, a decentralized agency was created - the National Forest and Wildlife Institute (INFOR) - while the federal agency, the General Forest and Wildlife Department, was also maintained. Theoretically, according to the law, both agencies have well-defined responsibilities. INFOR is intended to focus on special activities (reforestation, extension, research) while the General Department is to provide technical advice to the ministry on policy and legal matters. In practice, however, the two agencies notoriously interfere with each other, which diminishes both their national and local effectiveness to an alarming extent. If this bothers users in Lima, it especially affects rural users. They do not care whether the government employee is called a forest, agriculture, or livestock specialist as long as he provides the assistance they require. But in the majority of cases, the proliferation of natural resource and "environmental" public agencies has not improved local infrastructure, since personnel are in insufficient supply and lack even the minimum necessary equipment. For example, Forest District personnel commonly are not able to meet one of their most important responsibilities, inspection and control, because they do not have adequate transportation.

The general public justifiably believes public administration to be overly bureaucratic. The large number of employees and the traditional centralization causes federal employees to be concentrated in Lima, while provincial offices are short of personnel and money to train them (throughout the country the only public servants that receive systematic academic training are the armed forces and the police).

Within two or three years the constitutional mandate for regionalization should be implemented. Regionalization should force agencies to work together to apply the concepts of deconcentration (delegation of resources) and decentralization (establishment of offices with sufficient personnel). At all costs, "regional centralization," in which everything is concentrated in regional capitals, needs to be avoided, or the same patterns will be repeated.

To avoid the problems of top-heavy bureacracies and the fragmentation of public development agencies affecting natural resources, and because of the interest in seeing a single project through from beginning to end, the Pichis-Palcazu Special Project was established in the Selva. Already it has benefited the region by complementing road construction with other aspects of rural development, and by generating produce for the large markets of Lima and Huancayo. This commerce affects agriculture, industry, administration, and urban development.

The program works well because it incorporates administrative autonomy in each of its five subprojects (described above). Each subproject can then develop an *ad-hoc* work program that emphasizes work based on each valley's special characteristics, including natural resources, land occupied, and production enterprises. Because the budgets are adjusted to the size of each valley and to financing sources, funds are used efficiently.

The objectives of the Pichis-Palcazu Special Project were established only after experts analyzed the area's potential and limitations. One primary objective is to "preserve environmental quality" which is understood by the project's planners and superior authorities to be management of natural resources on a sustained yield basis, and with minimal disruption of cycles. Specific project activities include the establishment of a network of protected natural areas, reforestation through natural and artificial means, and strengthening of national forest administration.

The project's objectives can be summarized in the term "integrated development." Integrated development is economically and socially justified by the limited availability of new lands suitable for agriculture, livestock and forest production. The project's proponents estimate that integrated development will shorten the investment maturation period, especially if the area's forest resources are exploited, because the immense photosynthetic capacity of these forests compensates for their soil fertility limitations.

Within the special project's strategy, the land was occupied through the Centers of Development (CD), which preceded the road's construction. These centers are intended to initiate organized integrated rural development and prevent chaotic growth. Thus, the project's implementation began with a land ownership survey and land title program, giving priority to native communities.

From its beginning, the project was coordinated with the Ministry of Agriculture, the Ministry of Health, the Ministry of Education and the National Planning Institute. It initiated special activities with the Forestry Center (CENFOR) and the Center of Agrarian Research and Promotion (CIPA), which are parts of the National Forestry and Wildlife Institute (INFOR) and of the National Agrarian Research and Promotion Institute (INIPA), respectively.

The project also worked from the beginning with the health and education sectors for the benefit of the local population. Since a priority concern of the project has been, is, and will be, to strengthen local public agencies, it has established cooperative agreements with each principal agency which will gradually be phased out until the agencies are self-sufficient, although a longer collaboration will allow the project to pay health worker salaries and construct and operate health centers for five years. It also has signed an agreement with the Ministry of Health to initiate the River Medical Service, which will more efficiently serve populations in marginal areas. The Project will also organize and encourage an effective Rural Medical Service, using foreign and national volunteers.

Resistance from public agencies to working with the special project has been minimal and early jealousy and skepticism rapidly disappeared. Cooperation among personnel has yielded effective political support from the highest State authorities and enthusiasm and competency from project workers, for it has produced well-defined and suitable programs. To overcome the chronic lack of trained personnel, the project and its coordinating agencies are to begin a training program in the areas of experimental design and analysis, tropical soil fertility and management, tropical cultivation systems, and grass improvement and management.

The Pichis-Palcazu project is oriented towards a major agriculture extension effort. Extension programs are indispensable to real agrarian development, but they have been neglected in Peru since the 1970s. Because universities no longer produce extension professionals, extensionists working today generally have not been adequately trained. The project, therefore, has recently signed an agreement with the INIPA to ensure that extension training would be a priority from the beginning.

When analyzing the project's activities, some experts question the absence of a marketing effort in any of the project's phases. To this, the project's authorities respond that the project is essentially a catalyzing agent, trying to strengthen production without neglecting the influence of trade on the well-being of rural populations. Today the marketing issues are under reevaluation.

Daily practice has shown that the project needs to support a clear credit policy. To encourage this, it has agreed with the Peruvian Agrarian Bank (BAP) to provide credit of varying duration to benefit at least 25 percent of rural producers. Now in effect in the Pichis and Palcazu valleys, it will soon reach the Satipo and Chanchamayo Valleys. And together with the Peruvian Industrial Bank, the project is developing a Canadian line of credit totalling 20 million Canadian dollars. Some of these monies will be directed at forest product harvest and processing in the Pichis, Palcazu, and Pachitea valleys, and will go to the 100 hectare household forest plots and to forest production units of up to 5000 hectares in size.

Specific short-term solutions to specific short-term problems, then, have characterized the relative success of the Pichis-Palcazu Special Project. By attempting to meet its immediate goals in a timely fashion, it has laid the groundwork for steady progress towards resolution of the long-term conflicts and needs of the myriad of interests represented in the Central Selva in particular, and in the American Humid Tropics as a whole.

Chapter 4 - Major ecosystems of the American humid tropics with emphasis on the Central Selva of Peru

Classification of the American humid tropics

The green mantle which covers the majority of the American humid tropics hides an impressive diversity of habitats. The Central of Peru alone contains 11 different life zones (Table 4-1) with six additional transitional life zones (ONERN, 1976). This variety is, in large part, the result of mountainous topography. Because tropical humid conditions exist from sea level to 3,800 meters or more, this diversity is also found in Bolivia, Ecuador, Colombia, Venezuela, Panama, and Central America. Relatively minor mountain ranges and flooding in low lying areas also contribute to the mix.

The annual mean temperature in the lowland humid tropics exceeds 24° C and the precipitation equals or exceeds the return to the atmosphere of evaporated and transpired water. Annual precipitation is greater than 1500 mm, with no more than two dry months, and no frosts occur (NRC, 1982).

The Holdridge (1967) method of classifying natural life zones provides useful information for regional development planning. Table 4-2 illustrates how the Holdridge system corresponds with the Brack (1976) system regarding the Peruvian Central Selva. The latter system corresponds closely with the biogeographical classification of Udvardy (1975) as well as that of Cabrera and Willink (1973) (Table 4-3).

Provinces lying within the American humid tropics contain some 898 million hectares, of which the most important are the Amazonian (28.5%), the Paranan or Brazilian Rain Forest (20.7%), the Madeiran (18.4%), the Guyanan (9.5%) and the Yungas (7.0%). These five provinces contain more than 84 percent of the American humid tropics. The Peruvian Central Selva lies chiefly within the Yungas province, and to a lesser degree, in the Amazonian.

Yungas Province

In the Peruvian Central Selva the Yungas Province lies between 3,500 and 3,800 meters above sea level, where annual rainfall averages 2,000-4,000 mm but varies from a minimum of 800 to a maximum of approximately 6000 mm. Mean temperature ranges from 7-11 ° C in the coldest and highest zones to 19-26° C in the hottest and lowest areas (Tables 4-1 and 4-2).

Table 4-1
NATURAL LIFE ZONES IN THE PERUVIAN CENTRAL SELVA AND THEIR PRINCIPAL CHARACTERISTICS

	Life Zone	Altitude Range m	Mean Annual Precipitation mm	Temperature Range °C	Potential Evapotranspiration Ratios
TM-wf	Tropical montane wet forest	2800-3800	838-1722	7-11	0.25 - 0.5
TM-rf	Tropical montane rain forest	2500-3800	2000-3800	6-12	0.25 - 0.25
TLM-wf	Tropical lower montane wet forest	1900-3200	2000-4000	12-17	0.25 - 0.5
TLM-mf	Tropical lower montane moist forest	1800-3000	791-1972	13-18	0.5 - 1
TLM-rf	Tropical lower montane rain forest	1600-2600	3915	12-17	0.125 - 0.25
TP-rf	Tropical premontane rain forest	600-2000	5660	24	0.125 - 0.25
TP-wf	Tropical premontane wet forest	600-2000	2193-4376	19-26	0.25 - 0.5
TP-mf	Tropical premontane moist forest	500-2000	936-1968	17-25	0.5 - 1
T-df	Tropical dry forest	300-850	1020-1391	24-25	1,0 - 2
T-wf	Tropical wet forest	200-500	4000-8000	24	0.25 - 0.5
T-mf	Tropical moist forest	350	1916-3420	23-26	0.5 - 1

***Source*: ONERN (1976).**

Table 4-2
CORRESPONDENCE BETWEEN HOLDRIDGE LIFE ZONES AND THE BRACK CLASSIFICATION OF DISTRICTS AND PROVINCES IN THE PERUVIAN CENTRAL SELVA

	Holdridge System	Brack System	
		Districts	Provinces
TM-wf	Tropical montane wet forest	Elfin Forest	
TM-rf	Tropical montane rain forest		
TLM-wf	Tropical lower montane wet forest	Cloud Forest	
TLM-mf	Tropical lower montane moist forest		Yungas
TLM-rf	Tropical lower montane rain forest		
TP-rf	Tropical premontane rain forest	High Jungle	
TP-wf	Tropical premontane wet forest		
TP-mf	Tropical premontane moist forest		
T-df	Tropical dry forest		
T-wf	Tropical wet forest		Amazonian
T-mf	Tropical moist forest		

Source: ONERN (1976) and Brack (1976).

Table 4-3
BIOGEOGRAPHIC PROVINCES IN THE AMERICAN HUMID TROPICS

Cabrera and Willink	Udvardy	Area (000 km^2)	%
Amazonian	Amazonian	2,542	28.5
	Madeiran	1,646	18.4
Pacific	Yucatan	52	0.6
	Campeche	263	2.9
	Guerreran	170	1.9
	Central America	321	3.6
	Panama	68	0.8
	Colombian Coast	180	2.0
Yungas	Yungas	621	7.0
	Colombian Montane	154	1.7
Paranan	Brazilian Rain Forest	1,852	20.7
Atlantic	Sierra del Mar	216	2.4

Guyanan	Guyanan	849	9.5
Total	8,934	100.0	

Source: Cabrera and Willink (1973) and Udvardy (1975).

Elfin Forest District (*Monte Chico*)

The Elfin Forest district is found between 3,500-3,800 meters and 2,500-2,800 meters above sea level. This district corresponds to the Tropical Montane Wet Forest and the Tropical Montane Rain Forest of Holdridge (Table 4-2), Annual mean precipitation varies between 840 and 1,720 mm in the wet forest and between 2,000-4,000 mm in the rain forest. Low mean temperatures (only 7-12° C) and foggy conditions frequently occur.

This district is characterized by irregular relief, with slopes of over 60 percent in its higher regions adjacent to the Puna Province, with steep hillsides of more than 75 percent at lower elevations. Soils are relatively deep at the highest altitudes and very thin in the Tropical Montane Rain Forest life zone. Higher soils are slightly acid, of medium and heavy texture, and are classified as phaeozems or luvisols. Dystric and eutric cambisols also exist. At lower altitudes, lithosols predominate, but transitional forms approaching cambisols also occur.

At the highest altitudes, the vegetation is mostly scrub, with isolated trees that scarcely reach 3 to 5 meters in height. Several genera, such as *Berberis, Ribes, Baccharis, Gynoxys, Vaccinium,* and *Polylepis,* but *Buddteia, Escallonia,* and *Oreopanax* which have their origin in the Puna are also found here, along with species peculiar to the zone, such as those belonging to the genera *Podocarpus, Eugenia, Clusia, Brunellia*, *Rapanea*, *Ocotea*, *Myrcia*, *Laplacea*, *Solanum*, *Weinmannia*, *Pipper*, *Cinchona*, *Clethra*, and *Cecropia.* These genera increase in proportion, density, and development in the lower sections of the district, where they can grow to 15 meters in height. Grass species that occur at the higher altitudes completely disappear at lower altitudes, where forest openings are invaded by the bamboo *Chusquea.* Many Melastomaceae also occur, the trees usually appear covered with epiphytes, and tree ferns of the genera *Cyathea*, *Alsophila,* and *Dicksonia are* common (Tosi,1960).

Faunal species from both the Puna and the Yungas occur together here, but many species from other districts in the Yungas which are common in the Amazonian province are not present in the Monte Chico (Elfin Forest).

Cloud Forest District

The Cloud Forest district described by Brack (1976) includes the Tropical Lower Montane Wet Forest, the Tropical Lower Montane Rain Forest, and the Tropical Lower Montane Moist Forest, although fogs are rare in this last life zone. It lies between 2,500-2,800 meters and 1,600-1,800 meters above sea level and has an annual mean precipitation from 790 to 1,970 mm in the Tropical Lower Montane Moist Forest and reaches almost 4,000 mm in the Tropical Lower Montane Rain Forest. Temperature means range from a minimum of 12° C to a maximum of 18°C.

Topography here is predominantly sloping, with few flat areas. Soils are generally moderately acid to slightly basic and of moderate depth, have medium or fine texture, and high cation exchange capacity. They can include kastanozems and, to a lesser degree, lithosols and redzinas on the steepest sites. Other life zones in this district are characterized by considerable relief, with 70 percent or steeper slopes, and shallow soils, primarily lithosols. Cambisols and acrisols are also present (Tosi, 1960; ONERN, 1976).

The vegetation, like the fauna, is characteristic of the Yungas province and is very rich in endemic forms. Trees can reach 40 meters in height, although they average 20-30 meters. *Podocarpus* is very common in this district, as is *Weinmannia, Ocotea, Nectandra* and other *Lauraceae, Cinchona, Cedrela, Guarea, Roupala, Clethra, Clusia, Befaria, Laplacea, Ilex, Oreopanax, Cecropia, Brunellia, Ladenbergia,* and many others. The bamboo *Chusquea,* the tree ferns *Cyathea,* and one nonaerial *Carludovica,* as well as numerous shrubs, vines, epiphytes, ferns, mosses, and lichens also abound (Tosi, 1960).

On the whole, this district is very rich in fauna, especially birds, bats, and batrachians among the vertebrates, and a great variety of insects. Characteristic fauna are the cock-of-the-rock (*Rupicola*), the torrent duck (*Merganetta*), toucans (*Aularohrynchus, Pteroglossus*), the pudu (*Pudu mephistopheles*), the false paca (*Dinomys branickii*) and the spectacled bear (*Tremarctos ornatus*) (also found in the elfin forest).

The High Forest District

The High Forest district is located between 600-800 meters and 1,600-1,800 meters above sea level, and is a transition zone separating the Amazonian and Yungas provinces. In the Holdridge system, it incorporates the Tropical Premontane Rain Forest, Tropical Premontane Wet Forest, and a large part of the Tropical Premontane Moist Forest life zones. Mean annual rainfall of this district varies between 940 and 1,970 mm, with the least amount of rainfall occurring in the Tropical Premontane Moist Forest. Mean temperatures range from 17°C to 26° C.

In the Tropical Premontane Rain Forest portion of the district, the topography varies between rolling and moderately steep. The soils are comparatively deep, relatively acid, and of medium to heavy texture. Among the edaphic groups, the ortic acrisols, urvisols and the eutric and dystric cambisols predominate. Gleysols and fluvisols, which are the most fertile soils of the region, are also present. In the other two zones in the district, the topography is steep, with slopes of 70 percent or more. The soils are acid and shallow or moderately deep (ONERN, 1976).

The vegetation is quite varied and boasts trees of great commercial value such as *Cedrelinga, Juglans, Tabeluia, Cedrela,* Cordia, *Aspidosperma, Guarea, Trichilia, Aniba, Ocotea, Persea, Nectandra, Podocarpus, Weinmannia,* etc. Palms belonging to the genera *Euterpe, Bactris, Wettinia,* and *Geonoma* are abundant. In abandoned clearings one finds communities of *Cecropia, Psidium, Visma,* and *Melastomaceae, as* well as the bamboos *Chusquea* and *Guadua* and in less developed soils, the fern *Pteridium* (Tosi, 1960). Much of the district's fauna is also found in the Amazonian province, such as the mammals Tayassu, *Tapirus, Felis, Panthera. Lutra, Mazama, Hydrochoerus, Myrmecophaga,* and *Priodontes, as* well as a large number of birds, reptiles, and batrachians. The diversity of fishes is greater than in the districts mentioned above, but is still low compared with the Amazonian province.

Amazonian Province

The Amazonian province includes, in the Holdridge System, the Tropical Dry Forest, the Tropical Moist Forest, and the Tropical Wet Forest life zones, as well as the lower sections of the Tropical Premontane Moist Forest life zone. It extends from 600-800 meters in altitude to near sea level, although in the Central Selva its lowest altitude is approximately 150 meters.

Climatically, an enormous difference exists between the Tropical Dry Forest, which receives an average

900-1,400 mm of annual rainfall, and the Tropical Wet Forest which, while usually boasting an average mean precipitation greater than 4,000 mm, sometimes experiences almost double that amount. In contrast, the average annual rainfall of the Tropical Moist Forest ranges from 1,900 to 3,400 mm. Average temperatures are very stable, varying between 23° C to 26° C.

The topography of this province is predominately rolling or hilly although in the Tropical Wet Forest Zone it is occasionally steep. The soils are usually deep, fine-textured, and either acid or, in the dry areas, neutral. Acrisols predominate in the humid and very humid life zones. Vertisols and cambisols predominate in the dry life zone. In the humid life zones, vegetation is typically lush high forest, rich in bromeliads, orchids, vines, and reeds. Tree trunks are usually covered by epiphytes and vines, including Araceae, ferns, lichens, and mosses. The highest trees rise more than 50 meters. Four plant strata can be distinguished although five may occur in the very humid zone. The most conspicuous species in this province belong to the genera *Cedrela, Swietenia, Chorisia, Virola, Calophyllum, Brosimum, Guazuma, Hura, Simarouba, Spondias, Miroxylon, Aspidosperma, Duguetia, Aniba, Nectandra,* and Ocotea among others. Palm genera present include *Scheelea, Phytelephas, Socratea, Iriartea* and *Astrocaryum.* Stands of *Mauritia, Euterpe* and *Jessenia* occur in hydromorphic areas and in poorly-drained sites. Secondary growth is usually dominated by *Cecropia,* which sometimes forms pure stands.

In the Tropical Dry Forest the vegetation is shorter and forms three forest strata; scattered trees reach 30 meters in height. In this forest are seen various cacti, conspicuous arboreal plants belonging to the genera *Cedrela, Amburana, Hymenaea, Manilkara, Tabebuia,* and *Schinopsis,* and palms of the genera *Scheelea, Phytelephas,* and *Astrocarym.*

The fauna is typical of the Amazonian plain and includes a great diversity of primates (*Ateles, Alouatta, Cebus, Saimiri, Lagothrix, Saquinus*), bats, and rodents. Conspicuous mammals include peccary, tapir, capybara, deer, jaguar, ocelot, puma, otter, and nutria. Also occurring are the rare canids *Atelocynus* and *Speothos,* the procyonids *Nasua* and *Potos,* diverse mustelids, and a large number of edentates. Dolphins live in the rivers but not manatees. Birds are abundant and there are many reptiles and batrachians. The reptiles include *Caiman, Crocodylus, Melanosuchus niger,* and the turtles *Podocnemis unifilis* and *P. geochelone.*

Classification of the Central Selva within the American humid tropics

Now that we have seen something of the diversity of the major ecosystems in the Peruvian Central Selva we must remember that this region comprises scarcely 0.5 percent of the humid tropics in North, Central, and South America and includes only two of the six provinces recognized by Cabrera and Willink (1973) and two of the 13 recognized by Udvardy (1975). Numerous mountain ranges, although less significant than the Andes, also contribute to the region's complexity.

As the climatic, topographic, geologic, and edaphic characteristics all vary, so also do biota, although they may share similar characteristics. Many plant genera and species of both flora and fauna may occur throughout the large majority of biogeographic provinces, but a great many are also endemic to each province and occasionally to each life zone. For example, some conspicuous mammals, like the peccary (*Tayassu tajacu*), the jaguar (*Panthera onca*), the ocelot (*Felis pardalis*), the puma (*Felis concolor*), and the deer (*Mazama americana*) have a wide distribution. Others, like *Tapirus terrestris*, have extensive ranges, but only in certain provinces. *Tapirus bairdi*, meanwhile, appears in Central America, while *Tapirus pinchaque* is only found in certain districts in Peru, Colombia, and Ecuador. Other species are endemic to one or a few Holdridge life zones. For example the yellow-tailed monkey (*Lagothrix flavicauda*) is found only in the Atlantic province, and the monkeys of the genera *Leontopithecus* occur only in the Sierra del Mar province of Brazil.

Soils

Only 7 percent of the American humid tropics contain moderately fertile soils. The remainder is covered with soils that are acid and infertile (oxisols and ultisols), poorly-drained, sandy and infertile, or shallow.

The most abundant are the oxisols (50%), followed by the ultisols (32%). Both are acid and poor in nutrients, although oxisols have good physical properties and are deep and well-drained. The ultisols are similar morphologically since they are also well drained and deep. However, they exhibit a marked increase in the percentage of clay in their deeper portions and their physical properties are less favorable, since they usually occur on hillsides and are thus susceptible to erosion (NRC, 1982, Sanchez and Cochrane, 1980). Oxisols and ultisols also contain serious chemical deficiencies: high acidity, toxic levels of aluminum, deficiencies in phosphorus, calcium, magnesium, sulfur, zinc, and other micro-nutrients; low cation exchange capacity, and high phosphorus-fixing capacity. Some oxisols have low water retention capacity. On the other hand, evidence now indicates that these soils are not as susceptible to laterization as previously believed (NRC, 1982).

The young soils called inceptisols, entisols, gleysols, andosols, cambisols and fluvisols, and regosols and litosols in the Central Selva description may be either fertile or infertile and cover 14 percent of the American humid tropics. The remaining 4 percent are covered with alfisols (luvisols, eutric nitosols, planosols), spodosols (podzols) and vertisols.

Unfortunately, different nomenclature systems have been used in the edaphology of the humid tropics. Each method has its positive points, but it can become confusing for professionals who are not soil specialists. The U.S. National Research Council (NRC, 1982) has provided information (Table 4-4) that can prove useful in correlating different classification systems.

Table 4-4 - SOIL CLASSIFICATION TERMINOLOGY IN THE HUMID TROPICS

Taxonomic Classification[a]	FAO Description[b]	USDA System[c]	French[d]	Brazilian[e]
Oxisoles	Ferrasols	Latosols	Sols Ferraltiques fortement desatures typiques ou humiferes	Latossolos. Terra Roxa Legima
Ultisoles	Acrisols Dystric Nitosols	Red Yellow	Sols ferralitiques lesives	Podzolico Vermelho-Amarelo
Inceptisoles	(various)	(various)	Sols peu evolues	Solos corn horizonte B
Aqueptes	Gleysols	Low Humid Gleys	Sols Hydromorphes	Solos hidromorficos
Andeptes	Andosols	Andosols	Andosols	-

Tropeptes	Cambisols	Brown Forest	Sols brunifies	Solos corn horizonte B. incipiente
Entisoles	(various)	(various)		
Fluventes	Fluvisols	Alluvials	Sols minereaux bruts	Solos aluviais
Psammentes	Arenosols and Regosols	Regosols	Regosols	Regosols, Areias Quartzisosas
Fases Liticas	Lithosols	Lithosols	Sols lithiques	Litossolos
Alfisoles	Luviosols Eutric Nitosols Planosols	Eutric Red Yellow Podzolics, Terra Roxa, Planosols	Sols ferrugineaux tropicaux, lessives	Podzolico Vermelho-Amarelo equivalente eutrofico; Terra Roxa Estruturada, Planossolos
Histosoles	Histosols	Peat, Bogs	Sols organiques	Solos organicos
Spodosoles	Podsols	Podzols	Podzols	Podzols
Mollisoles	Rendzinas Phaeozems	Rendzinas Chernozems		Brunizems
Vertisoles	Vertisols	Grumusoles	Vertisols	Grumusols
Aridisoles (salino)	Solonchaks	Solonchaks	Sols halomorphes	Solonchaks

a. Soils Survey Staff (1975).
b. Dudal(1980).
c. Baldwin *et al*, (1938). Cline *et al*, (1955).
d. Aubert(1965).
e. Costa de Lemos (1968).
Source: NRC, 1982.

Ecosystems

Each biographic province, or district, and each life zone contains a number of units that are sufficiently differentiated, organized, and stable to be considered ecosystems themselves. Such areas include rivers, lagoons, ravines, swamps, floodplains, hills, and mountainsides. And ecosystem diversity is even greater if one considers the semi-natural (some would say artificial) ecosystems created through human intervention. Table 4-5 illustrates some of the most common ecosystems.

All ecosystems, as well as the species within them, are influenced significantly by other ecosystems, especially adjacent ones. Aquatic ecosystems, for example, are closely influenced by the terrestrial ecosystems that surround them. In effect, rivers are only functional parts of larger units. Their water runs off from land surfaces or arises from ground water that drains into rivers. Chemical and physical action of this runoff carries all it can move, including particulate and soluble material derived from the decomposition and remineralization of organic material.

Table 4-5
COMMON ECOSYSTEMS IN THE AMERICAN HUMID TROPICS

1. *Natural Ecosystems*		
Terrestrial Ecosystems	*Forested Ecosystems*	Flooded Forests
		Floodplain Forests
		Hill Forests
		Plateau Forests
		Mountain Forests
	Non-forested Ecosystems	Mauritia Palm Groves
		Marshes
		Savannahs
		Mangrove Swamps
		Islands
Aquatic Ecosystems	*Benthic Ecosystems*	Lakes and Lagoons
		Estuaries
	Lythic Ecosystems	Clear Water Rivers
		White Water Rivers
		Black Water Rivers
		Streams and Ravines
2. Semi-Natural Ecosystems		
Terrestrial Ecosystems	Exploited and Managed Forests	
	Secondary Forests	
	Secondary Vegetation Other	
	Than Forests	
Aquatic Ecosystems	Altered Lentic Ecosystems	
	Altered Lotic Ecosystems	
3. *Artificial Ecosystems*		
Terrestrial Ecosystems	Annual Agriculture	
	Perennial Agriculture	
	Rangelands	
	Forest Plantations	
Aquatic Ecosystems	Reservoirs	
	Ponds	

Biomass

Vegetative biomass (phytomass) of humid tropical forests is usually high. Table 4-6 illustrates this as biomass in tons of dry material found in different locations under different forest conditions. Phytomass from near Manaus Brazil equaled 990 tons/hectare of fresh material, including roots, which should amount to 283 tons/hectare as dry organic matter (Klinge, *et al*, 1975). This phytomass accumulates over long periods, probably centuries, and does not represent a productivity index, which is quite low in the humid tropics.

In contrast to phytomass, zoomass is very sparse. Zoomasses of hardly 69-210 kilograms/hectare have been found (Klinge, *et al*, 1975; NRC, 1982), 79 percent of which consists of soil invertebrates, especially mites, springtails, termites, and ants. Vertebrate biomass varies, on the average, between 7 and 30 kilograms/hectare, This is due to the poor availability of nutrients for herbivores and foliage insects, to wide species diversity, and to the small size of mammals compared to those on other continents. On the other hand, fish size in South America equals or exceeds fish sizes in Africa and Asia and the aquatic zoomass of white water lotic environments is proportionally high.

Productivity

Productivity is the biomass produced during a fixed period of time. Gross primary production of vegetation is very high in the humid tropics because of the available light, temperature, water, nutrients, and carbon dioxide. Most organisms depend on this production for nutrients, which become available to organisms through three different routes: food chains based on living plants; food chains based on dead plants; and, food chains based on plant detritus and microbes. Of these, the third is the most important in the humid tropics. This route provides the major part of the system's primary productivity since only microbes can decompose lignin and cellulose. Nevertheless, the three food chains are closely interdependent, as is demonstrated by the symbiosis between termites and microorganisms that decompose wood.

Low soil fertility is the principal factor limiting productivity. In the humid tropics most nutrients are found in living and dead biomass rather than in the soil (as in temperate and dry ecosystems). Root systems are shallow and penetrate overlying mats of organic material, but not the soil.

Table 4-6
VEGETATION BIOMASS VALUES FOR TROPICAL FORESTS IN LATIN AMERICA AND THE CARIBBEAN

Site	Characteristic	Phytomass (Metric tons of Dry Material/Ha)	Author
Puerto Rico	Low Montane Forest	198[a]	Ovington and Olson (1970)
Puerto Rico	Low Montane Forest	311	Odum et al (1970)
Panama	Lowland Forest	363[a]	Golley et al (1969)
Brazil	Rain Forest	380	Klinge (1972)
Colombia	Rain Forest	325	Salas(1973)
Colombia	Rain Forest	185	Salas(1973)
Colombia	Primary Rain Forest	326	Salas (1978)
Colombia	Primary Rain Forest	182[a]	Salas (1978)
Colombia	Primary Rain Forest	185 [a]	Salas (1978)

Colombia	Secondary Forest 16 years	203 [a]	Salas (1978)
Colombia	Secondary Forest 5 years	68 [a]	Salas (1978)
Colombia	Secondary Forest 2 years	19 [a]	Salas (1978)

a. Not including roots.
Source: Salas (1978).

Interdependence Between Species and Succession

Any disturbance, natural or human, that creates a new habitat or significantly alters an existing one, results in a fixed series of species composition called succession. For example, the first plants in an area benefit from low competition for light and nutrients. This may be the only opportunity for some 75 percent of the forest tree species to reach maturity (Hartshorn, 1978). At the same time, many invertebrates and vertebrates rely on succession for their life cycles: invertebrate species, when young, may require a home in successional vegetation, while as an adult, it may live in climax forest. In other words, successional areas are indispensable to healthy forest regeneration, as well as to the survival of numerous animal species.

Available data suggest that population interaction is more significant in regulating the structure and function of communites in the humid tropics than it is in temperate regions. The roles of bats, birds, insects, and other animals that feed on seeds in open forest clearings are examples of this. The Brazil nut tree, *Bertholletia excelsa,* depends on certain bees in the family Meliponidae for pollination, and its seeds have to pass through the digestive tracts of certain rodents to be able to germinate. When this tree is not in flower, the bees depend on the flowers of other small trees. Eliminating these trees, then, indirectly impedes Brazil nut fertilization.

Leaf cutter ants of the genus *Atta* are another example of interdependence. These ants are affected by plant succession, with their nests being more numerous in early successional stages and less so in climax forests. But the ants, in turn, influence plant succession through their selective use of plant species and their contribution of deposited nutrients.

Species Diversity

Species diversity in the humid tropics is extraordinary. Hundreds of species can occur on one hectare, including perhaps one hundred species of trees. The number of animals is still greater: 42,000 species of insects have recently been estimated as occurring on only one hectare (NRC, 1982), and Janzen (1982) found 50 species of ants on hardly one square meter. Over 100 species of mammals, 400 species of birds, 100 species of reptiles, and somewhat fewer batrachians can be found on only one tenth of a square kilometer. This diversity, which so successfully exploits humid tropical conditions and the low fertility of most tropical soils, makes it considerably challenging for man to exploit these ecosystems without losing some of their genetic resources, a substantial portion of which is endemic.

In large measure, evidence suggests that the diversity of tropical species may be the result of the climatic changes that occurred in tropical America during the Quaternary epoch, especially during the last 100,000 years. Particulary significant was the glacier-caused climatic conditions alternately favorable and unfavorable to life. During glaciation, biota became isolated in a few areas where they were able to survive because of the humidity. Between glacial periods, species spread out from these refugia and intermingled. The dispersion that followed repeated glacier-caused isolation created an astonishing diversity of species. The Pleistocene refugia that have been clearly identified in various countries, including Brazil and Peru, are centers of growth for endemic species; preserving them can effectively protect genetic patrimony.

Protection of major ecosystems in the humid tropics

Protected areas are areas that enjoy special legal status, that are under absolute protection or restricted use, and that guarantee the conservation of the ecosystems and species they contain. In Latin America and in other parts of the world, the diversity of terms designating protected areas and the objectives under these terms are so great that the International Union for the Conservation of Nature (IUCN) adopted a nomenclature classifying alternative management categories according to the primary conservation objectives followed in each case. Roman numerals in the list below indicate the IUCN equivalents of Peruvian categories. Seven categories are recognized by the Peruvian legislature: national parks (I-II), national reserves (III), national sanctuaries (III-IV), historic sanctuaries (V), forest reserves (VIII), hunting reserves (VIII), protected zones (VI), and communal reserves (VII). Of these, the first four are part of the National System of Conservation Units. The forest reserves are managed directly by the forest administration proper, not by that of the national parks, while the hunting reserves and communal reserves are managed by the wildlife administration. Protected zones (VI), as a rule, are transitional, usually becoming converted to one of the other categories.

The Peruvian National System of Conservation Units consists of 18 national parks, national reserves, and national and historic sanctuaries that, together, comprise 4,285,499 hectares or 3.33 percent of Peru's territory. The system also includes 2,560,739 hectares accorded the status of Biosphere Reserves, of which three are presently established. Studies of an additional 11 conservation units are at a fairly advanced stage. If established, these areas would protect more than 5 million additional hectares. It is therefore realistic to expect that by the end of the century Peru will be protecting, under special management, more than 7 percent of her territory.

Among the five national parks (1,984,606 ha), eight national reserves (2,218,006 ha), two national sanctuaries (11,315 ha), and three historic sanctuaries (35,392 ha), only four units belong to the designated Yungas province as classified by Udvardy (1973). These units are Manu (1,532,806 ha), Tingo Maria (18,000 ha), and Cutervo (2,500 ha) National Parks, and Machu Picchu Historic Sanctuary (32,592 ha).

Following Dourojeanni and Rios (1981), only 884,585 hectares of the.Yungas province are protected (4.1%), of which 95 percent belongs to the highlands of Manu. On the other hand, Tingo María and Cutervo are far too small to assure the conservation of their biotas and, in addition, are significantly altered by forest exploitation and shifting cultivation. Nevertheless, Yungas province has special significance because it contains the greatest biological diversity and the highest proportion of biological endemism in Peru. It is also the most threatened by agriculture and grazing expansion. Various studies demonstrate that, in the next two decades, 7 million hectares in this region will be affected, for a total of some 12 million hectares in all (Dourojeanni, 1980). When this happens the loss of floral and faunal species will be great.

Three areas in the Central Selva have been proposed as conservation units. The first is Cutibireni, in the Vilcabamba Cordillera, the second is Yanachaga, and the third is Sira-San Carlos. Yanachaga is an example of the Chanchamayo-Apunnnac Pleistocene refugium, while Sira-San Carlos would preserve a portion of the Pachitea-Ucayali refugium, and Cutibireni a portion of the Urubamba refugium. The projected national park in the Sira cordillera would enclose 1,022 hectares, the Yanachaga conservation unit would contain 226,000 hectares, and the Cutibireni would most likely contain close to one million hectares (Dourojeanni, 1980).

Conservation Units in the American Humid Tropics

Table 4-7 presents a list of the conservation units (national parks and equivalent reserves) recognized by IUCN (1980) that existed in the American humid tropics in 1980. It can be seen that there were 87 established units containing almost 143,000 square kilometers or 16 percent of the region. The Udvardy (1975) provinces best represented are the Panamanian (4.2%), the Amazonian (36%), the Colombian Coast (3,6%) and the Colombian Montane (3.3%). Those least represented were the Guerreran province, the Brazilian Rain Forest, the Sierra del Mar, the Campeche, the Madeiran, the Guyanan, and the Central American, all with less than 1 percent of their territory protected. Only the Yucatan province contained no recognized conservation unit.

The effectiveness of the conservation and management of these 87 units is highly variable. Some areas have been virtually abandoned, although that does not necessarily mean the resources that justified the establishment of these places have been lost.

Table 4-7
CONSERVATION UNITS IN THE AMERICAN HUMID TROPICS BY BIOGEOGRAPHIC PROVINCE (UDVARDY)

Biogeographical provinces	Number of units	Surface area (km^2)	% of all conservation areas	% of the biogeographical provinces
Amazonense	14	92,180	64.4	3.6
Madeirense	1	10,000	6.9	0.6
Yucatense	-	-	-	-
Campechense	3	935	0,7	0.4
Guerrense	2	112	0,1	0.1
Centroamericanense	17	2,863	2.0	0.9
Panamense	4	2,871	2.0	4.2
Costa Colombiana	4	6,450	4,5	3.6
Yungas	3	9,585	6.7	1.5
Montano Colombiana	5	5,090	3.6	3.3
Bosque Pluvial Brasileño	8	3,948	2.8	0,2
Sierra del Mar	8	2,962	2.1	0.2
Guyanense	18	6,053	4.2	0.7

TOTAL	87	143,049	100.0	

Source: IUCN (1980) and Dourojeanni (1981).

There exist no precise guidelines that specify the minimum percentage of a region's or ecosystem's territory which should be protected to assure the survival of its genetic patrimony or to realize other objectives. It is estimated, however, that this figure should at least be between 3 percent and 7 percent. The percentage of protected land in the American humid tropics is well below this figure; nevertheless, the last four years have witnessed the establishment of several new conservation units in Brazil and Central America. With those proposed for Peru and other countries, at least 2 percent of the land should ultimately be protected.

Other protected areas exist that belong to categories not included on the IUCN list: forest reserves, national forests, protected forests, watershed reserves, and others. However, these areas in Latin America generally exist only on paper and have not generated the management they require.

Products and Services Produced by Protected Areas

Among the products that come from protected areas are those that are made from non-woody plants, one of the few species whose exploitation can be acceptable in certain types of protected areas, such as forest and watershed reserves. Non-woody plants are very important to local economies. They provide a wide variety of products, including gums, latex, resins, barks and bark fibers, leaf fibers (especially palms), fruits, seeds, flowers, leaves used in construction, vines for ropes, ornamental plants, medicinal plants, plants used in magic, drugs, fodder, and edible fungi.

Protected areas in the humid tropics provide numerous and varied services such as flood and erosion control; a genetic bank, fresh water; ecosystem buffering; and recreation (Miller, 1980). The significance of these services depends closely on the objectives and size of each protected area. Thus, national parks, national reserves, and forest reserves, which are the largest protected areas, provide the most important services from a global perspective. All of these areas, excepting reserved zones, include the provision of some of these services as concrete objectives.

Protected areas may seem to be obstacles standing in the way of development. But if we consider that in two or three decades they will be the only large areas of the American humid tropics left that have not been severely altered by human activity, protecting them will be seen as the only way to insure the survival of the truly irreplaceable services they provide.

Conflicts between protected areas and other types of natural resource use

A number of conflicts exist between protection of an area and other types of natural resource use. These conflicts may be grouped into three categories: conflicts originating over the proposed use of planned or existing natural areas in ways incompatible with these areas' stated objectives; conflicts originating over the proposed use of such areas in ways which are moderately compatible with their objectives; and conflicts occurring in other areas and with other activities as a result of the existence of protected areas.

The first type of conflict is fundamentally irresolvable: one cannot cut and burn vegetation to make fields or pastures in a national park. This incompatibility is so absolute that compromise is not a viable solution. These conflicts must be avoided or prevented because resolving them always creates new problems.

The second type of conflict, unlike the first, may have some solution. This type of conflict arises when exploitation of a protected area's resources is not entirely compatible with the area's objectives. For example, a road might have to be built through a park or national reserve. If its construction adheres to certain restrictions, it may, in fact, be not only feasible but actually beneficial to the protected areas it traverses.

The third type of conflict appears when protected areas have adverse effects on human health and activities. The typical example is the national park or other natural area harboring animals that are agricultural pests, human and livestock parasites, and reservoirs of disease. The closer such areas are to susceptible human activity, the greater is their impact and the conflicts that result. For instance, vampire bats and large cats can attack livestock and then find shelter in adjoining protected areas. This type of conflict generally has an appropriate technical solution.

Important conflicts arise because of the amount of territory that protected areas occupy and the necessity to maintain these areas inviolate. Such is the case with national parks which need to contain large expanses of land. Because they protect examples of different ecosystems and their genetic diversity, they must, out of necessity, occupy lands potentially valuable for agriculture, livestock, or timber harvest. This, too, can aggravate conflicts.

Forest reserves are often created especially to protect highland watersheds. That is, they prevent erosion and maintain the quantity and quality of water supplies. While hunting, fishing or even mining (provided it does not pollute air and water) may not cause problems, conflict rages if forests boast valuable tree species (*Podocarpus* or *Juglans*) attractive to lumber interests. The harvest of large tracts of trees is incompatible with soil and water conservation, unless such harvest is conducted with utmost care.

In many cases, the significance of a conflict depends not upon the size of the protected area, or its attractiveness to industry, but on other factors altogether. Such is the case with national and historic sanctuaries. These areas are generally small, ranging in size from hundreds to several tens of thousands of hectares. They either protect designated ecosystems, species, or geologic phenomena, or else are designated as archaeological or historic treasures. However, these areas must remain absolutely inviolate. The importance of conflicts generated by them may become globally significant, as in the case of the hydroelectric plant built in the heart of Peru's Machu Picchu Historic Sanctuary.

It is necessary to keep in mind that conflicts arise not only in relation to the effect protected areas have on neighboring territory or on their own land. They also include activities conducted on neighboring areas that affect protected areas. This is the case with industrial contaminants, such as those produced by metal refineries, cement factories, or pulp and paper mills above or upwind of protected areas. Protected areas can also be damaged by fertilizers, pesticides, and other agricultural contaminants and urban contaminants that are transported by wind and water. The smaller the protected area is, the worse is the resulting damage. Such negative influence on conservation units and other protected areas have led to the creation of the concept of "buffer zones" or "strips" such as when national forests surround a park, reserve, or national sanctuary, or partially isolate them from agricultural and grazing areas and from industrial and urban development.

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Chapter 5 - Water resources

In this chapter we discuss atmospheric, surface, and subterranean water resources of the Central Selva, and the ways to insure their efficient distribution for drinking, industry, irrigation, and hydroelectric power. Other chapters in this study focus on water's role in conservation, navigation, and as habitat for aquatic species. We also plan to identify the interactions between water use projects and those which further various other development interests.

Water resources in the Central Selva of Peru

The rivers in the Central Selva arise high on the Atlantic slope and form part of the Ucayali watershed. With the Marañon, these rivers give rise to the Amazon River which empties into the Atlantic Ocean. All of them are winding; they form a network of channels that ultimately flow into the major watersheds of the Perene and Pachitea Rivers. Metereologic, hydrometric and topographic information about the rivers is scarce, with existing data describing only some of them (the Paucartambo, the Perene, the Ene, and the Tambo), expressed on photographic maps of the scale of 1:1,000,000. What is known is that the rivers are caused and nourished by the abundant precipitation of this humid region. Compared with rivers in the Brazilian Amazon watershed near Peru, some of the rivers of the region have high water volumes (Tables 5-1 and 5-2). While future systematic evaluation of river volume at gauging stations can reveal the true potential, some preliminary studies can give an idea of the watersheds' future. Table 5-3 presents some estimates for volume changes in the Ene and Tambo rivers, while Table 5-4 gives estimates on the sediments in those rivers.

Table 5-1
SPECIFIC FLOW VOLUMES OF AREA RIVERS

River	Q (m^3/s)[a]	Area (km^2)	q($1/s/km^2$)[b]	
Ene (Achaminga)	1,928.0	106,150	18.2	(1)
Tambo (Antario)	2,343.0	125,130	17,7	(1)
Pachitea	1,279.0-2,411.9	28,652	44.6-84.2	(2)
Palcazu	761.0	9,840	77.3	(3)

Paucartambo	108.4	2,988	36.3	(3)
Satipo	91.7	1,579	58.1	(3)
Pichanaki	46.9	569	82.4	(3)
Chanchamayo	198.0	7,655	25.9	(3)
Tulumayo	86.1	3,345	25.7	(3)
Palca	98.0	3,949	24.8	(3)

a. Volume by surface area.
b. Volume by unit.
(1) With gauges.
(2) The lower figure was obtained by the Federal Republic of Germany; the higher by ONERN.
(3) Figures obtained by ONERN.
Source: ONERN (1980); Federal Republic of Germany (1979).

The hydroelectric potential of the area's rivers (Table 5-5) is very large when compared with the energy needs of the area and the country as a whole, which, in 1981, consumed approximately 8,000 giga watt hours (GWH) and had a developed capacity of 3,282 megawatts (MW). If this potential is developed in the Central Selva where needs are small, principally in the highlands, it can be seen that the area can export large amounts of energy to more developed areas that lack this resource. Ground water will not play a role in hydroelectric power because of poor permeability and mediocre physical-mechanical quality of the terrain. Nevertheless, ground water presently plays an important role for human populations, and good yields can be obtained from wells.

Table 5-2
SPECIFIC FLOW VOLUMES IN RIVERS OF THE BRAZILIAN AMAZON

River	Q(m^3/s)	Area (km^2)	q(l/s/km^2)
Moa	36.0	1,210	30.0
Ituxi	341.0	14,205	24.0
Madeira	16,817.0	934,300	18.0

Source: Federal Republic of Germany (1979).

Table 5-3
HIGH WATER VOLUMES IN THE ENE AND TAMBO RIVERS

River	Area (km^2)	11 years (m^3/s)	25 years (m^3/s)	10 years (l/s/km^2)	25 years (l/s/km^2)
Tambo (Puerto Prado)	125,000	20,000	23,080	160	190
Ene (Paquitzapango)	105,000	16,700	19,000	159	189

Source: Federal Republic of Germany (1979).

Table 5-4
SEDIMENT LOAD IN THE ENE AND TAMBO RIVERS

River	Annual Water Flow Discharge ($10^6 m^3$)	Annual Sediment Flow Discharge (10^6 ton)
Tambo (Puerto Prado)	74,000	125
Ene (Paquitzapango)	60,000	105

Source: Federal Republic of Germany (1979).

Present water use and existing development plans

Chanchamayo Watershed

The Chanchamayo watershed, made up of the Tulumayo, Palca, and Oxapampa rivers, is the most developed area in the Central Selva. With Tarma (in the Palca watershed), San Ramon, La Merced, and the extensive agricultural areas around them are major population centers.

A hydroelectric plant belonging to ELECTROPERU lies between San Ramon and La Merced and uses water drawn from the Chuchuyacu River. The plant is small, with two 276 KW turbines that each handle 600 liters/second and a fall of 120 meters. This installation does not provide enough electricity for the populations of these two towns, although two 400 KW diesel engines and one 600 KW engine are operating.

Table 5-5
HYDROELECTRIC POTENTIAL IN THE PERUVIAN CENTRAL SELVA

Watershed/River	Site	Potential (MW)	Mean Energy (GWH/year)
Tulumayo	Tulu 10	155.5	832,0
	Tulu 20	166.5	1 079.2
	Tulu 30	215.5	1 336.1
	Tulu 50	243.0	1 510.0
	Tulu 70	198.6	1 239,8
	Subtotal	979.1	5 997.1
Palca	*Palca 10*	147.8	920.7
	Palca 15	122.5	798.6
	Palca 30	55.2	338.2
	Subtotal	325.5	2 057.5
Oxapampa	Oxa *20*	111.7	753.0
	Oxa 30	35.5	249.6
	Subtotal	147.2	1 002.6
	Total	1 450.8	9 057.2
CHANCHAMAYO PAUCARTAMBO	*Chan 10*	70.4	438.7

	Chan 25	139.5	944.2
	Chan 29	163.8	1 003.9
	Chan 30	96.8	669.2
	Total	470.5	3 056.0
PERENE (Total)	*Per 10*	212.2	1 480.8
	Per 20	67.1	416.1
	Per 70	395.6	3 087.7
	Total	674.9	4 984.6
SUMMARY:			
PERENE (Total)		2 597.2	17 097.8
Ene[a]	*Ene 40*	2 227.1	18712.4
Tambo	*Tam 40*[a]	1 286.5	8 324.8
TAMBO	*Subtotal*[a]	6 110.8	44 135.0
POZUZO	Poz 20	96.2	733.8
	Poz 27	237.8	1 473.7
	Poz 30	390.1	2 762.4
	Poz 50	138.3	868.5
	Subtotal	862.4	5 838.4
Area	*General Total*	6 973.2	49 973.4

a. Not including the potential of the Mantaro nor the Apurimac.
b. *Outside, but adjacent to the area.*
Source: Federal Republic of Germany (1981).

The food canning factory must use emergency equipment, since there is no daytime electric light, except during predetermined hours. Recent annual electricity consumption in the two towns was 4,630 KW in terms of energy and 1,652 KW in terms of maximum demand. A hydroelectric plant with approximate capacity of 6,300 KW is being constructed for the San Vicente mine on the Oxapampa River near San Ramon.

Clean drinking water for the two populations (CEPIS, 1980), reaches only 60 percent of the people in San Ramon and 50 percent in La Merced. While large consumers such as the food canning factory enjoy regular supplies from a well, none is provided to average customers throughout the day, and many homes are not even connected to pipelines. Although there is no scarcity of clean spring water, the growing populations need to use surface water, incurring increased pumping and treatment costs. Many homes take their water directly from the rivers, which are continually polluted by direct dumping of waste water.

Paucartambo Watershed

The Paucartambo river, which together with the Chachamayo forms the Perene, features rapids, many bends, and clearer water than the Chanchamayo. The Yaupe hydroelectric plant, with 108 KW capacity, has been installed along this river's headwaters. It belongs to the Central Mining Corporation and supplies electricity to the firm's mining operations in the Central Region of the country. ELECTROPERU is investigating the possibility of constructing a small plant on the Oxapampa river to serve the population in the Paucartambo area, while a definitive study has been prepared of the Yuncan Hydroelectric Plant on the Paucartambo river, above Yaupe.

Perene Watershed

Long and narrow motorized boats transport goods on the Perene River between the city of San Luis de Shuaro and the river's confluence with the Pangoa river. The river's waters are also used to irrigate citrus fruit plantations.

Pichanaki Watershed

On the Pichanaki River, a tributary of the Perene, a plant of approximately 1,000 KW capacity which will exploit a fall of 200 meters is being constructed near the population center of Bajo Pichanaki to serve both Bajo and Alto Pichanaki.

Pengoa Watershed

Two important population centers, Satipo and Mazamari, are in the Pangoa river watershed, which is made up of the Satipo, Mazamari, and Sonomoro rivers. The electricity consumption of these two cities, not including the special uses already described, was expected to be 839 KWh of energy and 420 KW of maximum demand. But both are experiencing problems similar to other cities: insufficient quantities of drinking water and electrical energy, and water that is supplied only during certain hours of the day. Satipo uses almost no well water.

Thermal diesel plants provide Satipo with electricity at present, but ELECTROPERU is considering constructing a hydroelectric miniplant on the Sonomoro river. Also being investigated is the possibility of constructing a 3,000 KW plant on the Chalhumayo to serve the town of Mazamari.

Tambo Watershed

The feasibility of constructing large hydroelectric plants on the Tambo river and its tributaries, the Perene and the Ene, is being studied. These would provide energy to localities outside the Selva. Two hydroelectric development alternatives are also being considered for a 200 km stretch along the Ene and Tambo rivers (Figure 5-1). Each requires a huge investment, yet both alternatives are economically attractive, and they could meet the region's rising electricity demand for the next 15 years.

Tables 5-6 and 5-7 show the impact of such projects on the river and adjoining areas and their principal characteristics, such as the relation between volume available to the turbines and the mean annual volume; firm power and average power; their installed potential; the relation between usable volume and annual drainage; and the range of variation of reservoir water levels during the reservoirs' operation.

These plant feasibility studies have also considered the area's seismic problems, although the most significant seismic activity occurs in the coastal region and diminishes as one approaches the jungle. It is felt that shock wave magnitudes lower than m_b=5 would not cause serious damage to the structures. Thus, only earthquakes of tectonic origin were examined. Few cases of magnitudes greater than m_b+6.2

were noted north of the area where the dams would be located, but one seismic magnitude of m_b+4.5, which occured a short distance from the Ene-Paquitzapango locality, was considered significant regarding future dam design.

Oxapampa Watershed

In Oxapampa, as in other towns in the region, a shortage of electricity is creating a number of self-producers. Without considering the so-called special uses, it is estimated that energy consumption soon could reach 418 MWH, and maximum demand could reach 213 KW.

The Oxapampa city water supply comes from the San Alberto river, from which it is collected by a simple impoundment system administered by the Provincial Council. Rural areas, however, obtain their water directly from rivers and wells and are, consequently, experiencing contamination problems. To meet the town's needs, studies have been conducted regarding construction of hydroelectric plants on the Pozuzo and Oxapampa rivers. As these plants are relatively large, they would serve Villa Rica as well as other towns in the region.

Figure 5-1 - DEVELOPMENT ALTERNATIVES ON THE ENE AND TAMBO RIVERS

Table 5-6
ENERGY CHARACTERISTICS OF LOCAL HYDROELECTRIC PROJECTS

Project	Installed Potential	Energy Produced (GWH/year)		Range of Operation
	(MW)	Fixed	Average	(m)
Sumabeni[a]	1,680	2,915	8,190	20
Paquitzapango	2,620	7,085	12,380	20
Puerto Prado 40	980	2,835	5,380	20
Total Alt. 1	5,280	12,835	25,950	-
Sumabeni	1,680	2,910	8,185	20
Cutiverini	1,470	2,945	6,295	15
Puerto Prado 90	2,600	6,655	12,945	20
Total Alt. 2	5,750	12,510	27,425	-

a. Outside the Selva area.
Source: Federal Republic of Germany (1981).

Pozuzo Watershed

The Pozuzo river has a number of potential damsites. The river could be diverted through tunnels in the Yanachaca cordillera, and, as the river is tightly enclosed by canyon walls until the "Pozuzo elbow," the local impact would be minimal, even if the new plants produced over 60 MW.

The feasibility of constructing a 1,000 KW plant on the Huacabamba river to serve the town of Pozuzo is being studied. The possibilities for constructing small hydroelectric plants on these rivers also appear favorable (a factory producing small Pelton wheels is located in the region). In 1982 a consumption of 36

MWH and a maximum demand of 25 KW was predicted without taking into account special uses.

Villa Rica suffers from light and water problems similar to those of other cities in the region. Without considering special uses, the town consumed 418 MWH of electric energy in 1982, with a maximum demand of 200 KW.

Ground water (springs) will continue to be used by rural households and small populations. Although its use is not practical for agricultural and investment operations which require vast amounts of water, it can be used for industrial purposes when surface water is not available and when pumping the water can be economically justified.

Table 5-7
HYDRIC CHARACTERISTICS OF LOCAL HYDROELECTRIC PROJECTS

Project	Mean Water Volume Qm(m^3/s)	Flooded Area (km^2)	Turbines Qt/Qm[b]	Coefficients Spillways Qmax/Qm[c]	Reservoirs Vu/Va[b]
Sumabeni[a]	1,790	131.0	1.5	26.5	0.5
Paquitzapango	1,900	423.0	1.4	23,9	1.8
Puerto Prado 40	2,340	25.6	1.5	23.2	0.1
Total Alt 1	-	579.6	-	-	-
Sumabeni[a]	1,790	131.0	1.5	26.5 0.5	
Cutiverini	1,900	423.0	1.4	23.9	1.8
Puerto Prado 90	2,340	126.0	1.5	26,2	0.3
Total Alt 2	-	503.0	-	-	1.2

a. Outside the Selva area.
b. Turbine volume over mean volume.
c. Maximum volume of the spillway over the mean volume.
d. Useful reservoir volume over the annual runoff volume expressed in the number of months of annual mean water volume.

Source: Federal Republic of Germany (1981).

From this summary of the rivers and watersheds, it can be seen that the Central Selva region contains abundant water resources that have yet to be fully exploited. Existing plans for their utilization, except for the Ene-Tambo hydroelectric effort, are relatively modest when compared to the area's true potential.

Measures required for water exploitation

The measures that must be taken to utilize water resources begin with the planning phase. Once a region containing water resources is identified, and an area that can use the resources proposed, the planner evaluates the social and economic benefits of the proposal, collecting basic data to determine water demands and to quantify available water resources. He studies future demand which depends closely on fixed social and economic parameters, such as agriculture and livestock production, urban population growth (including migration), water needs for predicted industrialization, and water and energy consumption by unit produced (Figure 5-2, Figure 5-3, Figure 5-4, Figure 5-5, Figure 5-6).

He must then evaluate the goods and services provided by water. Water demand, for example, must be satisfied at any cost, but for washing salts, it is necessary to determine the demand modules per soil unit through experiments on pilot areas. Likewise for contamination dilution demand it is necessary to determine contamination loads, pretreatment possibilities, and the water quality to be permitted following dilution. Sport and commercial fishing need to be identified, and their requirements established in accord with predicted annual yields of fish.

A small difference exists between hydroelectricity demand studies and studies of water demand for other purposes; electricity demand can be met by other than hydroelectric sources, while, for other uses, substitutes for water do not exist (Figure 5-3). The problem becomes even more complicated when the electrical systems under consideration feature hydroelectric plants interconnected with thermoelectric facilities. Thus, water demand for hydroelectric power can only be determined by noting the difference between electricity demand and the availability of all electricity-generating sources.

Among the more important aspects of planning are determining the availability of water resources, the cost of exploiting them, and the specific global implications of such exploitation. Such investigations are a necessary preliminary step to defining the programs and strategies to be carried out. Studies looking at the development potential of the resources need to pass through a process that begins with an inventory and that continues to pre-feasibility and feasibility investigations until final decisions are made for developing the project. (Figure 5-7) Such studies must also identify conflicts that can arise because of resource scarcity.

Figure 5-2 - INTEGRATED WATER RESOURCE DEVELOPMENT

Once the project area is identified, the project study steps begin, together with literature research, aerial photography, field studies, and hydrologic and geologic investigation. These investigations, carried out in stages because they are expensive, usually focus on the demands of the market, the economic potential of the project, and the project's predicted time span.

Office evaluations are always conducted before any prefeasibility studies. (Table 5-8) They estimate watershed project potential, the number of sites that should be investigates, and the expense of the field investigations. Such evaluations are also useful in establishing research priorities.

After completing the office evaluation, the planner identifies possible project conflicts with other interests already present in the area (quantifying these conflicts falls under the "special studies" category in the table, but identifying them begins with the identification of project sites). Next, he analyzes multiple use possibilities in the watershed, evaluates costs and potential land use, and investigates the logistical support necessary and locally available to build the project.

Figure 5-3
METHOD FOR DETERMINING WATER DEMAND FOR HYDROELECTRICITY

a) Method for determining electricity demand

b) Method for determining water demand for electricity generation

Figure 5-4 - METHOD FOR DETERMINING WATER DEMAND FOR HUMAN USE

The results of these special studies indicate interrelationships with other interests and activities, which can be positive (benefits) or negative (conflicts). It is not always possible to quantify the costs associated with these interrelationships, so, many times, indices are used to illustrate the activities and socioeconomic organization affected. These studies can provide the basis for selecting the best area for more detailed studies, the best project sequence for developing a watershed, and the best solution to meet a selected goal. Nevertheless, this information is still preliminary, and the planner must deal with such problems as choosing between diverse watersheds; defining the project sequence to meet diverse demands; comparing alternative investments (such as thermoelectric energy); considering projected demand and future water supplies as given when the risk that demand will not be met always exists; and defining the level of acceptable deficit cost risks for the lender.

Taking all of this into account, the planner comes to understand the balance between the potential water projects and the demands for water and arrives at alternative project sequences, each one with its respective costs and interrelationships with other projects and interests.

Figure 5-5 - METHOD FOR DETERMINING AGRICULTURAL AND LIVESTOCK WATER DEMAND

Figure 5-6 - METHOD FOR DETERMINING INDUSTRIAL (non-urban and non-mining) WATER DEMAND

Table 5-8
INVESTIGATION STAGES OF A WATER PROJECT

STAGES	OBJECTIVE
1. Office Evaluation	The first evaluation of the project possibilities; the number of localities where dams can be constructed and the cost of research to be conducted in subsequent project stages.
2. Prefeasibility	Evaluates the development potential of the entire watershed, studies the diversion of the available falls in the rivers and estimates the costs of each project.
3. Feasibility	Completely defines the physical characteristics of the project and studies its financing and economic aspects.

In practice, however, this process does not occur in an integrated form for all water uses. Usually, subsector plans are developed respectively for electricity, water supply, irrigation, etc. Projects are formulated that best meet the subsector objectives; competing interests are considered to be obstacles and are therefore ignored.

Identification of conflicts with other interests

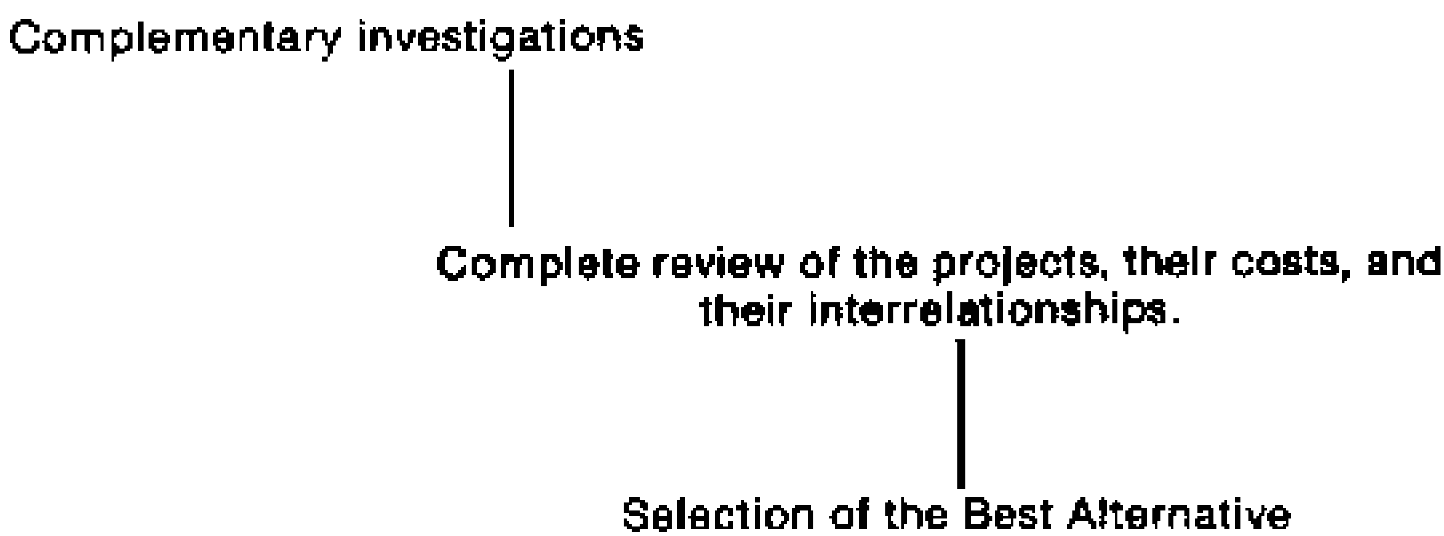
During the beginning of the planning phase, primary conflicts can be identified among the various interests intent on exploiting water resources. As the water project develops, other conflicts of interest usually appear - some between the consumers of the water product and others among those to be affected by the project's implementation. Others are provoked by hydraulic project construction and water resource management. The conflicts may be technological, social, economic, or institutional; they may occur from causes as wide-ranging as flooding, erosion, the dilution and transport of pollutants or the project's effects on climate.

Activities at every stage of a project interact with other interests both at the site or far away. For example, making a decision to proceed with a project immediately influences the prices of land, the availability of investors, and whether people will stay in the area or leave. Preliminary design activities at the site also directly affect the vicinity where construction will take place. Executing the project profoundly affects the construction area, as well as other interests outside it. Although most of these impacts have a positive economic effect on the community many can be less beneficial (Tables 5-9 and 5-10 illustrate, in percentage terms, the average cost of 12 hydroelectric plants constructed in Brazil, giving a clear illustration of the direct economic impact of project construction).

Figure 5-7
FLOWCHART FOR PREFEASIBILITY AND FEASIBILITY STUDIES

PRELIMINARY STUDIES

FINAL STUDIES



Big projects require large numbers of workers and follow time schedules which can last up to 10 years. The workers may come from other regions in the country, bringing their families with them when possible. They will certainly have an impact on the local culture, and may also bring with them transmittable diseases previously unknown in the project area.

Other problems are associated with the interruption of economic activities (particularly farming and grazing), the relocation of populations, and the pressures placed on infrastructure. Some landowners will have their lands expropriated and will be relocated to new sites, which will require the construction of new towns to support them and their work. People living in rural areas along the rivers may lose their homes when rivers rise because of a new dam. The area to be filled will have to be cleared and its fauna and archaelogical resources relocated.

Table 5-9
AVERAGE COST PERCENTAGES OF HYDROELECTRIC PLANTS WITH DAMS[a]

Average Cost of 12 Plants	%
Expropriation of lands and infrastructure	5
Relocations	3
Principal civil works	40
Equipment	25
Supporting infrastructure	9
Engineering and administration	18
Total	100

a. Constructed in Brazil.
Source: ELECTROBRAS (1982a).

Table 5-10
AVERAGE COST PERCENTAGES OF HYDROELECTRIC PLANTS WITH DAMS[a] (In terms of basic Investments)

Average Cost of 12 Plants	%
Expropriation of lands and infrastructure	5
Labor	31
Construction materials	23
Permanent and construction equipment	37
Transport of materials and equipment	4
Total	100

a. Constructed in Brazil.
Source: ELECTROBRAS (1982b).

To illustrate both process and problems, Figure 5-8 describes the steps required to develop a hydraulic work designed to provide water for various purposes: public water supplies, industry, non-urban and mining enterprises, livestock and agriculture, hydroelectric energy, nutrient transport, navigation, habitat for aquatic fauna, recreation, and tourism, and flood control; Figure 5-9 presents a simplified illustration of the interactions between a hydraulic work, its services, and the settlements to which the services are directed and gives a brief picture of the categories of problems that the planner must consider and resolve before approving construction.

Hydraulic works that do not include dams create less negative impact in areas such as the Central Selva that have abundant water, especially when the water being used comes from rivers with large falls. Problems associated with supplying water to neighboring towns or to agriculture and livestock operations can also be minor, since the quantity of water involved is small when compared with the volumes found in area rivers. Although the expropriation of lands at the project site can cause significant difficulties, lands neither upstream nor downstream from the site are negatively affected because river hydraulic regimens are not affected.

The services provided by the project to human settlements naturally represent an entirely positive impact.

On the other hand, the settlements can negatively affect both rivers and hydraulic works that serve other settlements, causing water pollution and sedimentation caused by soil erosion. The small size of this type of work prevents it from resolving problems caused by natural conflicts, such as floods or droughts.

Generally, hydraulic works with dams cause the most notable impact on the human and natural environment. This is true not only of large dams, but also of dams constructed in ravines. Small ravine dams can be used for several purposes, such as controlling erosion, reducing the impact of rising waters, raising low water tables, breeding aquatic species, enriching water with nutrients, and enabling water to be used for irrigation on hillsides. Care must be taken, however, not to cause the proliferation of diseases and mosquitoes.

Dams are capable of controlling the regimen of rivers, especially their low-water flows (large flow increases are usually only superficially controlled by dams). For example, the Puerto Prado Alto hydroelectric plant on the Tambo river, which has an average monthly low-water flow of 293 cubic meters per second (m^3/s), can maintain, for one month, a flow of 727 m^3/s. The 100-year flood, however, is eight times greater than the useful storage volume of the reservoir and the spillway must be designed in this case to accommodate 61,300 m^3/s, for an error made in operating the spillway can cause large floods. Once every five years, the river's water flow increases at this location up to 16,000 m^3/s. The project also is capable of altering hourly water volumes. It can change the volume passing through the turbines, increasing it to 50 percent more than the annual average.

Figure 5-8 - ACTIVITIES REQUIRED FOR DEVELOPING A WATER PROJECT

Another important function of dams is their capacity to trap sediments. This can cause two important changes: it can reduce the nutrients available to downstream fauna and flora, and increase the erosive capacity of the waters below the dam. Puerto Prado Alto is capable of trapping 62 percent of the sediments transported to the site.

The control of water flow and the trapping of sediments have both positive and negative consequences. For example, increasing minimum water flow facilitates downstream navigation; while reducing water flow reduces financial damage and loss of life downstream; reducing more frequent water flow increases, however, can adversely affect downstream agriculture dependent on them. Trapping sediments reduce the amounts deposited downstream, which can benefit navigation but can increase the erosive capacity of downstream water, and remove productive land along the original channel until a new soil equilibrium is attained; removing sediments increases the useful life of reservoirs downstream, but reduces the nutrients available to downstream fauna; and the erosive capacity of water used in operating the dam can affect the river's morphology downstream.

Figure 5-9 - INTERACTIONS CAUSED BY HYDRAULIC STRUCTURES

Thus, the operation of a dam can have a great impact on downstream conditions. Planners must, therefore, confront the problem of communicating this to people having an interest in downstream conditions.

Dams also are barriers that negatively affect fish, navigation, and population and ecosystems and, not only the dam, but the reservoir created by permanently flooding an area once covered with vegetation, can also create problems for many interests. Permanent inundations can eliminate forests, interrupt agriculture and livestock operations, and relocate human constructions and human and animal populations. The flooding can also damage the water quality in the reservoir itself. For example, decomposition of vegetation can alter the chemistry and biology of reservoir water. Decomposition commonly produces sulfuric acid and methane, both of which negatively affect equipment and aquatic life.

When high nutrient levels produce a proliferation of aquatic vegetation that increases the amount of decomposing organic material, more water is lost through evaporation, while the plants remaining in the reservoir can impede navigation, net fishing, and tourist and recreational use of the reservoir. Although such vegetation serves as a source of nutrients for fish, its presence conflicts with other uses. This unstable condition ends only after much of the vegetation is removed from the reservoir, a process that can require many years.

Human settlements and agriculture and livestock operations can also have a negative impact on reservoirs. Potentially significant can be bodily wastes, erosion that causes an increase in sediments and pollution that can transform reservoirs into sources of downstream diseases.

Problems do not only occur because of permanent inundation, but because of water volume fluctuations that cause the expanse of flooded areas to vary. For example, mosquitoes proliferate in areas that are uncovered following long periods of submersion, and people living alongside reservoirs can suffer difficulties when the distance to the water's edge increases during low water periods.

In the Puerto Prado Alto project 136 Km^2 will be inundated, with the operating water level varying by 20 meters. Nevertheless, the energy production capacity of this inundated area is small compared with projects in Brazilian Amazonia. The index that illustrates the productivity expected of the reservoir, in this case electrical energy, shows the benefit that low-reservoir water levels can provide. On the other hand, it does not reflect that these energy benefits are probably destined for distant areas, while associated problems will occur both at the site and downstream from the reservoir.

Reservoirs can also cause significant temperature and atmospheric changes when conditions altered by watershed use are being reestablished. In the present case, these changes will not be great as the area has much available permanent water. Besides producing hydroelectric energy and controlling water volume, reservoirs can be useful for sport and commercial fisheries, trade, recreation, and tourism.

Man can also affect the services provided by water. For example, dams can alter rapids to change the types of boats normally employed in the area. Or problems can arise when there is no satisfactory way to distribute the new water supply and when water shortages result from water loss and improper water use. Such problems frequently afflict rural populations. Those people often, therefore, need to be educated in proper water use, especially when they are relocated to areas served by unfamiliar water systems.

Drainage works can also have a significant impact on ecosystems. Even when they do not include dams, they can alter hydrologic regimens and sometimes influence distant areas. For example, the Brazilian Pantanal de Mato Grosso buffers the effects of the high water periods of the Paraguay and Parana Rivers, which are not synchronous. Thus, while draining a swampy area can increase land available for agriculture, such action needs to be carefully analyzed to determine its impact both in the area and downstream.

Finally, it is important to mention some natural phenomena and their impact on hydraulic works. Some hydraulic works can partially control some natural phenomena, such as floods. Natural phenomena, however, can increase project costs. They can require increasing the size of drainage works to accommodate rising water, building dams to regulate low-water volumes, and strengthening structures to withstand seismic tremors.

When no hydraulic constructions exist on a river, the people living downstream believe natural disasters are sent from God. When a dam is built, however, it becomes the cause of all the problems. More than anything, this is a communication and education problem between those responsible for the project and those to be affected by it and intensifies the need for careful planning, with full participation of all the people who will build and benefit from the new waterworks.

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Chapter 6 - Wildlife

The fauna of the Peruvian Central Selva is representative, in qualitative terms, of the fauna in other American humid tropical forests. But the numbers and varities of species here are peculiar to the Selva alone because of the mountainous and man-made ecosystems found here.

The vast majority of wildlife in the region consists of invertebrates, including perhaps as many as two million insect species and a much smaller number of vertebrates (some 250 species of mammals, 1,200 species of birds, and 300 species of reptiles and batrachians). As many as 85 percent of the birds and 82 percent of the neotropical mammals may be endemic to this region alone.

Another characteristic of the fauna in the American humid tropics is its great diversity, with impressive numbers of species occurring in small areas. This diversity is generally accompanied by a reduced number of individuals of each species found in a given region.

Overall, mammals here are small in comparison with those found in the Asiatic and African humid tropics. The heaviest animal is the tapir which hardly reaches 300 kg in weight. Peccaries weigh 20-30 kg, while deer weigh 16-21 kg. Similarly, terrestrial vertebrate biomass is low, averaging 10-30 kg per hectare. The remainder of the animal biomass is made up of invertebrates such as acarids, soil collenbola, ants, and termites, and can be less than 200 kg/ha (Fittkau and Klinge, 1973).

Wildlife exploitation: Goods

Food for Human Consumption

Meat is one of the principal goods provided by wildlife in the Central Selva as well as in other localities in the American humid tropics. Studies carried out in Peru and Brazil have demonstrated that hunting provides rural inhabitants with from 10-465 grams per capita of fresh meat daily (Berlin and Berlin, 1978; Denevan, 1971; Smith, 1976; Pierret and Dourojeanni, 1967; Rios, *et al*, 1973). Some of the highest and lowest numbers refer to the Central Selva: only 10 grams per capita are consumed daily by the Campa natives from the Gran Pajonal region (Denevan, 1971), and 465 grams daily by colonists from the Pachitea river area (Pierret and Dourojeanni, 1966). More recently, Gaviria (1980) recorded a daily consumption of 108 grams among the Campas in the Pichis river region. Taking into account the fact that fresh fish provides approximately half of the protein supplied by the same weight of fresh meat, it can be seen that hunting contributes 34-40 percent of the protein consumed in the Peruvian Amazonia (Table 6-1). This is slightly less than the protein contribution of fish and much more than that supplied by poultry, swine, and sheep.

Table 6-1
CONSUMPTION OF MEAT FROM WILD ANIMALS AND OTHER SOURCES IN PERUVIAN AMAZONIA (In grams of fresh meat per capita per day)

Sources	From Pucallpa to the Ucayali River	In Jenaro Herrera (Ucayali River)	Along the Pichis River
Fish	135,6	158.3	275
Wild Meat	52,0	75.8	108
Poultry Swine	22.1 12.0	25,7 10.2	9 12
Sheep	insignificant	insignificant	
Total	221.7	270.0	404

Source: Pierret and Dourojeanni (1967), Rios, *et al*, (1973), Gaviria (1980).

Although approximately 100 species are consumed by natives, and 60 by colonists, only some 15 species are consumed frequently (Table 6-2). Of these, *Cuniculus paca*, *Tayassu tajacu*, *Tayassu pecan*, *Geochelone denticulata*, *Dasyprocta variegata*, and *Mazama americana* account for 70 percent of wild animal consumption. The contribution of small game is equal to or slightly greater than that of big game.

Preferred meat comes from the monkeys *Ateles* and *Lagothrix*, the agouties (*Cuniculus* and *Dasyprocta*) and some birds (*Penelope* and *Mitre*). Also appreciated is the meat from peccaries (Tayassu) and deer (*Mazama*). In contrast, the meat from tapir (*Tapirus terrestris*) and capybara (*Hydrochoerus hydrochaeris*) *are* held in low esteem, although exceptions to this attitude are known: the capybara is very popular in Venezuela (Ojasti, 1971).

Terrestrial invertebrates can represent 3-7 percent of the animal protein consumed by natives and less of that consumed by colonists. Appreciated are coleoptera larvae found in the palms *Rhynchophorus* and *Rhinostomas* and caterpillars of several lepidoptera, as well as the queens of the ants *Atta* and *Acromyrmex.* Various terrestrial molluscs, such as those belonging to the genus *Strophocheilus*, *are* also eaten (Dourojeanni, 1965).

Table 6-2
CONTRIBUTIONS OF FAUNA TO THE DIETS OF RURAL POPULATIONS IN PERUVIAN AMAZONIA (In percentage)

Species	Ucayali River	Pachitea River
Small Game		
Cuniculus paca	14.8	16.5
Geochelone denticulata	9.9	17.2
Monos[a]	9.3	6.6

Dasyprocta	5.8	5.7
Aves[b]	3.1	2.5
Dasypus	5,1	2.1
Big Game		
Tayassu *tajacu*	12.6	16.6
Tayassu pecan	21.1	3.1
Mazama americana	8,1	17.4
Tapirus terrestris	10.1	6.8
Hydrochoerus hydrochaeris	-	5.4

a. Monkeys (*Ateles, Lagothrix, Saimiri*).
b. Birds (*Mitu, Crax, Penelope*).
Sources: Pierret and Dourojeanni (1966,1967).

The most avidly-sought eggs in the American humid tropics belong to the river turtles *Podocnemis expansa, P. unifilis,* and *P. sextuberculata* (Mittermeier, 1978; Ojasti and Rutkis, 1965,1967; Padua, 1981), but crocodile, tortoise, and some bird eggs are also exploited.

Honey from the wild bees *Melipona* and *Trigona* is used by natives and colonists, both directly and mixed with spirits. Some knowledgeable rural people obtain oil from the river frogs *Inia* and *Sotalia, as* well as small quantities from animals hunted for their meat. Colonists in the mountains obtain oil from the young of the oilbird, *Steatornis caripensis*, taking them from their nests in caves.

Skins and Hides

The best known and most abundant hides come from peccaries (Tayassu *tajacu* and *Tayassu pecan*), deer (*Mazama americana* and *M. gouazoubira*), crocodiles (*Melanosuchus niger* and *Caiman crocodylus*) and capybara (*Hydrochoerus hydrochaeris*). The greatest number of skins, and the most desired ones, come from the ocelot, *Felis pardalis;* otter, *Lutra amazonica,* kinkajou, *Potos flavus;* margay cat, *Felis wiedii*, jaguar, *Panthera onca;* and giant otter, *Pteronura brasiliensis.* From 1965 to 1976 475,000 skins and more than 5 million hides were legally exported from Peru (Peru, 1977) while contraband and customs underevaluations, along with poor grade specimens, could easily account for as many more (Dourojeanni, 1972).

Live Animals

A considerable number of live animals are captured and exported for decorative purposes and to serve as household pets. Most of these are birds belonging to family Psitacidae, parrots and their kin, but monkeys and other animals are also exported. In 1964 27,837 Psitacidae and 1,808 other birds left Iquitos for other parts of Peru, while 2,491 more were exported directly, as were 36,000 monkeys.

Primates are frequently used in scientific research, usually in biomedical studies in developed countries. Whitney (1976) points out, however, that of the 47,345 South American primates entering the United States in 1972, only 11,300 were destined for biomedical research, of which one half were *Saimiri sciureus* followed *by Aotus trivirgatus* and *Saiguinus mystax.* World demand for neotropical primates for this purpose could reach approximately 29,000 animals by the year 2000, most of which will be *Saimiri*, *Saiguinus, Cebuella, Cebus, Calithrix,* and *Aotus*. Other species are also used, including armadillos (Dasypus), oppossums (*Didelphis*), and peccaries (Tayassu). Many live captured animals are exported annually to zoos (an average of 150 species a year with different ones being exported each year) while circuses have more selective demands, particulaly for spectacled bears, *Tremarctos ornatus,* jaguars, and other spectacular animals. Present demand for live animals from the humid tropics for domestication purposes is limited, but could increase, notably for animals belonging to the genera *Cuniculus, Dasyprocta, Tayassu,* and *Tapirus.*

Interest in some vertebrates and invertebrates - especially insects - is growing because of the increasing importance of biological control of pests to agriculture and livestock development in the world's humid tropics.

Cottage Industry Products

Natives, colonists, local speculators, merchants, artisans, exporters and importers use diverse wildlife products, including feathers for fans, arrows, and headbands; beaks and cat teeth for necklaces and amulets; bones from many species for necklaces, arms, musical instruments and decorative objects: the feet and claws of felines and primates for amulets; tortoise and armadillo carapaces for musical instruments, and mounted bird and mammal specimens. Insects used include lepidoptera (*Morpho* and others), used in pictures, brightly-colored wings of scarab beetles, and specimens of the harlequin beetle *Acrocinus longimanus* and *Laternaria* beetles of the family Fulgoridae. One *Laternaria* beetle cost US$9 in 1964 in Tingo Maria.

Traditional Medicine and Magic

Serpents, frogs, and toads are considered to be of great value to local populations, especially among natives and old colonists, in traditional medicine and magic. Dolphins and procyonids (*Procyon*) among others are sought for the supposed aphrodisiac and magical qualities of some of their organs.

Medical Investigation

The armadillo *Dasypus novemcinctus,* known as the "carachupa," has been selected for medical research because of its low body temperature (32-34° C), and because a large number of these animals become sick with systemic leprosy while others are not affected by the disease. This is considered a model animal for studies of susceptibility and resistance. To obtain an idea of the animal's importance, it is estimated that a gram of infected armadillo tissue contains between 109 and 1,010 bacilli that can be isolated in a pure form. With such an enormous accessible bacterial population, preventive and curative vaccines have been produced and an antigen prepared that can help improve the condition of seriously ill patients and prevent those living with afflicted individuals from catching the disease.

Primates have become enormously significant in medical studies. Some monkeys, such as the pichico *Saguinus fuscicollis, are* widely distributed in Amazonia and are quite important in cancer research and arteriosclerosis investigations. The musmuqui, *Aotus trivirgatus,* is being utilized in human malaria studies because it is capable of becoming infected with *Plasmodium vivax* and *P. falciparum,* and with *P. malaria.* Occasionally, epizootics of yellow fever can occur in *Alouatta* monkeys, causing high mortality; other monkeys, including *Atetes, Saimiri, Cebus, Callicebus, Saguinus,* and *Aotus,* are also susceptible. All these animals are important because they can be used for more complete investigations of parasites, host reactions, chemotherapy treatments, and immunization tests.

Important studies now being conducted with monkeys focus on human hepatitis A. *Saguinus mystax* is used as an experimental model for serological tests for application in diagnosis and in epidemiological studies that can be useful in controlling and preventing this disease. This monkey can also help produce standard human immune globulins for hepatitis A vaccines while titi monkeys have been used in developing vaccines for hepatitis B. Not surprisingly, so many monkeys have been harvested in recent times that legal measures prohibiting their exportation have become necessary.

While biomedical investigation with fauna is flourishing, more direct research is needed into jungle animals that serve as reservoirs of parasites, bacteria, and fungi. It is important to know, for example, if the perezozo (sloth), the *Myrmecophaga tridactyla,* (giant anteater), and the *Tamandua tetradactyla* (lesser anteater), play an important role in leishmaniasis. We also need to know whether the tigrillo or ocelote, *Felis pardalis, as* well as other felines in Amazonia, are definitive hosts in the toxoplasm cycle, which would explain the high incidence of jungle toxoplasmosis.

Venomous snakes are important to pharmacology and medicine. The Aguaruna-Huambisha Community has attempted to breed snakes for commercial venom extraction and the development of mono- or polyvalent sera. The Department of Venomous Animals of the National Health Institute is constructing, with international assistance, a breeding facility in Pucallpa. This facility, in the animal's natural environment, shows great promise in producing more potent venoms and more effective sera.

Because there is such a large variety of venoms from Peruvian snakes, it is necessary experimentally to determine their pharmacological effects. Fourteen *Micrurus* and more than 11 *Bothrops* species exist, in addition to the unique species of the genus *Lachesis, L. muta,* and the rattlesnake, *Crotalus durissus terrificus,* in Puno Department. More information also needs to be gathered about Peruvian scorpions, although preliminary research indicates that they do not cause serious health problems. Little is known about the chilopods or centipedes beyond a few clinical descriptions, as well as the bites of ants and wasps, and the urticant action of the hairs of some caterpillars.

Collection

Considerable collection of all types of animals occurs for scientific purposes, especially for taxonomic studies. As much of this activity is not carried out by scientists it can be profitable for its purveyors. Many collected animals, particularly insects, are sold to hobbyists, while the heads and skins of jaguars, pumas, spectacled bears and occasionally tapirs are sought as hunting trophies.

Wildlife exploitation: Services

Wildlife's role in natural cycles is of transcendental importance, particularly the role invertebrates play in recycling organic matter. The evolution of flora and fauna depends on selection pressure applied by the animals that feed on, compete with, and interact in other ways with them. Regulating population densities of plants is also a crucial role for animals, one essential for maintaining natural genetic diversity.

Many economically important plants cannot prosper in the absence of pollinating insects and birds that sometimes are quite species-specific. For example, the Brazil nut tree, *Bertholletia excelsa*, depends on wild bees for pollination, as do numerous domesticated fruit trees. Many other wild plant seeds must pass through animals' digestive tracts before germinating.

Such animals as otters, giant otters, and crocodiles keep fish populations stable by eating the old, the sick, and the weak; terrestrial predators fill the same role with their prey species. Large crocodiles and capybara populations that used to inhabit some water courses seem to have helped sustain some fish stocks with their excrement. Both aquatic and terrestrial insects are an important food source for fish.

Wildlife in the humid tropics is an important tourist attraction, of both conventional and scientific, and foreign and domestic interest. Although not as spectacular as African wildlife, the fauna of the American humid tropics is famous for its diversity.

The animals of the American humid tropics are less frequently hunted for sport than wildlife in other parts of the world, because of both the low number of potential trophies and also the difficulty of hunting where there is low visibility, where the animals have nocturnal habits, and where there are bothersome insects and high temperatures. Nevertheless, they do attract some local, national, and foreign hunters. Small game species include birds, primates, rodents, armadillos and others; while peccary, tapir, and deer are sought-after big game.

Religious and moral beliefs have given human beings a profound sense of responsibility for the survival of their species. But the species most in danger of extinction today are often those most economically valuable to man. Table 6-3 presents a still incomplete list of those species in danger of becoming extinct in the Central Selva and in other parts of the American humid tropics.

Wildlife exploitation: Management

Since exploitation of wildlife varies in intensity, the degree of management can also vary; extensive, intensive, and superintensive alternatives can all be carried out (Table 6-4).

Extensive management refers to harvesting wildlife in the absence of a reliable census. Significant ecosystem manipulation is not usual, although some can be accomplished when done in concert with forest management. Low cost wildlife habitat management may also be achieved in woodlots on agriculture and range land. It is frequently the only type of management successfully implemented in the humid tropics. It can be carried out at regional or local levels and can incorporate hunting quotas according to sex and species, hunting seasons, hunting restrictions, minimum size requirement, arms and munitions regulations, and regulating traps and other capture methods.

Intensive management is implemented when it is possible to measure animal populations with some degree of accuracy and when it is cost-effective. I n humid tropical forests such management is applied only on small and isolated tracts of land and along water courses. Censuses, like all other advanced techniques, are justified when they are part of a package that includes significant environmental manipulation to control natural enemies, favoring vegetation that supplies wildlife food and cover, creating special breeding conditions, providing minor elements, etc. While hunting quotas in extensive management should be conservative, intensive management allows more precise adjustment according to biotic potential and is therefore more effective.

Table 6-3
FAUNAL SPECIES PROTECTED BY PERUVIAN LAW IN THE CENTRAL SELVA

Species in danger of extinction	
Pteronura braisilienses	

Vulnerable species	
Ateles paniscus	*Priodentes giganteus*
Saimiri sciureus	*Tremarctos ornatus*
Saguinus mystax	*Felis pardalis*
Cebus apella	*Panthera onca*
Cebus albifrons	*Flupicola peruviana*
Aotus trivirgatus	*Melanosuchus niger*
Pithecia monachus	*Caiman crocodylus*
Alouatta seniculus	*Podocnemis expansa*
Cyclops didactylus	*Podocnemis unifilis*
Tamandua tetradactyta	*Eunectes mirinus*
Myrmecophaga tridactyla	*Boa constrictor*
Rare Species	
Dinomys branickii	
Species of indeterminate status	
Potos flavus	*Felis yaguaroundi*
Fells wiedii	*Pudu mephistopheles*

Superintensive management features almost complete control of a special environment (such as in an animal breeding center) and can be either artificial (cages, pens, or pools) or semi-artificial such as a managed natural lagoon.

Unmanaged exploitation is the most common type of wildlife exploitation in the American humid tropics and probably will continue to be for decades. Such exploitation is not necessarily destructive if practiced by a small number of hunters on a wide area. It is, however, damaging where large numbers of hunters and heavy harvesting rates occur such as near new settlements and farmhouses.

Farm-Forest Ecotones

Legislation in Peru, Brazil and other countries requires from 15 to 50 percent of agricultural land be left in forest cover. Although these stipulations are rarely complied with completely, they contribute to the formation of a mosaic of agricultural, livestock, and forested areas creating ecotones, or transitional zones that encourage the proliferation of certain useful wildlife species. For example, rodents the paca and the agouti - can feed on domesticated plants, such as manioc and bananas in fields and young *purmas* and find refuge in climax forests or older *purmas*. Management techniques in these areas vary according to the available habitat, the wildlife species present, the size of their populations, and the management objectives. Management can focus, for example, on export species, or on wild meat production.

Table 6-4
WILDLIFE EXPLOITATION ACTIVITIES IN THE AMERICAN HUMID TROPICS

Activities	Principal Beneficiaries	Management Level	Principal Products

Unsound or unmanaged exploitation	Peasants, professional hunters, merchants	None	All classes
Management of agricultural land-forest ecotones	Farmers	Intensive or extensive	Locally-consumed meat and live animals
Managed forests under ordination	Professional hunters, wood-harvesters, merchants	Extensive or intensive	Meat, skins, hides, live animals
Exploitation of forests not under ordination	Professional hunters, wood-harvesters, merchants	Extensive	Meat, skins, hides, live animals
Management of protected forests	Professional hunters and merchants	Extensive or intensive	Meat, skins, hides, live animals, trophies
Management of grassland	Stockmen	Intensive	Meat for industrial use, hides
Management of riverbanks and water courses	Peasants, professional hunters	Extensive or intensive	Skins, hides, eggs
Management of hides, live animals artificial and semi-artificial conditions	Businessmen, specialized workers	Super-intensive (Breeding)	To be used in research
Management for tourism	People involved in tourism, workers	Intensive	Recreation, aesthetic experiences

Wildlife Management in Forests

Exploited forests in the humid tropics harbor wildlife that can provide sustained yields of various products.

Managing this wildlife can easily complement forest product management and maximize land use and profits. Such management may increase numbers of desirable species or reduce the populations of others.

On managed forests where 20-30 percent of the standing commercial timber is extracted on 50-year rotations, and where natural regeneration is accompanied by some silviculture, wildlife production can equal or slightly exceed that occurring under natural conditions. Since censuses are so difficult to carry out, extensive management is recommended for such situations.

A percentage of forests (10% or more), should be left intact as productive habitat. One or more tracts can be carefully located near water supplies where wildlife is abundant, to serve as animal reservoirs to repopulate surrounding hunting areas. Forested strips of at least 200-2000 mm wide separating clearings can also be considered to assure conservation of genetic diversity of plants and animals. Maintenance of gallery forests is important to protect aquatic resources, on which depend such species as otter, giant otter, and lizards; and to preserve terrestrial wildlife's drinking water supply.

Wildlife in these forests do best when the woods are reforested with the widest possible diversity of native species and age classes, especially trees that produce edible fruit.

Wildlife Management in unmanaged forests is less expensive than in managed forests and is very similar to that practiced in forest reserves. The principal difference is that harvest in unmanaged forests is unplanned and uncontrolled, which threatens the animals' health and safety and makes it more difficult to control illegal hunting.

In forest reserves, on the other hand, the vegetation remains unaltered but wildlife populations are adjusted to the areas carrying capacity. There tend to be more birds than mammals in forest reserves, leading to different management objectives. Sound wildlife management in reserves can attract profitable tourism and provide a non-destructive forest use that would help conserve soil, water and genetic resources.

Pasture Management

Pastures established for livestock also offer suitable conditions for certain wild animals living in bordering forests, such as deer and capybara, although the young of capybara is considered a serious competitor for grass. Nevertheless, the capybara is managed on the Venezuelan plains together with livestock, and it has been proven that controlled densities of this animal do not compete with livestock (Ojasti, 1973; Ojasti and Medina, 1972). In fact, given their reproductive potential and their efficiency in converting plant food to animal tissue, they offer a promising economic alternative (Ojasti, 1973,1978) (Table 6-5).

Management of Shorelines and Water Courses

Many of the most valuable wildlife species of the humid tropics live along the shorelines of rivers, lagoons, and streams and in the water courses, themselves. These include the otter *Lutra*, the giant otter *Pteronura*, the capybara, crocodiles *Melanosuchus, Caiman, Crocodylus*, the yapok (*Chironectes*), and the river turtle Poctocnemis.

Problems confronting the fauna associated with aquatic environments are deterioration of shoreline vegetation, water pollution, constant disturbance from navigation, fishing, and other human activities, and difficulty in controlling the illegal hunting that is so easily conducted from boats. When streams and lesser water courses cross forest reserves, exploited forests, woodlots in agricultural and livestock areas, and grasslands, their fauna merit careful management. This requires not only the measuring and evaluation of the most important species and the setting of conservation quotas, but also the maintenance of shoreline vegetation.

Rivers and lagoons can be managed intensively. For example, beaches used for nesting by turtles and crocodiles can be strictly protected from human abuse, and the eggs and young of these animals can be protected from their natural enemies. Brazil has extensive experience doing this with *Podocnemis expansa* (Brazil, 1973; Alfinito *etal*, 1976; Padua, 1981). Preliminary work has been carried out in Peru with crocodiles (Vasquez, 1981), as well as in other Amazonian countries (Blohm, 1973; Rivero, 1973), which suggest diverse management alternatives.

Management in Artificial Conditions

Wildlife management in semi-artificial and artificial conditions is practiced in Peru and Brazil with primates and crocodiles with excellent results (PAHO, 1976, Keliman, 1977; Coimbra-Filho, 1965; Coimbra-Filho and Magnanini, 1972; Coimbra-Filho and Maia, 1976,1977). Also discussed have been the possibilities of breeding numerous species of mammals, boas, and birds in captivity (Heltne, *et at*, 1980; Otero, 1978). Experimental animal breeding centers are being established in Manaus, Brazil and in Jenaro Herrera and Iquitos, Peru.

Table 6-5
COMPARISON OF CAPYBARA AND CATTLE PRODUCTION IN THE MATO GROSSO PANTANAL REGION, BRAZIL

Species	Individuals per 3 ha.	Age when harvested (years)	Weight when harvested (kg)	Average weight gain (gs/day)	Total weight gain (gs/day)
Cattle	1	4.5	490	283	283
Capybara	18	1.5	35	63	1,134

Source: Negret (1979).

Management for Tourism

Fauna in the humid tropics can be managed primarily to enable them to be encountered by tourists. For instance, in Manu National Park animals can be gradually accustomed to human presence at the salt licks and watering holes where they usually congregate. Artificial illumination may allow observation of nocturnal activity while animals can also be attracted with salt and food to locations where they can easily be seen.

Conflicts and compatibility between wildlife conservation and use and other activities

Conflicts and compatiblity will depend on the degree of wildlife management underway, and the interests of the parties to the conflict. For example, a type of indirect conflict is the intervention of preservationists and conservationists to change or stop projects for the sake of the local or global survival of wildlife species.

Conflicts with Forestry Activity

In both wild and controlled forests wildlife can damage natural and man-induced plant regeneration. Insects damage seeds, seedlings, leaves, flowers, fruits, buds, bark, and trunks causing death, retarded growth, and reduction of the quality of forest products (Table 6-6). Well known examples are the shoot borer that attacks Meliaceae (*Hypsipyla grandella*), ants of the genus *Atta*, Curculionidae, Cerambycidae, Scolytidae, and many Lepidopterae. Other invertebrates and a few vertebrates also are plant pests. Insects can reduce the durability and quality of wood and other forest products. Principal culprits include termites, ambrosia beetles (Scolytidae and Platypodidae) and wood borers (Lyctidae, Bostrychidae, and Anobiidae). Damage to trees can also be done by deer rubbing their antlers, carnivores scraping their claws, and other animals gnawing on plants.

Forestry activity can of course have an enormous effect on wildlife - principally habitat alteration and destruction. The impact on wildlife will vary directly with the amount of timber harvested. While we know that forest clearing can benefit herbivores and, therefore, carnivores because grasses grow in the cleared areas, too much selective harvest can completely eliminate certain species of invertebrates and inconspicuous vertebrates. Wildlife habitat can be reduced by clear-cutting and other super-intensive harvesting methods, and by cutting forests that adjoin rivers, streams, lagoons, and *colpas* (salt licks where animals congregate to obtain minerals).

Inventories, road construction, cutting trees into logs, dragging and transporting them all can seriously disturb vertebrates, destroy bird nests and young, and trample reptiles and mammals, especially nocturnal species. If timber is extracted as part of a management program that allows the forests to recuperate, damage is minimal. If, however, forest exploitation is uncontrolled, as is frequently the case, damage is serious and long-lasting.

Conflicts with Agriculture

The most common conflicts are caused by both invertebrate and vertebrate pests attracted by crops. Wildlife management in ecotones and in woodlots in agricultural areas unquestionably can create some problems. These can include damage caused to agricultural crops, such as when Dasyproctidae attack manioc and monkeys and parrots eat bananas, papayas, corn, and cacao; damage to crops caused by the birds and rodents that find refuge in woodlots; damage to animals in pens, particularly poultry, caused by small predators that are either the focus of management, such as ocelot, or that are not, such as the *Tayra eira barbara*, various Didelphidae (*Glironia*, *Marmosa*, *Philander*, and *Didelphis*), and *Nasua nasua* and other Procyonidae; damage to livestock caused by diseases of which wildlife are the reservoirs, and by attacks of vampire bats, *Desmodus rotundus*. Deciding not to manage wildlife in woodlots and grasslands will not solve these problems, because rodents and injurious birds will proliferate even without forests nearby, due to the enormous abundance of food provided them by agriculture. Populations of small predators can also increase because prey such as poultry is available. Furthermore, in all colonies, abundant *purma* woodlots exist, as a consequence of shifting agriculture.

But the most serious conflict between the agriculture and wildlife sectors is habitat destruction. In the last 50 years more than six million hectares of Peruvian forest have been removed to make room for agriculture and livestock. At present, deforestation in Peru is proceeding at a rate of 250,000 hectares a year. In all of tropical America, 4,337,000 hectares of forest are being converted annually (FAO/UNEP, 1981).

Agriculture pesticide and fertilizer use can also be indirectly detrimental to wildlife. These contaminants can enter wildlife habitat through runoff, percolation to the ground water, and currents of air. Soil erosion caused by agriculture can pollute water courses and pesticides can produce explosive population increases of pests when they unintentionally destroy beneficial species.

Conflicts with Livestock

Many pests, particularly insects and acarids, can damage natural and cultivated grasses. Wildlife can also act as reservoirs for diseases that can affect livestock. Of these diseases, the best known in the tropics is rabies, which is maintained in various wild animal species, including bats. Deer can harbor hoof and mouth disease, while numerous insects, acarids, and other invertebrates act as livestock disease vectors.

Table 6-6
PRINCIPAL TERRESTRIAL WILDLIFE SPECIES CAPABLE OF CAUSING PROBLEMS IN THE CENTRAL SELVA

Scientific Name	Types of Damage
Family Didelphidae *Didelphis asarae*	Attacks poultry.
Family Cabidae and Callithricidae	Reservoirs of various human diseases, such as yellow fever, rabies, malaria, and hepatitis.
Family Emballonuridae, Phyllostomatidae, Vespertilionidae and Molossidae	Reservoirs of various human diseases such as rabies. Damage fruit.
Family Desmodontidae *Desmodus r. rotundus*	Attacks livestock and humans, reservoir of rabies and other diseases.
Family Bradypodidae *Choloepus hoffmani*	Principal reservoir of leishmaniasis.
Family Dasypodidae *Dasypus novencinctus*	Reservoir of leprosy. Damages pastures and crops.
Family Cricetidae *Orysomis sp.* and others	Pest of agriculture and stored products.
Family Hydrochoeridae *Hydrochoerus hydrochoeris*	Damage crops and competes with livestock for grass.
Family Dasyproctidae *Cuniculus paca* *L. Dasyprocta* *v. variegata*	Damage crops, particularly manioc.
Family Erethizontidae *Coendou b. bicolor*	Accidents caused by spines.
Family Mustelidae *Mustela frenata, Eira barbara*	Damage poultry and other small domestic animals.
Family Filidae *Felis pardalis*	Damage poultry and other small domestic animals.
Felis wiedii	Damage poultry and other small domestic animals.
Fetis concolor	Attack livestock.
Felis onca	Attack livestock.
Family Falconidae *Micrastur sp.*	Damages poultry.
Family Psittacidae *Amazona*, *Aratinga* y *Pionus*	Damage crops and fruit.

Family Icteridae, Fringillidae y Thraupidae	Agricultural pests, particularly rice.
Family Elepidae *Micrurus* spp.	Poisonous bites. Bites poisonous to humans.
Family Viperidae *Bothrops sp.*	Bites poisonous to humans.
Family Crotalidae *Lachesis muta*	Bites poisonous to humans.
Family Iguanidae *Iguana iguana*	Damages poultry.
Family Ranidae *Dendrobates* sp.	Poisonous cutaneous secretions.

Many of these pests are internal and external livestock parasites. Some wild herbivores, such as capybara and deer, can become competitors with cattle for both natural and cultivated grass (this competition, however, is rarely serious; in fact, the animals often complement each other, because each species has its own food preferences).

Attacks on livestock by predators, particularly jaguar and puma, is a somewhat less serious problem, caused by stockmen eliminating the usual prey of these carnivores. Ocelots and other wild cats, the tayra, *Tayra barbara.* the oppossum, *Didelphis,* and birds of prey of course all can prey on poultry. Finally, venomous serpents can kill livestock, with snakes belonging to the genera *Bothrops* and *Crotalus* doing the most damage.

Livestock operations usually reduce and destroy wildlife habitat less significantly than the agriculture that commonly precedes them. Nevertheless, as cattle ranching becomes more prevalent in the American humid tropics, livestock operations tend to destroy the natural vegetation along the shorelines of rivers, streams, and lagoons, devastating the wildlife that live in, or drink from, these water courses. Additionally, when livestock graze within a natural, planted, or second-growth forest, they prove detrimental to the forest and the fauna that live in it, and compete with the livestock for food.

Livestock also can harbor native and introduced diseases, such as hoof and mouth disease and hemorraging septicemia, that can affect wildlife. Meanwhile, dogs, which are sometimes used to control livestock and guard homes, are a constant danger to wildlife, since they will hunt wild animals if their owners feed them inadequately.

Conflicts with Fishing

Otters, giant otters, and crocodiles often compete with large fish for the same prey. Various aquatic mammals and reptiles can also damage boats and nets, but the scarcity of these animals make them less of a problem. More serious are fishing boats damaging wildlife such as manatees with their hulls and propellers. Nets and even fish-hooks can kill many turtles, young crocodiles, and other wildlife species.

Conflicts with Human Inhabitants

Illegal or poorly-conducted hunting is the principal way human inhabitants of the forest - farmers, stockmen, woodharvesters and villagers - damage wildlife. Most hunting is illegal, except that practiced by natives living in traditional ways. Furthermore, even hunting that is permitted by law can negatively affect wildlife if it is not carried out along with careful management. The following types of hunting are recognized: subsistence hunting, which is perhaps the least detrimental to wildlife; sport hunting; pest control hunting, which can be damaging depending on the method used and how intensively it is applied; and commercial hunting, which can be the worst of all.

Forest and petroleum workers that enter virgin territory have opportunities to take excessive numbers of animals. Large numbers of a single species (*Tayassu pecan,* e.g.) can also die when they cross rivers or pass through settlements, becoming easy prey to hunters who massacre them. The capture, storage, and transport to national and international destinations of live animals also causes substantial mortality, sometimes exceeding 50 percent, although price increases and restrictions on live animal commerce are diminishing this loss.

The mere presence of human beings in an area disturbs fauna, with some species leaving and others becoming accustomed to the situation. Human presence can seriously interfere with reproduction, while boat, plane, and nocturnal terrestrial traffic can cause wildlife accidents and produce disturbing noise. No less important is the damage inflicted on wildlife by urban and industrial pollution transported by wind and water.

Conflicts with Infrastructure

The inundation of extensive areas by man-made reservoirs is a classic example of human action eradicating or seriously affecting wildlife habitat. Hydraulic works, in particular, can increase humidity and create swamps; large constructions that include artificial lakes also modify the microclimate. Roads, dikes, and drainage works can interrupt faunal movement and migration.

Conflicts with Mining and Fossil Fuels

The principal problem created for wildlife by fossil fuel exploration and production is soil, air, and water pollution. Cases are well-known in which ruptured pipelines and salt water dumping in Amazonia have caused serious problems, but habitat destruction by strip mining is most frequent in the humid tropics.

Areas of compatibility between the wildlife sector and other sectors

Multiple Use

Multiple use of forests, grassland, and aquatic ecosystems is economically desirable, as it optimizes the use of diverse resources. On the other hand, it is often technically and economically difficult to implement. Successful multiple use of forests that includes the exploitation of forest wildlife has been well-documented in temperate regions. It should prove equally applicable to humid tropical regions. Natural grassland can simultaneously support livestock and wild animals, such as the capybara. Certain fisheries can also be managed in association with the management of some valuable wildlife species.

Biological Pest Control

Often both vertebrates and invertebrates are economically indispensable in reducing pest damage in forest plantations, grasslands, and cultivated fields. Insects, bats and birds which eat insects and snakes can control noxious rodents in agricultural areas. Further, crocodiles, which rarely attack humans, actively prey on piranha, which are notably dangerous to animals and man throughout Amazonia.

Utilizing the Ecotone Effect

As ecotones produce more than the ecosystems that form them, they have considerable wildlife potential. The most productive natural ecotones occur along the shorelines of water courses and the boundaries of swamps and seasonally-flooded areas. Human activity, particularly agriculture and livestock operations, creates other ecotones. These include cultivated field-forest, grassland-cultivated field, and grassland-forest ecotones, as well as ecotones formed by all of these environments with secondary herbaceous, shrubby, and forest environments.

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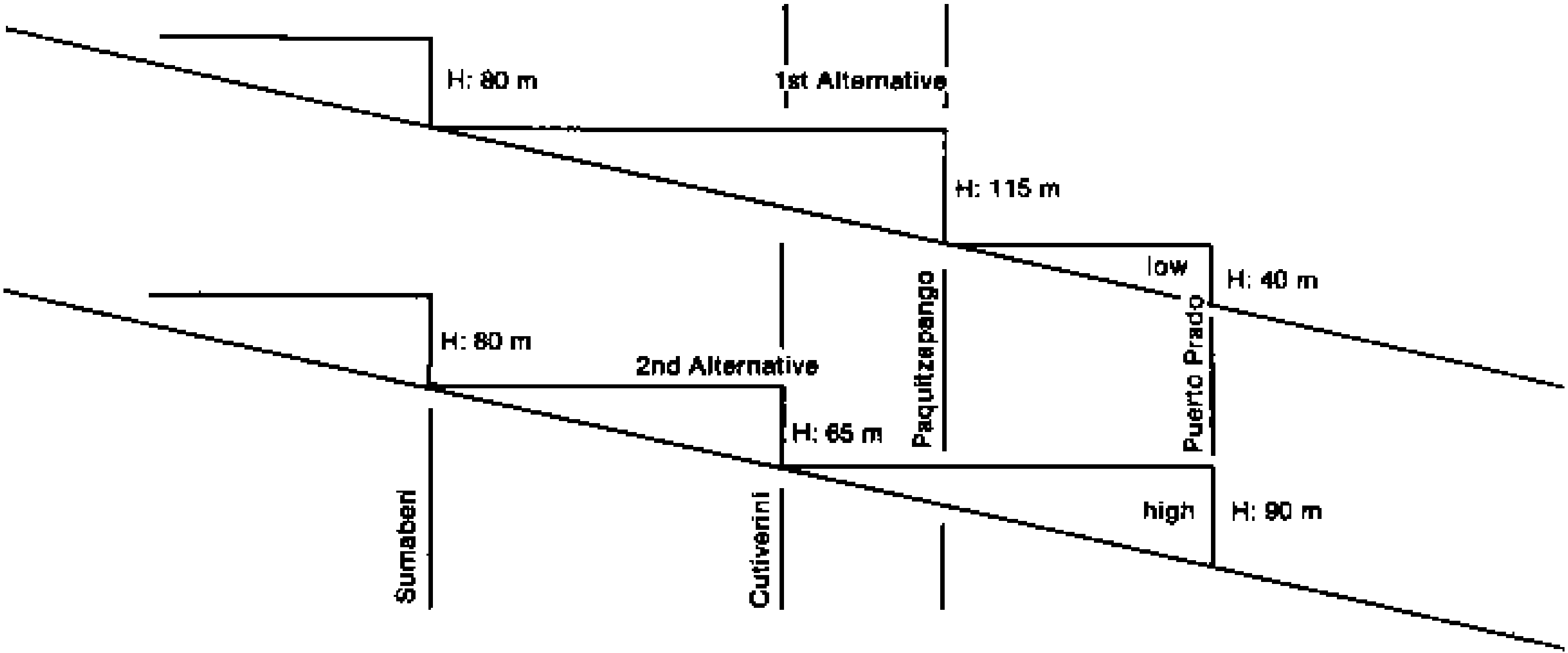
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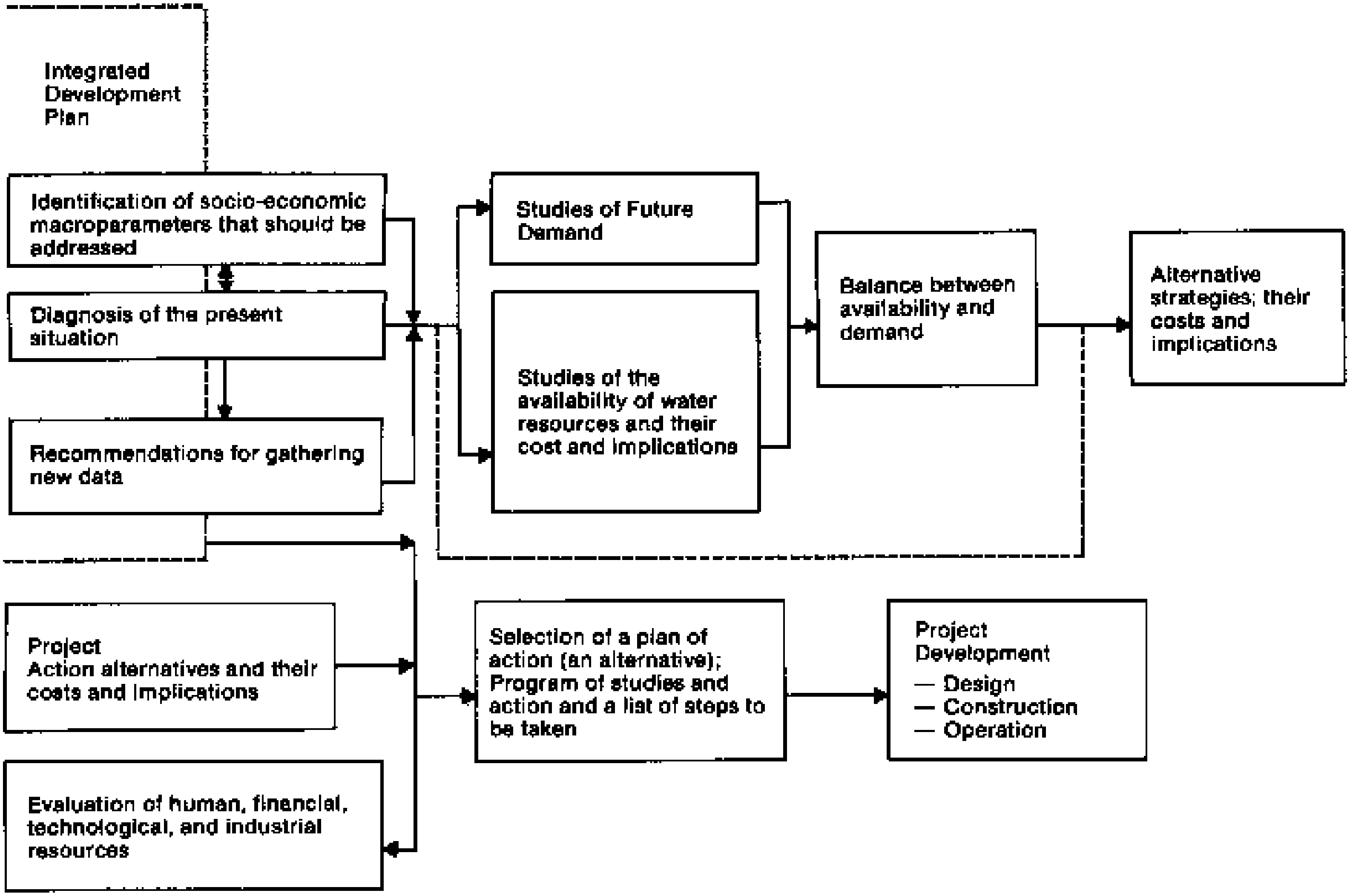
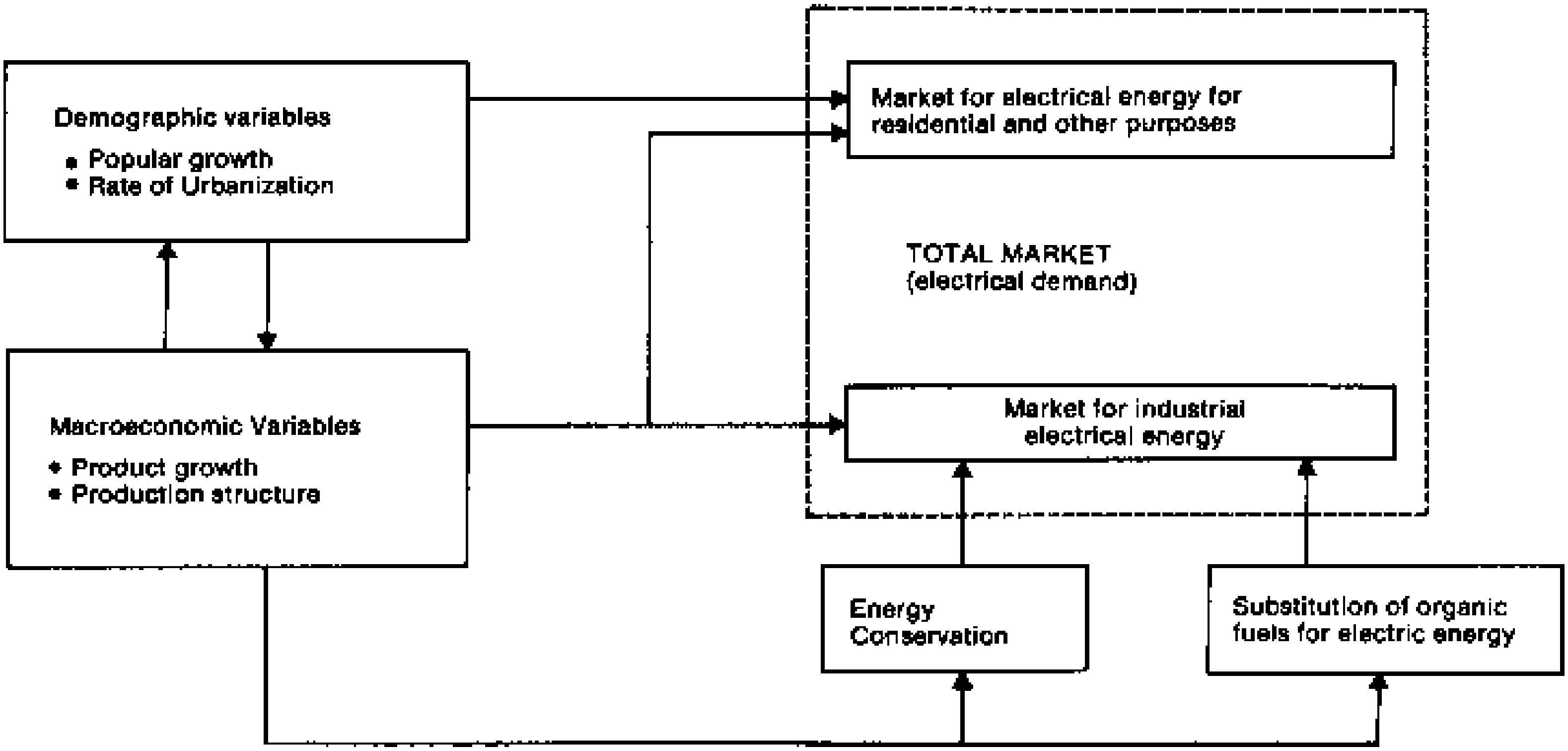

Integrated Development Plan
Identification of socio-economic macroparameters that should be addressed
Diagnosis of the present situation
Recommendations for gathering new data
Studies of Future Demand
Studies of the availability of water resources and their cost and implications
Balance between availability and demand
Alternative strategies; their costs and implications
Project Action alternatives and their costs and implications
Evaluation of human, financial, technological, and industrial resources
Selection of a plan of action (an alternative); Program of studies and action and a list of steps to be taken
Project Development
— Design
— Construction
— Operation


Demographic variables
• Popular growth
• Rate of Urbanization
Macroeconomic Variables
• Product growth
• Production structure
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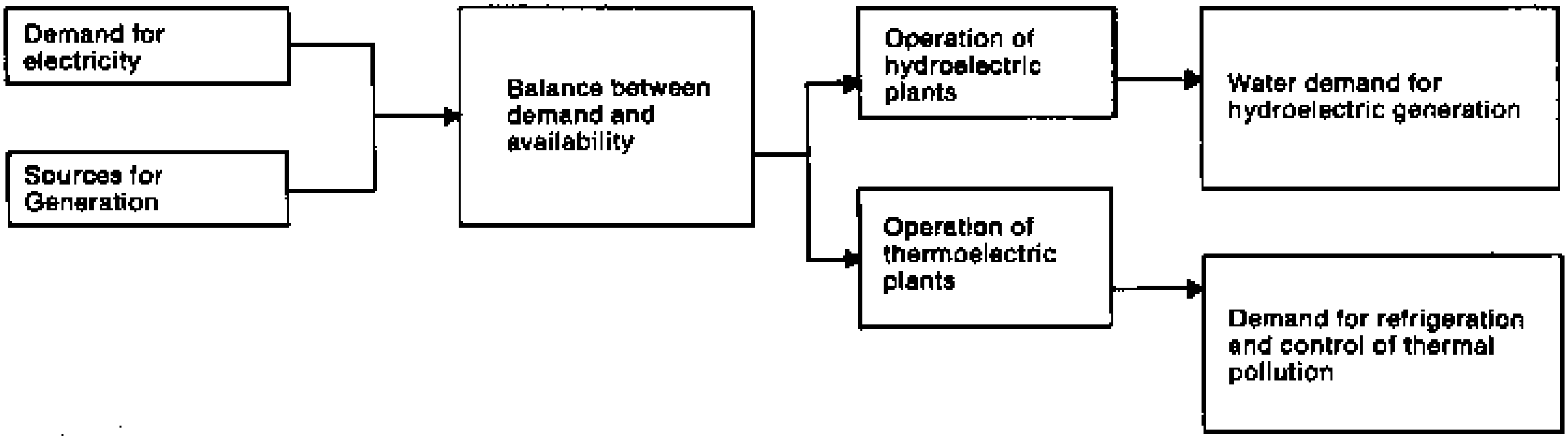
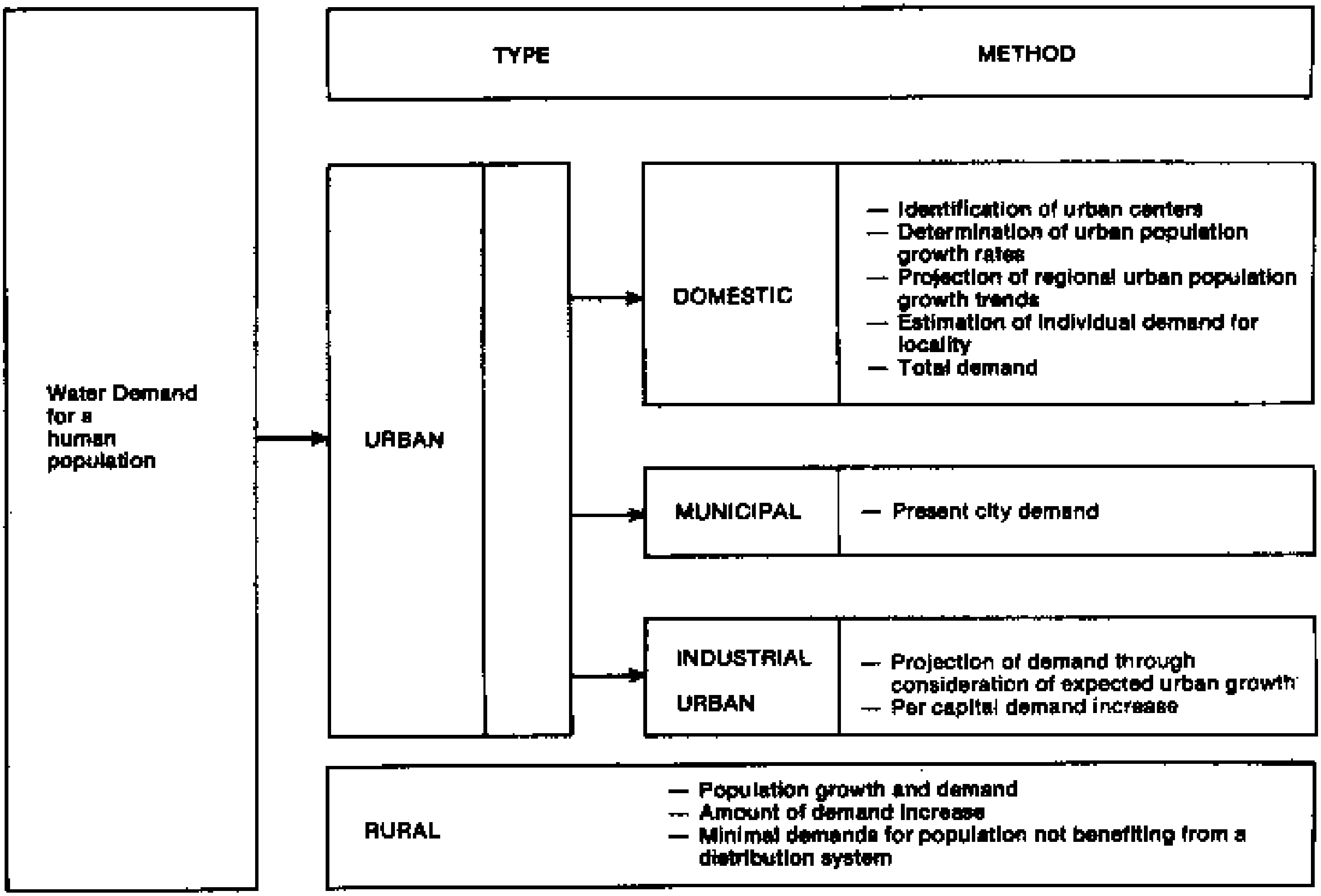
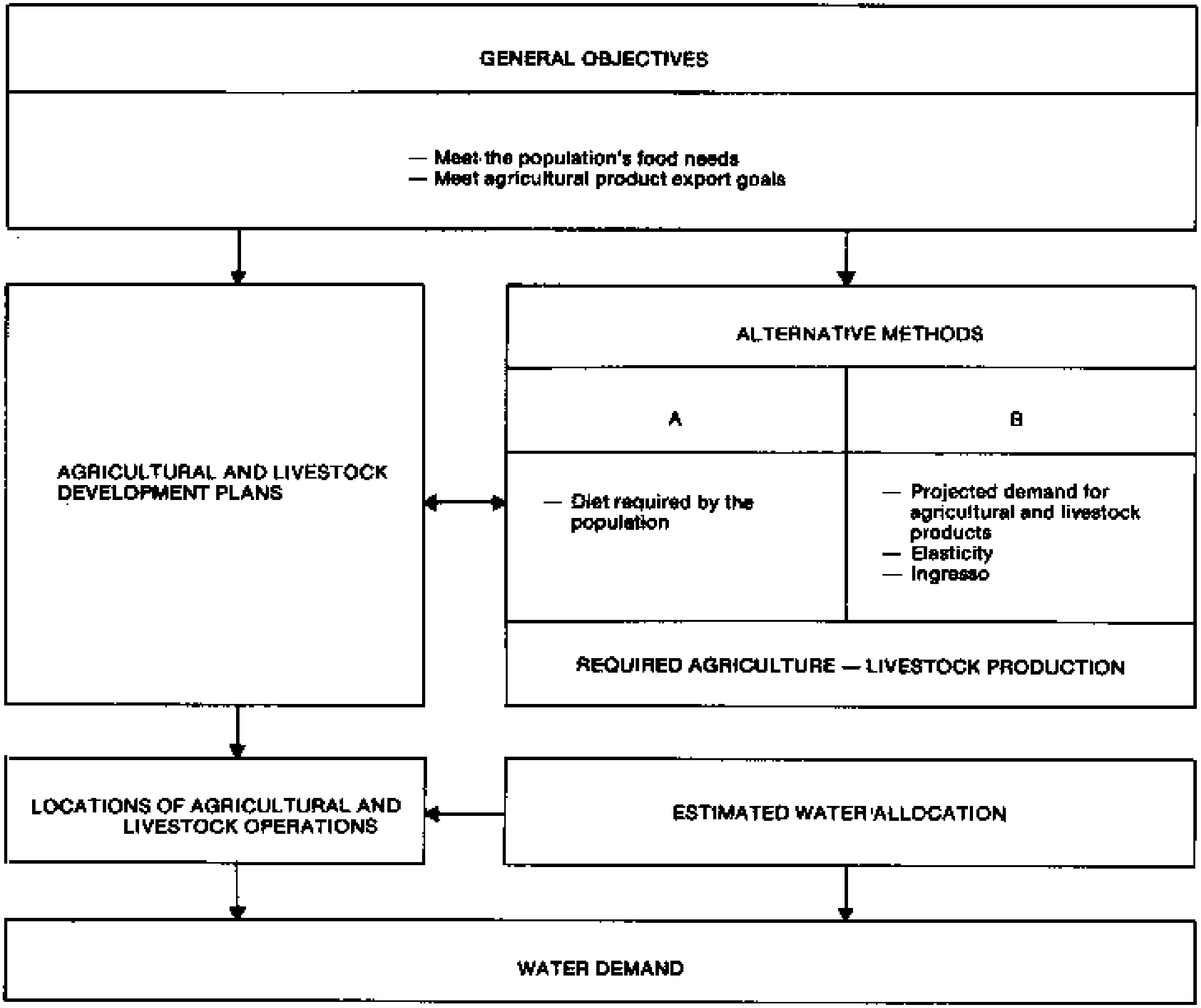
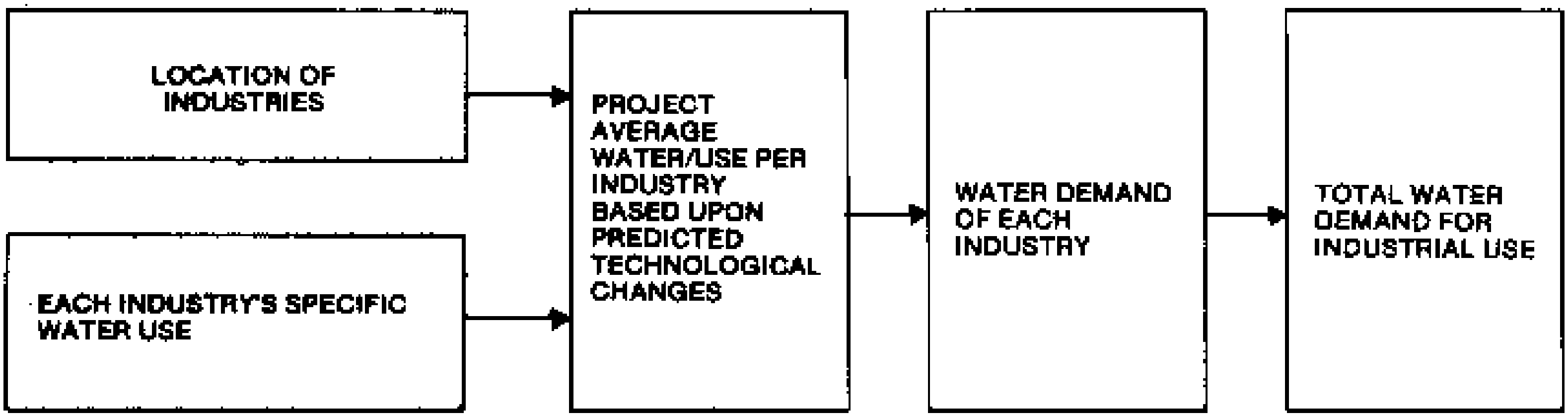
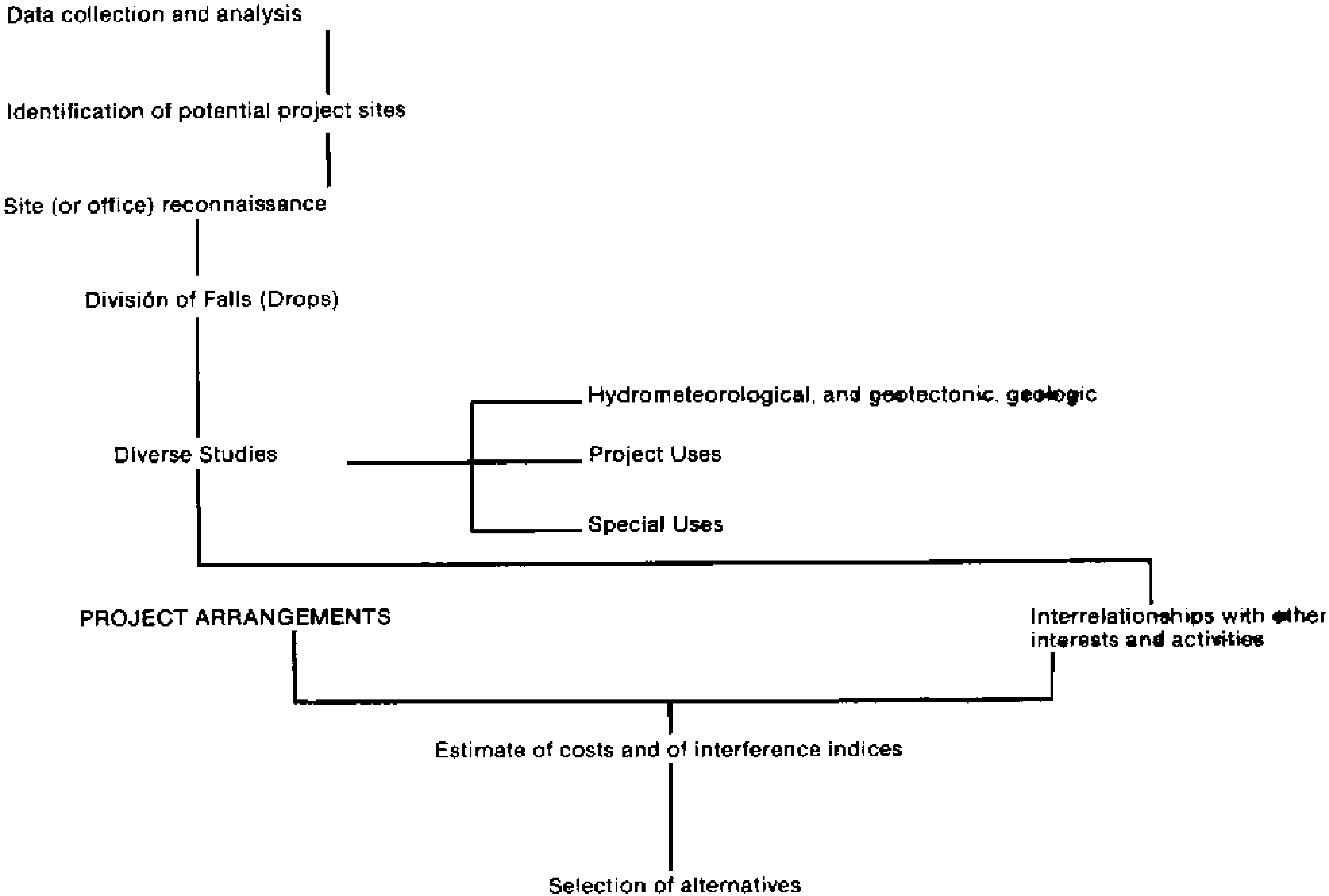
TOTAL MARKET (electrical demand)
Market for industrial electrical energy
Energy Conservation
Substitution of organic fuels for electric energy

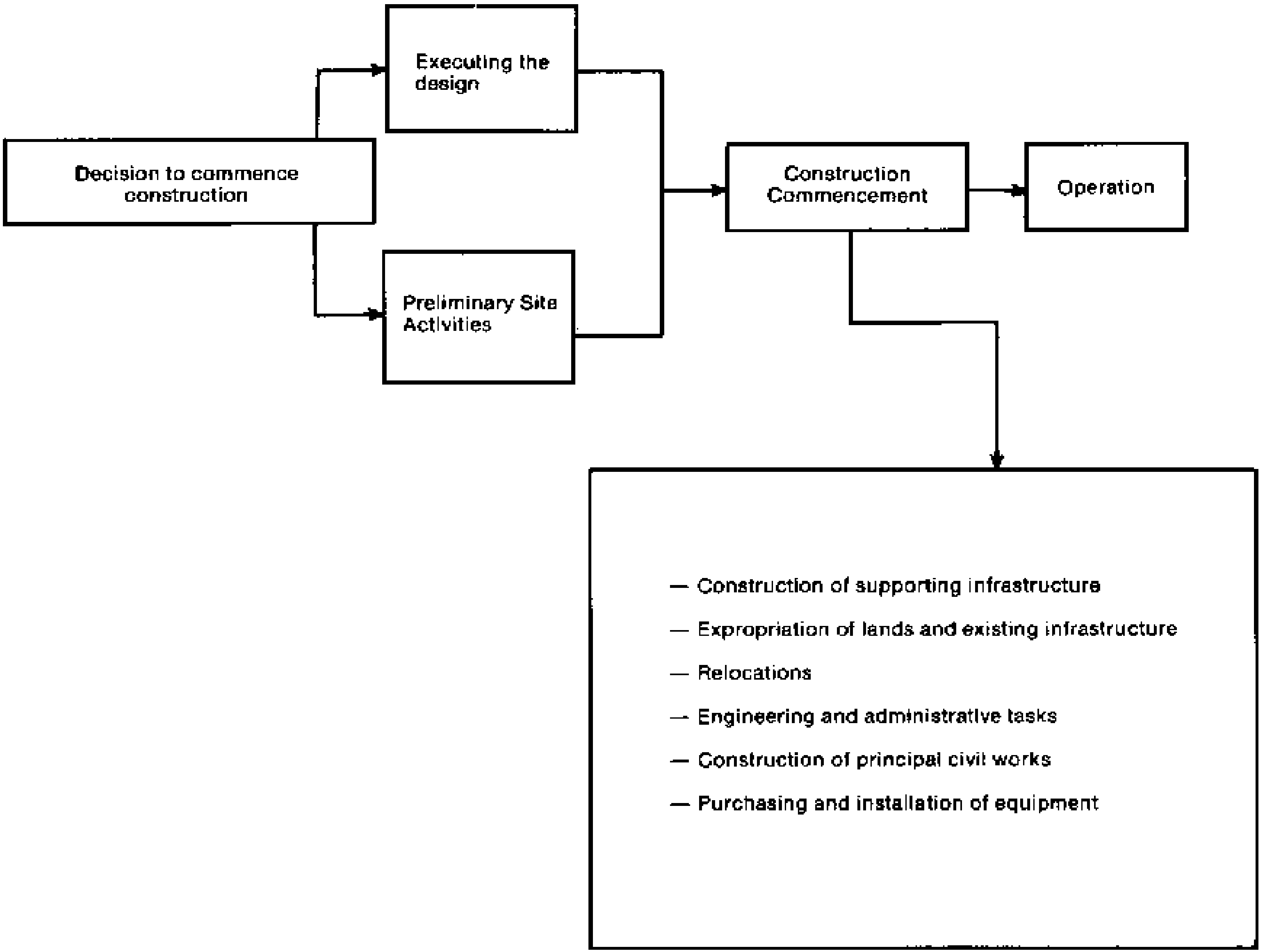

Demand for electricity
Sources for Generation
Balance between demand and availability
Operation of hydroelectric plants
Operation of thermoelectric plants
Water demand for hydroelectric generation
Demand for refrigeration and control of thermal pollution

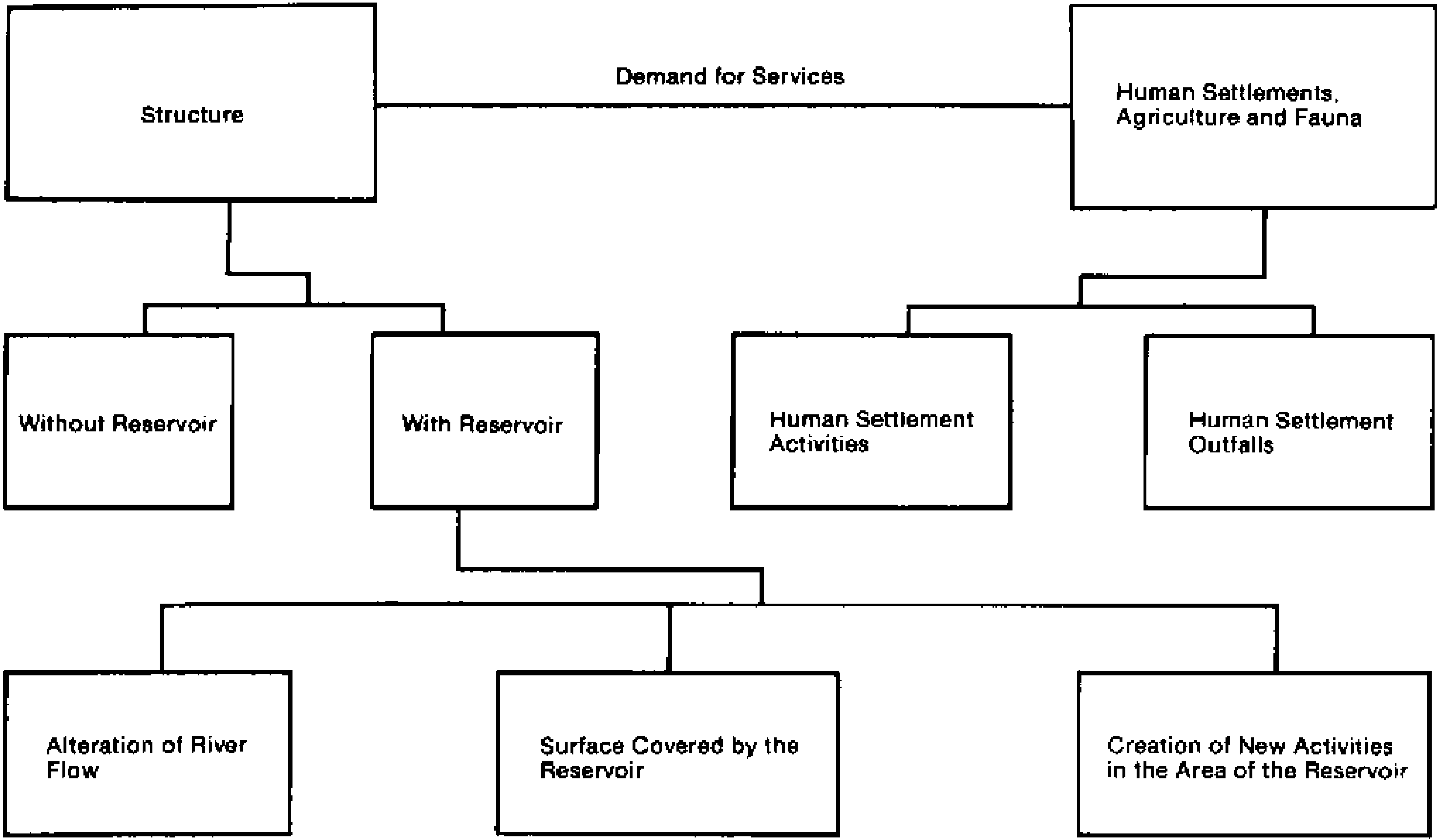

TYPE
METHOD
Water Demand for a human population
URBAN
DOMESTIC
— Identification of urban centers
— Determination of urban population growth rates
— Projection of regional urban population growth trends
— Estimation of individual demand for locality
— Total demand
MUNICIPAL
— Present city demand
INDUSTRIAL
URBAN
— Projection of demand through consideration of expected urban growth
— Per capital demand increase
RURAL
— Population growth and demand
— Amount of demand increase
— Minimal demands for population not benefiting from a distribution system


GENERAL OBJECTIVES
— Meet the population's food needs
— Meet agricultural product export goals
AGRICULTURAL AND LIVESTOCK DEVELOPMENT PLANS
ALTERNATIVE METHODS
A
B
— Diet required by the population
— Projected demand for agricultural and livestock products
— Elasticity
— Ingresso
REQUIRED AGRICULTURE — LIVESTOCK PRODUCTION
LOCATIONS OF AGRICULTURAL AND LIVESTOCK OPERATIONS
ESTIMATED WATER ALLOCATION
WATER DEMAND


LOCATION OF INDUSTRIES
EACH INDUSTRY'S SPECIFIC WATER USE
PROJECT AVERAGE WATER/USE PER INDUSTRY BASED UPON PREDICTED TECHNOLOGICAL CHANGES
WATER DEMAND OF EACH INDUSTRY
TOTAL WATER DEMAND FOR INDUSTRIAL USE


Data collection and analysis
Identification of potential project sites
Site (or office) reconnaissance
División of Falls (Drops)
Diverse Studies
Hydrometeorological, and geotectonic, geologic
Project Uses
Special Uses
PROJECT ARRANGEMENTS
Interrelationships with other interests and activities
Estimate of costs and of interference indices
Selection of alternatives


Decision to commence construction
Executing the design
Preliminary Site Activities
Construction Commencement
Operation
— Construction of supporting infrastructure
— Expropriation of lands and existing infrastructure
— Relocations
— Engineering and administrative tasks
— Construction of principal civil works
— Purchasing and installation of equipment


Structure
Demand for Services
Human Settlements, Agriculture and Fauna
Without Reservoir
With Reservoir
Human Settlement Activities
Human Settlement Outfalls
Alteration of River Flow
Surface Covered by the Reservoir
Creation of New Activities in the Area of the Reservoir

Chapter 7 - Health factors affecting settlement of the American humid tropics

The determination of many South American governments to exploit the known and unknown resources of their rain forests has led to a proliferation of diseases which threaten man's safety in the jungle. Governmental pressure to exploit the resources of the rain forest has forced man to move into the Selva and confront conditions to which he is neither accustomed nor adapted. Here he is exposed for the first time to diseases characteristic of the rainy tropics, while at the same time he is introducing new diseases to indigenous Selva populations. The scarcity of epidemiological studies and the relative ignorance of health professionals about tropical disease contribute to the persistence of these pathologies and reduce the possibility of controlling and eradicating them. Consequently, planning and development programs in the Central Selva and elsewhere in the humid tropics must give high priority to disease prevention and teach settlers the natural healing properties of the flora and fauna of their region. Such an effort may permit man to live safely in ecosystems to which he is not thoroughly adapted.

Five major types of invaders threaten human bodies in the Peruvian Selva: parasitic, viral, bacterial, mycotic (fungal) and animal (those caused by insects, snakes and fish). Among the most serious problems confronting newcomers to Amazonia are parasitic diseases, because they are so difficult to control. In virgin jungle, human parasitosis should not exist; but if a parasite-free population comes into contact with native populations that are affected by many parasites, infection of the newcomer is inevitable. On the other hand, a wide range of viral infections and such diseases as measles, hepatitis, and poliomyelitis represent a danger to native communities, since these communities have not been exposed to them and their immunity is very low. Tuberculosis and other respiratory diseases are also a common threat to people already weakened by parasites, anemia and malnutrition. Furthermore, various fungi can cause pulmonary diseases, particularly those that produce systematic mycosis (South American blastomycosis, histoplasmosis, and asperfillosis).

Bacterial and mycotic skin and genera) infections abound in the humid tropics, where unsanitary living conditions, skin moisture, and the lack of adequate health care transform individuals into sources of infection and encourage the spread of disease.

Insect bites can be very serious, especially for people who are in Amazonia for the first time and have not developed immunity to them. Insect bites can produce intense cutaneous allergic reactions, opening the skin to allow the introduction of bacteria, such as yellow fever, malaria, chagas disease, and leishmaniasis.

Parasitic diseases

As people migrate from the mountains to the Selva, they bring their parasites with them. Parasitic diseases occupy first place among the diseases of the humid tropics. They are widely distributed and represent a serious health problem. Because sanitary conditions in the jungle are inadequate, people are infested by almost all of the intestinal protozoans, particularly *Entomoeba coli, Endolimax nana, lodamoeba butschlii,* and *Dietamoeba fraglis.* The most medically important, however, is *Entamoeba histolytica,* widely known as the cause of amoebic dysentery. A high percentage of the population of the Andes is infested by *E. histolytica,* which actually lives commensally with man, feeding on food waste in the colon that still contains a large amount of carbohydrates. There, it reproduces and encysts, before being eliminated in the feces. In the absence of sewage systems these cysts contaminate the soil; thus, the food and water that sustain man are converted into sources of infection that affect great numbers of people, while flies and other organisms help spread it. Even one infected person can be responsible for the spread of *E. histolytica* in the jungle, because the climatic conditions, the level of nutrition, and the presence of other jungle intestinal parasites, particularly nematodes and bacteria that damage the large intestine, all favor the spread of the disease.

Besides *E. histolytica,* which can be present in 20 percent or more of mountain populations, another parasite, *Balantidium coli,* is also quite common in swine and occasionally affects man (Lumbreras, 1954a, 1954b). Studies carried out on indigenous populations in the mountains found that 15 percent of the people had the parasites. Fewer were infested among jungle populations, but there the parasite's effects are more serious. *B. coli* spreads the same way as *E. histolytica:* a person from the mountains brings it with him when he enters the jungle; it attacks persons whose colon mucosa are damaged through other causes such as bacteria or helminth parasites like *Trichiuris trichiura,* which allows *B. coli* to penetrate the mucosa, causing ulcers and symptoms similar to *E. histolytica.*

Giardia lamblia, another widely distributed intestinal protozoan, can cause digestive problems in children, notably diarrhea and malabsorption, and it can lead to dehydration, which, if not treated promptly, can cause malnutrition and death. *Isospora belli* is a protozoan that affects the cells of the mucosa in the small intestine. It exhibits a life cycle similar to malaria that includes sporozoites, macro and microgametes, and cysts that are eliminated in feces and that contaminate the soil.

Protozoans that attack other tissues and organs besides the intestine warrant special attention. Within this group are flagellates, among which stand out trypanosomes, leshmanias, and sporozoans, the most important of which causes malaria and toxoplasmosis. Various wild vectors of Trypanosoma cruzi, the source of Chagas' disease or *Trypanosomiasis americana,* have been identified in the Central Selva (Lumbreras, 1972; Lumbreras, et al, 1975). Known vectors are *Panstrongylus geniculatus, Rfiodnius robustus, Rhodnius pictípes,* and *Eratyrus mucronatus,* all of which have been found in parts of the Central Selva infested by the parasite.

Vectors of this disease generally live in palm trees (as has been demonstrated in Venezuela) and occasionally enter homes, where they can attack man and domestic and semi-domestic animals. It is well known that *Trypanosomiasis americana* is azoonosis and, therefore, can infect other animals that serve as reservoirs, such as monkeys, marsupials, bats and other mammals and birds. Some vectors, such as *Rhodnius robustus*, can complete their reproductive cycle within a home, where the females deposit eggs and the emerging larvae feed on man and domestic animals. *R. herreri* has been found to do this in the Huallaga and Marañon valleys; *R. robustas*, on the other hand, does not complete its life cycle in homes, even though adult females frequently enter them,

Two forms of leishmaniasis exist in Peru; the cutaneous form, Uta, which predominates in the Andes, and the cutaneous-mucosa form, Espundia which predominates in the jungle (Hinojosa, 1982; Lumbreras, et *al*, 1975). Throughout both the low and high forests in Amazonia, the clinical cutaneous-mucosa form is found - attributed to *Leishmania brasiliensis*, dominant in the Central Selva, and to *Leishmania brasiliensis guyanensis*.

The genus *Lutzomya* is generally the vector of leishmaniasis, notably the species *L. peruensis* which appears to exist in the Amazon region. Besides this genus, *Psychodopygus* and *Brumptomyia* have been considered possible vectors in other countries. In Peru, however, these genera have not been yet determined to be jungle leishmaniasis vectors, though they are found in the country. The habits and habitat of the disease's vectors need to be investigated, so that they can be controlled. It is also important to know which mammals serve as reservoirs; suspected are the rodents *Cryzomys*, *Dasyprocta*, and *Neacomys*; marsupials, and sloths.

Jungle leishmaniasis is a zoonosis; thus man is an occasional victim. The disease generally appears in people who work in the forest, including coffee workers, rubber workers, trailblazers for petroleum geologists, and those who pan for gold. In populations settled in cleared areas, leishmaniasis tends to disappear because the vectors disappear.

Toxoplasmosis is another protozoosis frequently found in humid jungles, particularly in the high forest (Lumbreras and Muñoz, 1963, Lumbreras et al, 1971). In some parts of the high Amazon region, 75 percent or more of the population are reported to possess antibodies, The cat is the definite host, but all other animals, including birds, are susceptible to infection. Man can acquire the infection through eating insufficiently-cooked meat containing toxoplasma cysts.

Malaria and its Central Selva agent, *Plasmodium vivax* and *Plasmodium malariae*, constantly threaten jungle populations. In 1969,3,168 cases occurred, with a morbidity rate of 24 and a mortality rate of 0.3 per 100,000 inhabitants when the total population was 12,998,100. In 1980, there were 80,000 cases in a Peruvian population of 17,779,500 people, with morbidity being 450 and mortality 4.0 per 100,000 people.

Malaria flares up repeatedly in the humid tropics because eradication and control campaigns such as insecticide spraying have been difficult to maintain. Patients acquire malaria in the tropics then carry it to other regions, particularly the coast, and it becomes necessary rapidly to extinguish the disease in these areas to prevent further spread. In the Ene river region, malaria is hyperendemic and both types of Plamodium, *P. vivax* and *P. malariae*, occur there, with the latter predominanting (Cantella et *al*, 1968). Forty species of anopheles mosquitoes, vectors of malaria, have been described in Peru, only three, however, are significant; *A. pseudopunctipennis* which is distributed throughout except in the low jungle; *A. Benarrochi* which predominates in the low jungle, and *A. darlingi* which is found along the Brazilian border. *A. rangeli,* in the high jungle, and A. *oswaldoi,* in the low jungle in the south, are secondary vectors. *P. falciparum* is also suspected in the Central Selva. *P. falciparum* is especially dangerous because in many countries, including neighboring Brazil and Bolivia, this parasite has demonstrated resistance to chloroquine treatment and, furthermore, has proven fatal when attacking the central nervous system.

Malaria is debilitating in itself, and predisposes its victims to contracting other diseases, particularly tuberculosis, which is well-known as a cause of anemia. If malaria occurs together with other parasitic infections, like uncinariasis, which also produce anemia, the consequences can be more severe. Such is now the case in the Central Selva, in the Chanchamayo Valley, and in Perene.

Helminthiasis, caused by metazoan parasites, constitute another large group of parasitic diseases (Lumbreras, *et al,* 1977). Among these, *Ascaris lumbricoides* is widely distributed in Amazonia. It predominates in the Peruvian humid tropics, where it achieves greater size than in the mountains or along the coast, and in spite of the indiscriminate use of antiparasite medicine, it infects 40 to 60 percent.

Three other parasites, *Ancylostoma duodenale, Necator americanus,* and *Strongyloides stercoralis are* found almost exclusively in the humid tropics, with *Necator americanus* being the most common. In general terms, the prevalence indices of the uncinarias (*Ancylostoma* and *Necator*) can fluctuate from 15 percent to 70 percent, depending on the region and the sanitary conditions. People contaminated with uncinariasis eliminate eggs, which produce larvae. The eggs live in the warm, moist soil until they come into contact with and penetrate the skin of their host. When the parasite enters a blood vessel, it is transported to the lungs, where it passes through the walls of the alveoli. It next enters the respiratory tract and comes to the larynx, after which it passes to an upper section of the small intestine where it installs itself and grows. Attaching its "head" to the mucosa, the parasite begins to suck blood, causing anemia that becomes especially severe with massive infestations. Because of this, pallid children are frequently encountered in the tropics, with the rims of their eyes and the palms of their hands almost white. This anemia, combined with malabsorption, causes diarrhea and serious malnutrition. The condition is aggravated when it is combined with certain bacterial infections, which explains the frequency of bronchial and respiratory infections common in Amazonia.

The other parasite endemic to the humid tropics is *Strongyloides stercoralis.* The symptoms appear when larvae penetrate the skin and pass through the same cycle as the uncinarias, entering the lungs before eventually arriving in the digestive tract. The eggs are eliminated in the feces. Developing in warm and moist soil, some of them become filariform and wait to penetrate the skin of any person who comes into contact with them. Other larvae differentiate into free-living males and females; the females lay eggs and repeat the cycle, continuing the soil infestation of strongyloides larvae prolonging the possibility of infection. The prevalence of S. *stercoralis* in the Central Selva fluctuates between 16 and 40 percent (Lumbreras and Muñoz, 1963b).

Trichiuris trichiura, known as *Trichocephalus dispar,* is another cosmopolitan nematode that abounds in Amazonia. It imbeds in the lining of the large intestine, and absorbs nutrients. Because treatment of the parasite was difficult until recently, almost all people living in the jungle had it, with children in many cases exhibiting a special form called trichocephaliasic colitis.

For more than two decades, colonists have introduced *Hymenolepis nana,* a cestode parasite or platy-helminth worms that live in the intestines of man and higher animals. I n 1982, Lumbreras *et al,* found that 21.8 percent of 132 children given parasite examinations in La Merced contained *H. nana.*

Infestation begins with the ingestion of mature eggs that contaminate food, some fruits and vegetables, and water. The parasite propagates easily in poor sanitary conditions.

Another relatively important parasite is *Fasciola hepatica*, which has been found in Tingo Maria. Veterinarians have detected it in livestock and have found the intermediate host, snails of the genus *Limnea*. It does not constitute a human problem at the moment, but improved control measures for livestock are needed to prevent its spread. Lumbreras *et al*, have found two cases of human paragonimiasis with associated lung damage, one from Tingo Maria, the other from Aucayacu. Human beings acquire them by eating the river crab, *Pseudothelphusa chilensis* which serves as the intermediate host. In Cajamarca and Libertad in the north *Paragonimus mexicana* (synonym: *P. peruvianus*) infests many, while human paragonimus in the Central Selva has not yet been identified, but *P. inca* and *P. amazonicus* have been found in certain animals.

Viral diseases

In the Peruvian jungle some viral diseases are native while others are imported. The latter include measles, which decimates non-immune native populations, poliomyelitis, parotiditis, and others which could be easily controlled with a massive vaccination program - if such an effort were possible. Viral infections indigenous to this region are less well understood, and thus more difficult to treat or eradicate.

Widespread in the tropics, yet still poorly understood in Peru, are the arboviroses. Serological investigations made in the high Central Selva region have confirmed the endemic existence of Mayaro virus (Buck *et al*, 1967), which belongs to arbovirosis group A. In endemic regions, the percentage of infection can fluctuate at between 10 and 50 percent of the population. The Mayaro virus is characterized by fever that is generally benign and of short duration. It has been isolated in mosquitoes, which transmit it, and in some wild vertebrates. Specific antibodies in the blood, produced by the virus' presence, have been isolated in monkeys, wild rodents, and oppossums, but in Peru itself antibodies have been found only in man.

In arbovirosis group B, Ilheus is endemic in the Amazon and especially prevalent in the low jungle. The agent of this arbovirosis has been isolated in mosquitoes of the genera *Psorophora* and *Aedes*, which seem to be the principal vectors, and in birds. It can also be inoculated into other animals, such as rats. Brazil, Trinidad, Colombia, Panama, Honduras, and Argentina all report the virus, but it has been confirmed in Peru only through the presence of antibodies in the blood serum. When present in man, it is probably clinically undetected in the majority of cases.

Dengue-2 is another Group B arbovirosis, although in Peru there have not been clinically demonstrated cases, nor has the virus been isolated. As with the majority of arboviroses, there is a high percentage of undetected infection. This virus has been isolated in domestic and wild birds, bats, and horses. In man, its occurrence is benign, with complete regression following a few days of fever and headache. However, in some exceptional cases, elderly patients exhibit serious symptoms of encephalitis and meningoencephalitis.

Finally, arbovirosis group B includes jungle or wild yellow fever, which is endemic in Peru (Lumbreras *et al*, 1982). It can be transmitted throughout the year, especially in December, January and February, because human migration into the jungle increases for agricultural purposes during these times. Important disease transmitters are mosquitoes of the genus *Haemogogus, H. caricornii falco, Aedes* and

Sabethes. Yellow fever afflicts monkeys in the jungle, with the virus circulating among nocturnal howler monkeys (of the genus *Alouatta*, notably *A. seniculus*), squirrel monkey, (*Saimiri sciureus*), and the monkey genus *Ateles* of which *A. belzebuth* and *paniscus are* found in Peru. It is difficult to establish the frequency of infection, but many monkeys die. Some rodents and marsupials are also suspected of acting as reservoirs of the virus. The disease is prevalent in high forest 400-1000 meters above sea level, and most cases in Peru appear in Huanuco, Junin, San Martin, Madre de Dios, Ayacucho, Apurimac, and Puno. Recently, clinical cases have been recorded from the Yavari river near the Brazilian border, as well as other areas in Loreto. In man, yellow fever varies in its effects, from undetectably mild to fatal. It affects visitors to the interior of the jungle, with the time of incubation between the bite transmitting it and the appearance of the first symptoms between three and six days.

Vampire bats are the source of another important viral disease, a form of rabies (*Rabia silvestre*), which is restricted to Latin America (Acha and Szyfres, 1973). Of the bat species which carry the disease, *Desmodes rotundus, Diphylla ecaudata,* and *Diaemus youngi. D. rotundus* is important epidemiologically because of its wide distribution, from Mexico to central Argentina. This bat transmits bovine paralytic rabies, which is responsible for enormous cattle and livestock losses in many regions in tropical America. In cattle, the incubation period can be from 25 to 150 days, making detection and control difficult. Approximately 500,000 head are lost annually in Argentina, while in Peru, at the end of 1970 cattle mortality reached 40 percent of the total stock in a region near Pucallpa. Since 1929, when the first case of vampire bat-caused human rabies was observed, more than 170 cases have been recorded in Latin America.

Another viral problem in Amazonia is hepatitis A or endemic, infectious, or icteric epidemic hepatitis. *Saguinus* monkeys experimentally inoculated with active human serum can become infected, however, as can chimpanzees (McAler *et al*, 1975). Since electron microscopes have detected the virus in patients' feces, the probable route of infection is fecal oral. When viral hepatitis B has been detected in the jungle, it is suspected that insect bites are the cause.

Neither virus nor bacterium, the eye disease trachoma, characterized by granulomatous conjunctivitis, affects more than 500 million people. The infectious agent is *Chlamydia tracginatus* which has been found in different parts of Amazonia and its known reservoir is man, who spreads the infection through ocular secretions and possibly nasal mucous, or with objects contaminated with them. Its seriousness is aggravated by environmental conditions, such as dry winds, dust, fine sand, and the absence of water.

Diseases produced by Bacteria, Rickettsia, and Spirochaetes

Among bacterial diseases, tuberculosis, produced by *Mycobacterium tuberculosis,* is of primary importance in Amazonia, where malnutrition and the socioeconomic and hygienic conditions all encourage its presence. A person's predisposition to acquire respiratory infections originates with parasites which during their life cycles in a human body pass through capillaries to the alveoli, injuring the upper respiratory tract. This trauma is aggravated by malnutrition and parasitic anemia (Lumbreras, *et al*, 1967).

Another type of *Mycobacterium, M. lepras,* produces leprosy. This disease is found throughout the Ucayali watershed, in Amazonas, in parts of Huallaga, along some tributaries of the Marañon river, and in the highlands of Apurimac (Lumbreras *et al*, 1982). It becomes a mutilating disease when it is not diagnosed and treated; both the tuberculoid form and the lepromatose form affect the nerves, produces trophic disturbances and problems with sensation in the fingers and toes. The patient is also subject to mutilating accidents because of his inability to detect pain or heat.

The common staphylococcus bacterium produces serious infection in the humid tropics where conditions are favorable to its growth. In addition to common skin infections, infections like *Piomiositis tropical*, which was originally observed in Amazonia, can also be encountered. Produced by *Estafilococo dorado* in the majority of cases, the disease primarily affects the muscles in the thigh; thus, people who suffer from this infection characteristically cannot walk because of the intense pain.

Another health problem in Amazonia is *Meningitis meningocosica.* The disease is cyclic; after five years, it disappears, producing only occasional isolated cases.

Finally, the widespread availability of penicillin has reduced the threat of three historically important diseases: the *flan, cuchipe.* or raspberry, that is produced by *Treponema pertenue; Mal de Pinto* or white lion disease produced by *Treponema herrejoni;* and syphilis produced by *Treponema pallidum. Flan* was mentioned by Luis Pesce in 1908 and was widely distributed in Amazonia. Clinical cases have been observed very rarely in some high jungle regions, particularly Pozuzo. One penicillin injection is sufficient treatment. *Mat de Pinto* was found in numerous valleys on the Andes' western slope, the lower sections of the inter-Andean valleys of the Marañon and Huallaga rivers, and upper reaches of Amazonian tributaries. This disease is known in the jungle as mange and, other parts, as leprosy. It produces a series of scaly and whitened lesions (caused by witchcraft, some believe) generally localized on the face, legs, and soles of the feet where they are called llaga. Penicillin has virtually wiped out this disease, as it has helped to control the spread of syphilis.

Recent studies of human and animal leptospirosis have been carried out in different regions of the country finding a high percentage of human infection in the central tropics. In the Central Selva, Liceras de Hidalgo (1981) demonstrated serological infection in 9 of 15 marsupials of the species *Philander opossum*, and, more importantly, the presence of leptospiras in 11 of 15 different animals. The same author also demonstrated that 3 of 15 *Didelphis marsupialis* possessed antibodies; he also found mild serological infections in a squirrel (*Sciurus* sp.), a rabbit (*Silvilagus* sp.), and an iguana (*Tupinambis nigropunctalus*).

Mycotic diseases

In the Amazonian jungle superficial fungi called dermatophytes produce a series of diseases which affect the skin, hair, and nails (Burstein, 1968). Other types of skin lesions are caused by other dermatophytes, such as *T. rubrum, T. mentagrophytes*, and others. In the humid tropics, forms of superficial mycosis that attack hairy skin can be found relatively frequently, especially on the heads of children.

Among the most important mycoses that can be acquired in the humid tropics are the fungus diseases acquired through the respiratory tract that can extend to different organs and systems of the body. Two of them are paracoccidiodomycosis, also known as South American blastomycosis, and histoplasmosis. Known in Peru as Tingo Maria fever (Zuñiga, 1970), histoplasmosis was first observed in people visiting Las Lechuzas caves located in Tingo Maria where the fungus grows in the feces of the abundant oilbirds (*Steatornis caripensis*). In endemic regions like the Central Selva as many as 100 percent of people tested for the fungus were found to have it, but those who actually get sick or die are few. The rare fatal cases are apparently due either to damage to the host's immunity, or to the virulence of the infecting strain.

Lobomycosis or *Blastomycosis queloidiana* has also been diagnosed in the Peruvian jungle. This is caused by the fungus *Loboa toboi,* which has numerous other names such as *Glenosporella loboi, Blastomyces loboi, Glenosporopsis amazonica,* and *Paracoccidiodes loboi.* This mycosis only affects the skin.

Another systemic or generalized mycosis that can be found more frequently in the humid tropics is Maduro-mycosis, known also as wooden foot. It is caused by many agents, the principal one being *Madurella mycetomi.* This mycosis is characterized by a marked deformation in the feet.

Finally, some systemic mycoses are not restricted to the humid tropics. One of these is cryptococcosis which is produced by *Cryptococcus neoformans.* Although it enters the body via the respiratory tract, it causes serious damage to the central nervous system, and death if it is not treated

Fauna harmful to man

Common in Amazonia is the nigua, *Tunga penetrans.* The fecund female of this small flea usually enters the skin of the foot (though other parts of the body are also susceptible) where her abdomen becomes distended from ingested blood and from growing eggs. The consequences to the host can be itching, inflammation, and secondary infection, which can be especially dangerous when the infection is tetanus, caused by *Closiridium tetani.*

Izango, Japa inacue, or *isangue* is produced by a *trombicula.* This tiny red organism, one millimeter long, generally attacks uncovered parts of the leg and produces an intense itching that requires continued scratching.

Acarosis, known commonly as *mundialito* or *mange,* comes from a mite, *Sarcoptes scabiei,* that penetrates the skin and produces itching between the fingers and toes, on the wrists, the waist, the groin and genitals, under the breasts of women, and near the armpits. Infections from mites other than *Sarcoptes* also cause cutaneous itching; they sometimes are found in straw mattresses and are not necessarily attached to the skin.

Other infestations are caused by fly larvae. They can be biontophages, which feed on living tissue at some stage in their life cycle, or necrobiontophages, which must feed on the dead tissue of living animals. Among the biontophages of the humid tropics is *Dermtobia hominis, a* large fly with a brilliant green abdomen that hunts in full flight a hematophage insect, possibly a *Culex* mosquito or the stable fly *Stomoxis calcitrana,* and deposits on their abdomens eggs that are held in place by a gummy substance. When the hematophage insect bites a human victim the eggs are left on the skin. The larvae rapidly hatch, and one enters the skin through the insect bite. This larva implants itself under the skin in subcutaneous tissue and grows slowly. The condition is also known as myasis forunculosa and, in the jungle, as *suturo, suchllacurro, pacacuro,* and *gusano de monte,* among others. Natives have methods of treating it.

Other myasis found along the coast, in the mountains, and in the jungle are those produced by the biontophage fly *Cochlyomyia hominivorax.* In contrast to *Dermatobia* the female deposits a large number of eggs along the edge of cutaneous lesions and, after a short time the larvae hatch and voraciously enter the open lesions (Lumbreras and Polack, 1955). It is quite possible that other myasis exist in the region. These can include the cosmopolitan urinarias *Fannia carricularis* and *Oostras ovis* that produce ocular myasis in man and are found where livestock, particularly sheep, are raised. Cases have also been recorded in the humid tropics of caterpillar dermatitis, cutaneous reactions caused by irritating substances found in the hairs of butterfly and moth caterpillars. These lesions are transitory and not serious. Wasp and bee bites occasionally cause problems with people sensitive to them.

Spider bites do not seem to be particularly harmful in the humid tropics. Only spiders of the genus *Ctenus* are considered potentially dangerous, but cases of human illness from them have not been reported from hospitals or health centers.

Snakes on the other hand do cause trouble for people and animals. Of the genus *Bothrops* the most frequent is G. *atrox,* which is widely distributed and which causes 70 percent of the incidents in the jungle (Pesce and Lumbreras, 1957; Meneses, 1974a, b). It is followed by B. *bilineatus,* known also as loromachaco, an arboreal snake found throughout Amazonia. *B. castelnaudi,* known as the jergon de arbol, is also widely distributed in Amazonia, as is *B. microphthalmus,* the *jergon pudridora* and *G. cloremelas* or lamon, an arboreal snake found in the Oxapampa region, among others. Serpents of the *Bothrops* genus can cause cutaneous necrosis, severe pain, swelling, and vesicle formation. Sixteen species of snakes of the family *Elapidas* are distributed throughout the jungle; they are known as coral, naca naca, chaquira, and coralillo. Finally, widespread in the jungle is the serpent *Lachesis muta* (Vellard, 1948; Kostritsky, 1971), commonly known as the schuschupe. Its bite causes intense pain in the bitten area, visual problems, and cutaneous necrosis. In the majority of cases the bite proves fatal in a few hours. The bite of *Lachesis muta* may be rare, but it also may be that cases are not reported because those bitten die in deep forest.

Consideration of animal hazards in Amazonian rivers can begin with the canero (*Vandellia cirrhosa*), a fish of the family Pygidudae, which grows to 20 cm. in length. It is carnivorous, aggressively and rapidly attacking man and animals and producing a lesion from which it sucks blood. The Chuccha-canero, which includes *Vandellia plazaii, V. cirrhosa,* and *Urinophilus diabolicus,* is so called because it resembles a piece of hair, measuring 8 cm. long and 0.5 cm. wide. It enters the urethras and other natural openings of men and women, causing intense pain and serious hermorrhaging.

Three species of fish known throughout the world also cause trouble in Amazonian rivers (Sánchez, 1951). The first is of the genus *Serrasalmus, S. rhombeus,* and *S. natteri,* commonly known as piranhas. With their sharp teeth, they tear out chunks of flesh and, as they generally attack in numbers, they can kill humans. Another dangerous fish is the ray, *Potamotrigon hystrix.* It forms large colonies during seasons of low water when they appear on sandy bottoms. Their camouflage makes them difficult to distinguish, and they react violently when stepped on, causing painful wounds with two spines in their tails. Finally, in the swamps and lakes of Amazonia the electric eel, *Electrophorus electricus* is found. This fish produces electric discharges capable of killing lower animals and of knocking men senseless, sometimes resulting in drowning.

Medicinal plants

Floral resources are widely employed in Peru, especially in the jungle. They are used directly as medicine and indirectly in the treatment of psychological diseases, usually in rituals (Chirif, 1978; Ortega, 1979). An infinite variety of plants and tree resins exists. Many have been studied scientifically, their active ingredients obtained, and their pharmacological effects proven. Many others, however, are still used empirically.

Cinchona officinalis, known as cascarilla, *C. calisaya, C. calisaya* del monte, C. c. del pajonal, and quina-quina, is a species of major importance because its bark yields the quinine that was the first treatment for malaria. Known since the 16th century, quinine's use has diminished in recent times due to the development of other chemotherapeutic products, but it is now coming back into use because some plasmodia, among them *P. falciparum,* have developed a resistance to chloroquine.

Ficus anthetmintica, known as hoje, oje, and huito, is a tree, the bark of which produces a milky resin that acts very effectively as a purgative and a vermifuge to kill intestinal worms. It is exported as a powder and can be administered in capsules. Another species, *Ficus cariica,* or higo, produces dry fruit, which, softened in water, is used to wash and rub out freckles. The latex of the green fruit is also used to cauterize callouses, while, heated, the dried fig is employed to treat inguinal adenitis, and the water in which dried figs have been steeped, with salt and vinegar added, is used to combat dandruff. *F. glabrata,* known as pitongo by the Machinguenga Indians, is used as a purgative by rubber workers. *F. killipii,* called chimico negro or renaco Colorado, is used as a remedy for sterility in women.

Peperonia rubea, or lancetilla del monte, is mixed with beaten eggs and used to combat colds and bronchitis. *P. inaequalifolia* or congona is applied to cases of gingivitis and otitis with good results. *Chlorophora tinctoria,* a tree known as insira and limulana, produces a bitter-tasting and ill-smelling bark that is used as a tonic and astringent and, in large doses, as a purgative. Ashes made from its wood are recommended in the treatment of gout and rheumatism, and its astringent fruit is gargled to treat mouth problems and sore throats. Its root is used as a diuretic, while its bark resin is used by some indigenous tribes painlessly to extract the roots of molars.

Genipa americana, known as huito, isso, jagua, mandi, palo Colorado, and yaco-huito, has a fruit rich in tannin. When fermented, it produces a liquor called guacamote and an indelible ink used to dye hair black. When green, the fruit is wrapped in banana leaves, toasted over a slow fire, and applied to the skin. The skin turns black and repels mosquitoes for eight days, after which it becomes clean and free of side-effects. The seeds can also be used as a rapid and vigorous emetic.

Psidium guayava, known as guayaba and jagua, has agreeably-tasting fruit. The tender leaves of the shoot are chewed and then squeezed until drops appear. The treatment is used for severe conjunctivitis and dysentery. Furthermore, the leaves and root are astringent, and the boiled bark is used to combat stomachache.

Hura crepitans, commonly called hura and catahua, is a large jungle tree, the bark of which is chemically similar to curare and thus very caustic and poisonous. If chips of its wood come into contact with the conjunctiva, its caustic effects can cause blindness. Its seeds are utilized to provoke vomiting and as a purgative, in some cases causing dysentery. An oil is extracted from the fruit for use in lamps, and cigars made from the leaves can be used to combat asthma.

An infusion made from the bark of *Paullina yoco,* commonly called yoco, yoco blanco, and huarmiyoco, is employed as a stimulant to combat hunger and fatigue. The soft tissue is scraped off and squeezed until juice containing caffeine is obtained and added to cold water. The beverage creates a prickling sensation in the fingers and a sensation of well-being.

Theobromoa cacao, known as cacao, cacahuillo, canga, ccarhua, kimituhi by the Campa Indians, and turanqui by the Shipibo Indians, is used as a medicine for convulsive cough, while the boiled husks are used for dysentery. The dense chocolate is applied to bronchial diseases, taken as a galactophore when mixed with powdered rice and cinnamon, and used as a poultice for pulmonary problems when combined with egg yolk, grease, and sulfur.

Erythrina poeppigiana, known as amashisa and oropel, is a tree with bark that produces a resin used for contusions and swellings. It has been found to contain various medically-important alkaloids.

Fifty-five of the 700 species belonging to the genus *Cyperus* in Peru are known in the jungle as piri-piri.They are very effective when used for snakebite; the bulb of the plant is chewed, the sap swallowed, and the remaining material is applied directly to the bite and the area around it.

Chenopodium ambrosioides, known as paico, amush, camatai, and cashiva, has been used since 1906 in many ways; when boiled, it is used as a vermifuge, as an abdominal colic, and for the treatment of hemorrhoids. Its oil is used to combat parasites. It has been demonstrated that chenopodium oil can eliminate 70-90 percent of ascaris infestations; unfortunately it is so toxic it sometimes proves fatal.

The leaves of the tree, *Meca parviflora,* known as yanamuco, are chewed, initially coloring the teeth black, but then leaving them clean and white with their enamel intact after a few days. *Abuta grandiflora,* or caimitillo, sananga, and trompepero sanango, is a shrub, small tree, or vine, the root of which is used as a remedy for anemia and colds.

Jatropa curcas, known as pinon or pinol, is a euphorb that produces seeds used as a purgative (just one seed is effective for adults) while the plant's leaves are used to heal cutaneous abscesses. *J. gossypifolia* produces seeds with abundant oil and with purgative and emetic properties. Furthermore, its latex treats burns and alleviates hemorrhoidal inflammation, while its leaves are used as poultices for swellings.

A large number of species belonging to the Piperaceae family are referred to as cordoncillo, matico, mocco-mocco, and yerba del soldado. Of these, *Piper elongatum* is used as a powder to heal ulcers by encouraging the growth of scar tissue, while as an infusion it is employed to treat wounds. The euphorb, *Euphorbia cotinoides,* or huarus, juquilla, or yuquillo, is widely employed to cure conjunctivitis or mal de ojos.

Voucapoua americana, a legume known as huacapu, produces an oil that acts as a purgative, and its bark brings about abortion. Allcuchuchu, meaning dog nipple, is a plant that sprouts red flowers with white corolla centers that are always filled with water. Peasants believe that if the water is collected before dawn, and applied to the breast it will enable women to produce milk even though they are old or have never had children.

Seventy-one species of *Passiflora* exist in Peru, commonly known as *tumbo. P. mixta* and *P. mollissima* are found in the jungle. Their fruits are eaten and used to eliminate kidney stones, while their leaves are used as vermifuges and to induce abortions. Syrup made from their roots is used to treat pneumonia.

The mint *Melissa officinalis* is called abeja (bee), because it is attractive to this insect, and toronjil. An infusion of this plant is an antispasmodic, either alone or mixed with orange rinds. Boiled, it is employed as a sedative, to treat stomachache, and to help in childbirth.

The leaf sap and boiled roots of *Scoparia dulcis*, known as escobilla, escobilla del Peru, nucnu pichana or piqui-pichana, are used as astringents and as antipyretics to combat fever. *Jacaranda copaia,* or amchi-ponga, aspingo, chichara caspi, ishpingo, ishtapi, para-visco, and soliman de monte is reported as having been used to treat syphillis, and its flowers have proven effective in treating dysentery. Also used for dysentery is the bark of the tree *Byrsonima coriacea,* called indano, indano Colorado, chanchi, and quillo sisa. Powder made from the plant is also used to cauterize bleeding wounds.

Pseudocalymma alliaceum, known commonly as sucho-ajo and ajo sacha, is a shrub used for pain, kidney diseases, and as a poultice.

A red resin is obtained from the sangre de drago or sangre de grado, *Croton salutaris* and C. *palonastigma,* by making incisions in the bark; it has powerful astringent and hemostatic effects. Pulverized and placed in a container of boiled plantain, it is used to stop hemorrhaging of organs and wounds. It is also used for the treatment of gastric and duodenal ulcers and to cauterize skin lesions. A piece of this gamoresin in the mouth holds loose teeth, while powder obtained from the tree is effective in the treatment of hemorrhoids and rectal prolapse.

Condaminea corymbosa, belonging to the Rubiaceae family, is called sauco or ccaratu and is often used mixed with cinchona. Another plant, also known as sauco, as well as ccola, kyola, ram rash, and yalan, produces flowers which, when boiled, are employed as sudorifics and are widely used to combat smallpox. A boiled mixture of sauco and chamomille, lavender, and cows-milk is applied to bladder and prostate irritation. It is also felt that the leaf poultices, plasters made from soap, and juice from the flowers all favor suppuration and thus reduce inflammation of inflamed ganglia and adenomegalias. Also, boiled, the plant is used to bathe cheeks to combat toothache, while a medicinal mouth-wash made from the boiled fruit is applied to relieve stomach problems.

Numerous species of legumes of the genus *Cassia* are used for various purposes. C. *alata* effectively treats certain skin problems especially herpes infections, while a strong concoction kills piques, niguas, or *Tunga penetrans.* In India, it is utilized for all types of venomous bites, and juice extracted from the leaves and mixed with lemon juice is used to cure rashes.

C. bicapsularis, known as alcaparillo and alcapaquilla is used as a purgative, although in some cases it can produce colic. Another species, *C. cuspidata*, was introduced to the country during the conquest. Its mucillaginous pulp is considered to be a laxative.

The llanten, llantai, or llantin macho, is a cultivated plant. A concoction made from it is used as an astringent for cleaning wounds. Its whole leaves, fried in olive oil, are effective analgesics for eye pain. Known scientifically as *Plantago mayor,* the leaves, either macerated or in an infusion, are also applied as an enema to cases of dysentery. Combined with barley, marshmallow, purslane, and ivy, it is used to treat hemoptysis (hemorrhaging of the lung lining that leads to blood expectoration). A concoction made from the plant's leaves, rosemary, and egg white is also used to control hematemesis (vomiting of blood arising from lesions of the mucosa of the digestive tract).

Annona cherimelia, chirimoyo, or chirimoya, is native to the Peru-Ecuador border, and its lightly roasted leaves are applied to the temple to relieve headache. A concoction made from the root is used for dysentery, and it is thought that the powdered seeds can kill lice. For obstructions of the biliary ducts and the digestive tract, *Hidrocotyle umbelata,* or oreja de abad, mantejillo, mateollo, or mattecllu; is often employed. It can also serve as an aperient and diuretic, while large doses are used as an emetic.

Often plants are used in rituals that may also have therapeutic properties. One of these, *Banisteriopsis caapi,* or ayahuasca, soga de muerto, ayawasca, capi, yaque or punga huasca has been reserved for sacred rites throughout the northeast of Peru up to Ecuador, Colombia, Venezuela, and northeastern Brazil. Small doses produce euphoria, while larger doses produce dreams rich in images, color, and clarity, and a wide range of hallucinations. In the last stage the user falls into a deep sleep, losing almost all sensibility. *Ayahuasca* is used as a medicine, an aphrodisiac, and for divination. Benisterine is the plant's active alkaloid.

Some of the medical claims made for these plants have been scientifically observed; others require study. Accounts of the healing effects of plants, resins, seeds, fruits, roots, are abundant among the people of Amazonia, but this information needs to be collected and confirmed as much as possible through careful examination. Perhaps the solution to many of the health problems encountered by man in the humid tropics may lie in the careful and conscientious use of the naturally-healing substances that are already there.

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Chapter 8 - Human occupation of the Central Selva of Peru

Geography of human settlements

All 1,285,215 square kilometers of Peruvian territory lie within tropical latitudes of 0° and 18° South. Several geographic factors create extremely diversified natural ecosystems: a cold current along the coast causes the temperatures to be lower than expected; the Andean cordillera, snow covered year-round, creates east-west differences; while the narrowing of the Andes, and the diminishment of rainfall creates north-south differences. Four distinct zones are created: coast, mountains (sierra), high forest (Selva Alta), and low forest (Selva Baja) to which distinct demographic, economic, and socio-cultural characteristics correspond.

The coast - only 12 percent of the country - supports 50 percent of the country's population, many of whom have migrated there from the mountains (Table 8-1). These migrants have been attracted by fertile irrigated land in the coastal zone (around 750,000 hectares), which supports a highly productive agriculture and no less than 65 percent of the country's industry. As a consequence, dynamic cities have developed, the most significant being the Lima-Callao metropolitan area which contains 45 percent of the country's urban, and 27 percent of its total population.

Table 8-1
DISTRIBUTION OF THE PERUVIAN POPULATION BY REGION, INTERCENSAL GROWTH, AND DENSITY[a]

Regions	1940		1961		1972		1981		Growth Rate (%)			Density (Hab/Km²)			
	N	%	N	%	N	%	N	%	1940-61	1961-72	1972-81	1940	1961	1972	1981
Coast	1,759	28	3,860	39	6,243	46	8,513	50	3.8	4.5	3.5	10	24	39	53
(Lima-C.)	645	10	1,846	19	3,303	24	4,601	27	5.1	5.5	3.7	168	480	858	1,195
Rest	1,114	18	2,014	20	2,940	22	3,912	23	2.8	3.5	3.2	7	13	19	25
Mountains	4,034	65	5,182	52	5,953	44	6,704	39	1.2	1.2	1.3	10	13	15	17
Forest	415	7	865	9	1,342	10	1,814	11	3.6	4.1	3.4	1	1	2	2
Country	6,208	100	9,907	100	13,538	100	17,031	100	2.2	2.9	2.6	5	8	11	13

a. In thousands of inhabitants.
Source: INE, Peru, 1981.

The mountains, covering 28 percent of the territory, have high-relief topography with deep narrow valleys and steep slopes. Four thousand meters above sea level, mesas or "punas" of gentle topography provide approximately 14 million hectares of natural grassland for sheep and South American camelids. In contrast, cultivated areas (approximately 1,800,000 hectares), are largely found on steep slopes, and are suitable for annual dry farming (only 21% of the land is irrigated). The sparse industry found in the departmental and provincial cities of the mountain region provides limited employment opportunities. It has not attracted public investments because of limited markets, inadequate infrastructure (roads, electricity, and water), and high production costs. Moreover, since the 1969 agrarian reform, most of the land has been occupied by agricultural societies and agrarian cooperatives made up of relatively few people. The majority of the people - peasant or indigenous communities and unaffiliated members of dispersed settlements - control limited and scattered land parcels that scarcely allow the ever-growing families to survive.

Consequently, Andean populations, particularly after World War II, migrated either to coastal valleys and cities, or to the Selva Alta. This partially explains why the mountains, which supported 65 percent of the country's population in 1940, have steadily lost population (Table 8-1). By 1981, in fact, the region contained only 39 percent of the country's people and a growth rate below the national average.

Forests cover 78 million hectares, or 60 percent of the national territory - 13 percent in Selva Alta and 87 percent in Selva Baja. Fifty-four percent of these forests are exploitable, 32 percent are protected, 8 percent are suitable for livestock production, 3 percent are suitable for intensive and permanent agriculture, and the remaining 3 percent are covered by rivers, lagoons, roads, towns, and cities. Population in the forest region has increased since the 1940s, from 7 percent to 11 percent of the national total. Most of the 1,800,000 people of the region are concentrated along the larger rivers, which provide the most useful lands. The riverine people - 220,000 inhabitants - belong to more than 1,300 native communities and 56 ethnolinguistic groups.

Rapid occupation of forest lands began in the last century, when modern industry and an expanding world market enabled the people to profitably exploit the products found in these forests. Between 1862 and 1918, great quantities of rubber were extracted, until competition from Asiatic rubber plantations stopped the growth of South American plantations. Wood extraction and export began in 1918, skin, hide, and exotic animal export began in 1928, barbasco export began in 1931, and chicle and petroleum export began in 1938. All of these activities define an export economy fundamentally tied to foreign markets.

The area of this study lies within the high forest (Chanchamayo, Satipo, and Oxapampa provinces). Within this region live no less than 230 native communities belonging to the Campa (191 communities), Amuesha (28 communities), and Campa Ashaninga (4 communities) ethnolinguistic groups. These communities contain approximately 38,000 inhabitants, atiny percentage of the 1,394,869 tribal people living in the forests of South America and Panama (Mayer and Masferrer, 1979).

History of the Central Selva

Evidence derived from archaeological sources, the archives of religious missions, and the anecdotes of travelers and scientific expeditions permit a precise picture of the occupation of this part of the country and contribute to a better understanding of the present situation of human use and settlement.

Pre-Hispanic Period

When the Spaniards arrived in the Central Selva, the watersheds of the Chanchamayo, Perene, Pichis, Bajo Urubamba, and Alto Ucayali rivers, and the Satipo and Gran Pajonal regions, were occupied by the Campas, while the Palcazu and Alto Pachitea watersheds were occupied by the Amueshas (Map 8-1). Both ethnic groups belong to the Arahuac linguistic family; their ancestors settled in the region around 1800 B.C. (Lathrap, 1970).

Comprised of scattered tribes of few people, neither group advanced higher than 1,500 meters above sea level, the critical cultivation altitude for manioc, their basic foodstuff which accounted for 70 percent of their agriculture (Denevan, 1979). Shifting agriculture, hunting, and fishing were the mainstays of their subsistence. Besides manioc, they grew corn, pituca, sweet potatoes, beans, dale-dale, peanuts, arracacha, gourds, sachap-apa, peppers, and pineapples. They also raised coca, small portions of which were used for medicinal and magical-religious purposes, and cotton, used for garments, ornaments, weapons, and baskets. Since Campas in the Gran Pajonal region today cultivate no fewer than 49 species for food, medicine, magical-religious ceremonies, and for other uses; they undoubtedly cultivated these and perhaps many others in the past as well.

Their basic planting technique is still in use today: cutting and burning to prepare the terrain, reproducing in large measure the vertical structure of moist tropical forests. They felled large trees with stone axes until the arrival of the Spaniards, and planted seeds or sprouts with a hoe, now replaced in part by the machete and bar. These crude methods of farming suggest that hunting, fishing, and gathering provided more food than agriculture.

In the past *purmas* (land lying fallow covered by secondary forest) were allowed a rest period of about 10 years before being recultivated. Even today, notwithstanding a scarcity of available land, natives use fields for a maximum of three years (Varese, 1968) before leaving them fallow.

Around 1000-1400 A.D. populations belonging to the *taruma* (Tarma) and the *Huanca* (Mantaro Valley) ethnic groups expanded (Parsons and Natos, 1978), and for the first time penetrated the Chanchamayo and Satipo valleys. The remains of platforms and terraces of obvious Andean workmanship are testimony to these immigrations and coincide with the Andean ideal of dominion over a maximum variety of biotypes (Murra, 1970). Although there seem to have been no further penetrations, it is possible that continual contact through trade existed between the mountain people and the Campas and Amueshas.

Colonial Period

After the native people had completed the occupation of the coast and mountains, Francisco de Orellana discovered the Amazon river in 1542 and so began the "Amazon cycle" of historic and economic development and, with it, the area's occupation by missionaries, adventurers, and soldiers. During the first half of the 17th century, Franciscan monks, following the same penetration routes as the Incas, began to establish settlements in the Central Selva, to convert the Indians to Christianity. In 1635 they founded the Cerro de la Sal Mission, which today is Villa Rica, and the mission of San Juan Buenaventura de Quimiri near present-day La Merced. By 1667, 38 missions contained approximately 8,500 people, mostly Campas. The Convent of Santa Rosa de Ocopa (Mantaro Valley) founded in 1725, helped them to reach thousands more.

The missionaries also established a series of towns that served as administrative and religious sites (although not without constant native resistance and revolt). Several ranches grew sugar cane and coca, tobacco and cacao, and all the "occupiers" maintained an active commerce with Tarma, Cerro de Pasco, neighboring towns, and the coast. The natives, for their part, gathered and exchanged wildplant products, such as vanilla, achiote, and cascarilla that were in great demand in colonial cities and in Europe. They also established artisan centers, the most significant near present-day San Ramon where they produced machetes, axes, nails, and hammers at a foundry. Toward the end of 1740, according to the missionaries' chronicles, 45 towns existed in the Chanchamayo, Perene, and Gran Pajonal regions (Basurto and Trapnell, 1980).

MAP 8-1 - PERU - DISTRIBUTION OF NATIVE COMMUNITIES IN THE PERUVIAN SELVA

This rapid development was interrupted in 1742 by a militaristic movement led by Santos Atahualpa, who sought to reestablish the Inca empire. The movement attempted to incorporate Campas, Amueshas, Piros, Mocholos, Simirinches, and Shipibo-Conibas, and because it tried to drive out all the Spaniards and mountain people, the area remained closed to colonization for almost a century (Chirif and Mora, 1977). Although the natives returned in some ways to their pre-colonization state, their patterns of life had been profoundly altered by new crops (sugar cane, rice, coffee, plantain, and citrus fruits); new domesticated animals (cattle, swine and poultry); new tools and new manners of commerce.

After the departure of Santos Atahualpa around 1757 the Franciscans restored their missions. In 1779 the military forts of Palca and Huasahuasi were founded, and a trail was constructed to Chanchamayo (although it was abandoned five years later because of the lack of support from the colonial administration). In 1788 neighbors from the town of Acombamba (Tarma) returned to their corn and coca fields near the Tulumayo river and people from Tambillo (Ayacucho) recovered their old fields at Monobamba, near the same river (Recharte, 1981).

During the rest of the 18th century and the first decades of the 19th immigration into the region was small because of the absence of adequate support from the colonial administration, and the wars for independence and ensuing conflicts between *caudillos* in the first years of the republic. In 1824 ecclesiastic officials decided to abandon their missions in the region (Ortiz, 1969).

Republican Period

The early days of the second half of the 19th Century marked the beginning of full and permanent occupation of the Central Selva. Influenced by economic changes in the other two regions of the country, a policy that encouraged road construction in, and colonization of, the area; and the War of the Pacific, the Campas and Amueshas (who had lived in the area for 3,500 years) were forced into a marginal existence.

Large estates were established in the mountains for sheep-raising and farming to satisfy the needs of coastal cities and to provide more agricultural goods for export (CIDA, 1966). Appropriation of commercial lands also encouraged occupation of the area, because it produced labor surplus that could be directed toward work on the new ranches in the Central Selva. Legislation in 1845 declared tribal organizations to be the owners of the lands they occupied, and colonists to be the owners of the land where they lived. This policy would later create deep conflicts between these two groups.

The fort of San Ramon was established in 1847 at the confluence of the Palca and Tulumayo rivers; under its protection, both mestizos and natives from Tarma began farms and ranches. Large property extension claims were made for commercial purposes, while smaller farms were planted in corn, manioc, and coca to meet traditional consumption needs.

The establishment of Fort Quimiri (La Merced) in 1869 permitted further immigration into the Chanchamayo Valley, which around 1874 began to include Italians, Germans, French, and, after the War of the Pacific, significant numbers of Chinese (Stewart, 1951). Only a small percentage of this contingent worked as agricultural laborers; the majority went into business in the growing settlements of San Ramon and La Merced. The Franciscans, meanwhile, opened new areas to Andean peasant immigration; they established the Asunción de Quillazu Mission (Oxapampa) in 1881, and in 1886 the missions of San Luis de Shuaro and San José de Sogorno, both in Chanchamayo (Ortiz, 1967).

By 1890, 65 important farms existed in the valley cultivating coffee and sugar cane for the production of spirits. Numerous smaller farms growing the same crops were cultivated principally by seasonally-migrating Andean people, in keeping with the model, probably Pan-Andean, of exploiting the maximum number of ecosystems to support the economy of their societies (Murra, 1970). But labor scarcity was the chief obstacle to expanded production on these farms and led to the dependence upon four systems of labor provision. The few larger farms contracted Chinese workers, but the majority used the *enganche, melbra*, and *contrata* systems to obtain labor.

The *enganche* system consisted of sending money to peasants in the mountains for travel costs and as prepayment for a set number of work days, a figure which increased dramatically as the workers incurred "debts" for food, medicine, clothes, and tools. This way the farmers assured that the workers would stay on the job while their services were required. A variation of the *enganche* system featured paying the workers before they returned to their home towns for work they would promise to do the next season.

The *mejora* system consisted of the farmer entrusting between 1-10 hectares of land to peasants. These peasants (the *mejoreros*) would then clear the forest, prepare the land, plant coffee plants, and cultivate them until crop production began. At this point, the crop was delivered to the owner, and the peasant received his promised wages. The peasant used his own tools and had the right to plant food crops for his family, either on separate land parcels or among the coffee plants, but he could not establish permanent plantings. This system led to a subsidiary type of system, the *maquipuras,* in which the peasant doled out the land entrusted to him to his relatives and friends, paying them less than the landowner was paying him.

The *contrata* system contracted workers to clear, prune, and harvest on coffee plantations. For an agreed-upon sum of money, the contracted individual worked with his family and, if necessary, additional salaried workers. Thousands of temporary migrant peasants would descend from the mountains with their families to harvest crops.

Until 1919, when the Tarma-San Ramon-La Merced road was completed, coffee and sugar cane were the only profitable crops, because products were transported by pack animals. Small quantities of fine woods, principally cedar and mahogany, were also transported in this way, but later, fruit production and selective large scale forest exploitation began, rapidly and profoundly altering the valley.

The road policy of the late 1800s (which continues today) encouraged the penetration of the forest's interior. It eventually led the Amazonian Hydrographic Commission to find a route for a road connecting the coast with a navigable river, thus making possible a link with Iquitos. Construction of the Pichis road began in 1860 and after only five months a 155 kilometer horse path connected San Luis de Shuaro with present-day Puerto Bermudez. Navigation began in 1892 between Puerto Bermudez and Iquitos.

Government policy in the 19th Century encouraged settlement of the forest by Europeans. To this end, between 1832 and 1898, the Government approved a series of legal devices and regulations that granted and distributed land and led to the occupation and colonization of Pozuzo, Oxapampa, Villa Rica, and Palcazu.

The first group of 297 Germans and Austrians arrived in Callao in 1857 destined for the Mayro, a tributary of the Palcazu river. These colonists founded the town of Pozuzo in 1859; it had delineated streets, a church, and wooden houses constructed in the styles of their Tirolean homelands. They planted coffee for export and crops for domestic use, and raised cattle to make cheese and butter for the mining centers in the mountains. Their contact with the exterior was sporadic and they came to rely on the natural ecosystems of the forest, while retaining their European cultural values. Not until 1974 did the construction of a road break up their isolation and dependence on local natural resources.

In 1868 and 1895 other German colonists joined the original group and available land became scarce. Spurred by the need to be closer to their markets, some colonists founded Oxapampa in 1890 and Villa Rica in 1920, after receiving a land concession of three thousand hectares in the Etay Valley. Oxapampa began to trade with La Merced in 1944 and Villa Rica in 1953, bringing about a growth in the lumber industry, an increase in commercial coffee and fruit plantations, and a decrease in livestock enterprise.

The natives of the Perene and Ene rivers began to lose their land in 1889 when Congress passed a law giving Amazonian lands to agricultural, livestock, and rubber operations. With the income generated by these enterprises, Congress hoped partially to settle debts contracted in the War of the Pacific. Two million hectares of land were turned over to foreign creditors. The land could not be divided into lots larger than a half-million hectares, and the grantees had to begin to colonize within three years and conclude no later than nine years afterward. For each year of delay beyond the deadlines, they would lose a third of the land they had received. The colonists had to be of "European race" and were exempt from taxation (Manrique, 1972).

The creditors, mostly English, ceded their ownership rights to the Peruvian Corporation, which received the first half-million hectares along the Perene and Ene rivers in 1981, although many lots were not delivered because of contract violations. In 1903 the corporation sold significant portions of the concessions, contravening the prohibitions of the 1889 Law. Other parcels were planted in coffee by *mejoreros.* In the meantime the corporation received a series of other economic benefits: payment for lands invaded between 1956 and 1958, money from users of the road the corporation had constructed, and money from transferring lands to other corporations. These lands were originally occupied by numerous Campa and Amuesha families, which lost their freedom of movement and which became obligated to lend their labor to agriculture, rubber harvest, and domestic work. In short, the Corporation used various mechanisms to maintain possession of the land, control production, and obtain labor.

The Palcazu watershed, the last frontier for the Amueshas, was explored at the end of the 19th Century by foreign rubber companies as far as Iquitos that obtained concessions for exploitation. The descendants of the original European settlers in the Pozuzo region also arrived to gather and sell rubber, depending on the Amuesha for labor and on the rubber companies for marketing. When the rubber boom ended in 1918, these families remained in the valley.

The European immigrants and their descendants monopolized the economic activity in the valley until 1960; cattle-ranching, lumber, leather and other industries were all under their control (Smith, 1981). They permitted the Amueshas to carry out subsistence farming on the colonized lands. In 1960 petroleum prospecting began, leading to a large number of land claims and more immigration. When the promise of oil wealth was not realized, the majority of such claimants abandoned the area, and in 1969, after the concessions on lands that had remained idle were annulled, the Amueshas began to solicit the recognition that they owned the lands they were occupying. This petition crystallized in the passage of the Forest Agrarian Promotion and Native Communities Law in 1974.

Back in Satipo, in the Campas territory, the Franciscans reestablished the Panzoa and Samamoro missions and others. By the end of the 19th Century, small fields of corn, coca, and manioc were being cultivated by a few people on the high portion of the Mantaro Valley, but the completion of the Comas road in 1917 led to a more extensive colonization. Another road to Concepción which was built in 1940 greatly increased the ability of people to travel throughout the country, but an earthquake destroyed a large part of this road in 1947. Many colonists emigrated during the next three years until the road reopened. Then an occupation more rapid than the one before began, giving rise to the rapid growth of Satipo, Pichanaqui, and Mazamari. Since 1975 the new road to La Merced has enabled the region to become even more dynamic.

The Central Selva since 1940

Population Process

The population of the Central Selva has increased from around 23,000 inhabitants in 1940 to approximately 213,000 in 1981. Most of this growth was the result of migrations, the now easy accessibility of the region, and its proximity to important extraregional markets. Also important has been the continued availability of land for agriculture and livestock in areas such as Satipo, which remains open to colonization along other access routes.

This accessibility since the 1920s explains its rapid growth in comparison with the other two Central Selva provinces (Table 8-2).

Table 8-3 presents sociodemographic indicators for the country and its natural regions. In every case the forest exhibits notable differences from the other two regions: higher mortality and birth rates; a life expectancy higher than the national average; a large number of children under 14; a surprisingly low illiteracy rate; and a high percentage of people involved with agriculture, livestock management, hunting, and forestry.

The Settlement Process Today

Three steps may be distinguished in the settlement process followed by Central Selva colonists. First, a family, because of its experiences as *enganchados, mejoreros,* and *contratistas,* or as voluntary laborers harvesting coffee, decides to obtain a parcel of land in the Central Selva, either purchasing it, or receiving it as a gift. Although they own the land, during the first few years they do not stay there permanently. Generally they divide their time between valley and mountains in two to three months periods. The women remain in the highlands and care for the property, crops, domestic animals, and small children; and the men do the sowing and harvesting in the Selva. This movement between the mountains and the forest, suggests the operation of two contiguous economic systems - the one providing subsistence, the other providing products for the market - which lasts from three to five years, the time required for the coffee plants to begin producing.

Table 8-2
POPULATION OF THE CENTRAL SELVA IN COMPARISON WITH THE HIGH SELVA AND THE PERUVIAN SELVA

Dpt. Province	1940	1961	1972	1981	Rate of Growth		
					40-61 (%)	61-72 (%)	72-81 (%)
Junin							
Satipo	2,490	14,360	37,660	64,595	8.7	9.2	6.1
Chanchamayo	14,145	34,576	61,482	98,508	4.3	5.4	5.3
Oxapampa	5,881	25,783	39,794	49,857	7.3	4.0	2.5
Total	22,516	74,719	138,936	212,960	6.7	6.2	4.6
- Central Selva in relation to the High Selva (%)	14	18	19	20	-	-	-
- Central Selva in relation to the total Selva (%)	5	8	10	11	-	-	-
- High Selva	164,444	411,497	725,417	1,059,686	4.1	5.0	4.2
- Low Selva	264,153	488,289	677,987	852,709	2.8	3.0	2.5
Total	428,597	899,786	1,403,404	1,912,395	3.6	4.1	3.4

Source: INE, Peru, 1981.

Table 8-3
SOCIODEMOGRAPHIC INDICATORS FOR THE COUNTRY AND FOR GEOGRAPHIC REGIONS

Indicators	Coast	Mountains	Forest	Country
1. Natural population growth rate (1972-81).(%)	3.5	1.3	3.4	2.6
2. Fertility rate (1970-75). (%)	4.2	7.0	7.3	5.6
3. Mortality rate (1970-75). (%)	8.9	17.1	13,3	13.0
4. Infant mortality rate (1970-75), (%)	62.9	156.2	127.7	114.0
5. Life expectancy at birth (years) (1970-75),	62.0	50.2	53.8	55.2
6. Percentage of illiterates in population 15 years old or older (1972).	13.5	44.3	24.8	27.6
7. Age Structure (1980). (%)				
- 0 to 14 years	40.5	44.6	48,6	42.8
- 15 to 64 years	54.4	51.3	49.4	53.8
- 64 or more years	3.1	4.1	2.0	3.4
8. Percentage of PEA in agriculture (1981)	16.8	63.9	59.6	38,4

Source: INE, 1981; Aramburu *et al*, 1982.

After the coffee harvest begins, while fruit trees and other crops are being planted, the entire family moves to the forest to provide more labor for the harvest and to guard the land against possible invasion by others looking for land relatively close to roads. This move does not really empty the land where the colonist originally lived, since control is maintained to provide security in case of mishaps on the colonized land, and because he is spiritually attached to the land of his ancestors.

The presence of the entire family in the new settlement permits the amount of cultivated land to be expanded. If more workers are needed, other families lend the labor - *ayne* - which will eventually be reciprocated. If the work is too much for both family and friends, additional workers are hired, which renews the cycle by attracting new potential colonizers into the area. The 1972 Agriculture and Livestock Census of the three provinces in this Central Selva sector found that of a total of 14,258 agricultural and livestock units, 49 percent used only family workers, 44 percent used part-time salaried workers, and the remaining 7 percent used full-time paid workers.

Relocation is the third step in this pattern of land use. Some colonists, having exhausted the fertility of the soils, search for new lands in more remote areas and begin the process anew. Their land is sold or simply abandoned and occupied by other less experienced colonists. Others, before this inevitable step, find more profitable part-time or permanent employment elsewhere. Some move to the cities and work in the commerce, goods, or service sectors; significant numbers return to their places of origin.

Land Tenure

As in the past, land continues to be the focus of some basic problems in the Central Selva. Access to sufficient expanses of land is limited. The best lands, such as those with alluvial soils, have been occupied for a long time by the first colonists who established modest farms. As a result of the agrarian reform of 1969, however, some farms have been converted to cooperatives while others have been subdivided for sale to peasants.

Because many people divide their land to pass on to their children, most of the farms are quite small. As Table 8-4 illustrates, in 1972,23 percent of the 14,258 agricultural and livestock units were less than five hectares in size, and 14 percent were only 5-10 hectares. Twenty percent of the units were between 10-20 hectares large; these farms, however, were actually less impressive than their size would indicate, because, typically, not all of the land on these parcels was exploitable.

In the mountains three to five-hectare parcels of poor land can maintain a family and produce surplus crops. But this is not true in the Central Selva, where much of the soil lies on steep slopes, is susceptible to erosion and leaching, and requires years of lying fallow to recover its productivity. Wide dispersion of the agricultural parcels also significantly prevents better land use, since 27 percent of the 14,258 units are comprised of two and three parcels and 4 percent contain between four and nine parcels (much of it is on steep slopes). Nor do native communities, contrary to popular belief, accumulate large amounts of land. For example, each of 13 Amuesha communities in Palcazu incorporates an average 2,971 hectares; in Chanchamayo, each of seven Campa communities has only an average 868 hectares; and each of seven Campa communities in Oxapampa has an average 2,695 hectares (Chirif and Mora,1977).

Table 8-4
SIZE OF AGRICULTURE AND LIVESTOCK UNITS IN THE CENTRAL SELVA: 1972

Unit Size	Hectares		Land Area	
	N	%	N	%
Less than 1.00	1,008	7	295	-
1.00-1.99	553	4	4,735	1
2.00 - 2.99	538	4		
3.00 - 3.99	534	4		
4.00 - 4.99	605	4		
5.00 - 9.99	2,041	14	50,911	11
10.00 -19.99	2,796	20		
20.00 - 49.99	4,178	29	183,345	41
50.00 - 99.99	1,108	8		
100.00 -199.99	644	5	125,512	27
200.00 - 499.99	184	1		
500.00 +	69	-	93,552	20
Total	14,258	100	468,352	100

Unit Distribution

	Unit	*Land Area*
Chanchamayo	5,705	134,417
Satipo	4,439	119,895
Oxapampa	4,114	214,040
Total	14,258	468,352

Source: INE, 1972.

Land Use

Land use intensity, technology, and production all vary according to various population components. Production, except for that of the natives, is directed at commerce (Table 8-5). Coffee accounts for no less than 50 percent of the cultivated land. Next in importance is fruit, accounting for 15 percent of the land, while subsistence crops (manioc, corn, rice, beans, peppers, and others) account for scarcely 20 percent of the cultivated land.

All available space on small farms is used, regardless of steepness. Erosion and leaching, however, occur rapidly in the rainy Selva as soon as plant cover is removed, while in other parts of the country rainfall is not as intense and erosion damage is only observed over a prolonged period of time. Those native communities that still have access to sufficient land, as in Palcazu and Pichis, continue to rotate land every three or four years. However, when demographic pressure and land restraints force a less frequent rotation, degradation of farm land results.

Commerce

Coffee, fruit, wood, and meat are principally destined for export. Fruit is sent directly to Lima through the wholesale market, except for small amounts that are consumed in the mountain urban and mining centers. Coffee is sent primarily to international markets, while wood is sent to Lima, as is meat from Palcazu and Satipo. Subsistence crops are consumed locally, in nearby towns and Andean mining centers.

Buyers and sellers operate idiosyncratically, according to the size of their operation. The smallest producers sell from their fields, from central locations visited by buyers and truckers, and from weekly town markets. The medium sized producers sell their harvest to larger-scale merchants, while the largest producers sell directly to the wholesale market in Lima. Many sell coffee through businesses in which they are stockholders. Meat from Palcazu and Satipo is acquired primarily by a corporation in which several important coffee-growers are stockholders. Wood is sold directly at the sawmills or warehouses in Lima. Fruit processors obtain their raw material when market prices are low, setting their own terms. Because of the complicated and little-understood chain of intermediate stages, fruit prices can increase 15 times from field to consumer. Rarely in any of these transactions do prices favor the small farmers.

Problems confronting settlements in the humid tropics

Types of Rural Settlements

On the coast rural settlements are nuclear. The peasant lives in the town, but goes daily to tend his parcel of land in the countryside. The corral for his animals is part of his town dwelling, and the animals breed in stables and graze on the country property or on other accessible land. This system follows a model, imposed during the colonial period on Indian towns to help control the populations, collect taxes, facilitate religious instruction, and establish colonial institutions.

Table 8-5
PRINCIPAL CROPS IN THE CENTRAL SELVA

Valleys	Years	Avocado		Bananas		Fruits		Coffee		Subsistence Crops		Total	
		N°	%	N°	%	N°	%	N°	%	N°	%	N°	%
Chanchamayo	1970	867	3	1,300	4	1,959	5	27,145	75	4,765	13	36,034	100
	1975	2,585	6	2,100	5	3,725	9	27,570	64	6,965	16	42,965	100
	1980	1,210	4	1,983	5	4,053	10	25,447	64	6,879	17	39,572	100
Satipo	1970	2,544	8	3,340	11	3,202	10	13,947	44	8,499	27	31,532	100
	1975	101	1	3,000	13	837	4	12,241	50	7,623	32	23,802	100
	1980	145	1	2,391	10	544	2	12,663	54	7,637	33	23,450	100
Oxapampa	1972	633	5	1,132	9	618	5	7,169	54	3,644	27	13,196	100
	1980	528	6	532	6	500	5	4,114	45	3,447	38	9,121	100
	1970	3,411	5	4,640	7	5,161	7	41,090	61	13,264	20	67,566	100
	1975	2,694	4	5,100	8	4,562	7	39,811	60	14,600	21	66,767	100
	1980	1,355	2	4,374	7	4,697	7	38,110	60	14,516	23	63,052	100

Farm cooperatives arose in the agrarian reform of 1969 on the foundation of the old farms. The settlements also are nuclear, with the cooperative members living in the vicinity of the former farm-house (now primarily the administrative center of the cooperative) in *rancherías,* usually constructed in rows. In cooperatives and coastal settlements water is provided by the state, while drainage and electricity are provided by the landholders or, in some cases, by the cooperatives themselves.

Many of the old Indian villages have grown into district capitals with urban infrastructures and services. However, these are still rural settlements, as is demonstrated by the dominant agricultural activity around them. A similar phenomenon occurs in some of the linear settlements that appear regularly along some stretches of road; initially they provide some services, such as rest and refreshment, to truck-drivers, and then they develop other services for themselves. The dispersed settlement, characterized by the home being located on the farm parcel, is less typical of the coastal region.

Varied types of settlements are found in the mountains, ranging from totally dispersed to nuclear. The most dispersed communities are those made up of shepherds who raise alpaca and sheep on the *puna*. They live on farms, from which they daily tend their livestock, grazing them in the open and sheltering them at night in corrals contiguous to the living quarters. They sell or barter their wool and fibers and then acquire other foods and goods in neighboring communities.

Peasant communities, whether officially recognized or not, are typically of two types, nuclear or linear. Nuclear settlements exhibit patterns similar to coastal settlements, the towns in most cases having become district capitals. Isolated homes frequently appear around the settlement. Recently, linear settlements have appeared along some stretches of road forming "sister communities" of homes and small businesses separate from the main settlement, though still linked to it by common ownership of land.

Forest settlements are varied. They can be categorized as riverbank populations, native communities, spontaneous colonies, and planned colonies.

Riverbank populations fundamentally consist of the descendants of people who arrived during the height of the rubber boom, and natives that have practically lost their ethnic identity such as the Cocamillas of Huallaga. Settlements of these populations follow along the river-banks. The people live on individual parcels, although nuclear settlements can appear around schools. From the family homes, the people pursue agriculture, small livestock ranching, fishing, hunting, commerce, and wood harvest. In some places, large-scale floodings have forced the settlements to farm on high ground, such as at Choro Yacu on the Amazon river and at Jenaro Herrera on the Ucayali river.

The native communities center their traditional forms of settlements and tribal organizations around the *maleca* (the large family and ceremonial building), as demonstrated by the Matzas on the Galvez and Yavari rivers. Their homes are built on dispersed parcels of land near some kind of community center, such as a school, a playing field, or a church. These dispersed settlements also tend to locate along river banks or lagoons.

Spontaneous settlements follow Andean patterns, with the colonist erecting his home on land he has obtained by inheritance, purchase, grant or some other way. Distances between homesteads are small when the parcels are small and greater when they are large. The colonists usually try to construct their homes near water sources and roads, which they often work together to construct. Compelled by the desire for a school, a church, or a playing field, the colonists frequently erect a town with a central plaza and delineated streets, and in which they usually obtain a lot for a second home. Such towns frequently compete with each other for the status of becoming district capitals.

Colonists in the spontaneous settlements have come from the same home area, and their communities are similar to those they left in the Andes. Volunteer work resolves family labor shortages and establishes needed services, such as roads, schools, and churches, while a few towns may join together to offer municipal services, and to help establish various state agencies.

Linear settlements predominate in planned colonies, in which family parcels are delineated on maps. In cases where nuclear settlements also are affiliated with the cooperative, each colonist has a home for himself and his family and benefits from an associated center for administrative, technical, and social services (such as schools and health care). These "Basic Services Centers" are far from the established towns that the colonists visit regularly for commercial, religious and other purposes. In Tingo Maria, a type of mixed settlement called bilocular, occurs, which contains both family parcels and one large parcel for communal use. Individual family farms are not an efficient way of working this land, but cooperatives have problems too stemming from the heterogeneity of their members, the absence of adequate basic services, technical and credit deficiencies, and rudimentary education in the art of manufacturing and farming cooperatives.

Planned Settlements

Since the 1950s governments in the American humid tropics have adopted policies to redistribute their populations, in part to combat the erratic and massive migrations from countryside to city. These policies have included the establishment of forested areas in planned settlements designed to avoid the undesirable consequences of spontaneous migration. The planned settlements presuppose the presence of great amounts of inexhaustible resources, able to support thousands of surplus people. The reality, however, can be glimpsed in the Brazilian, Bolivian, and Peruvian experiences (Nelson, 1973).

Brazil began to develop small planned settlements in 1970. The National Institute of Colonization and Agrarian Reform (INCRA) was created to undertake Integrated Colonization Projects (PIC's), designed to meet economic objectives and to bring order to spontaneous colonization efforts. They were concentrated in northeastern Mato Grosso (P/C *Paulo de Assis Ribeiro*), Rondonia, and eastern Acre, and they were to settle 29,000 families. But they failed, independent studies revealed, because of bureaucratic incapacity, poor selection of colonists, the counterproductive ease with which land titles and loans could be obtained, the high tax costs of supporting the settlements and inadequate social services and commerce mechanisms.

The 1954 completion of the paved Cochabamba - Santa Cruz road in Bolivia sparked spontaneous migration to the eastern part of the country, and initiated work toward some planned settlements. With technical and financial assistance from the Andean Mission of the UN in 1953, the Cotoca Program resettled 78 families from the Andean high plateau and valleys, but by 1975 only 10 families remained. Apparently the excessive paternalism, which gave a house, one or two cleared hectares, tools, and other investments to each family, failed to produce the desired results, and the discouraged colonists returned to their communities of origin.

In 1954 Arena Colony, with 240 families, 130 of them of Japanese origin, was established in a cooperative arrangement between Bolivia and Japan. The Japanese families subsequently broke away to form Okinawa Colony. I n1951,18 Mennonite families established another colony in the vicinity of Santa Cruz. This series of settlements encountered serious difficulties with erosion and poor soil, inadequate technical assistance, and lack of the necessary knowledge to make the enterprise work.

The Bolivian Economic and Social Development Plan of 1962-71 sought an intensive colonization in the Alto Beni (La Paz), Chimore (northwest of Cochabamba), and Yapacani-Puerto Grether (northwest of Santa Cruz) areas. The effort was to be financed by the Inter-American Development Bank and the Bolivian Government and was intended to settle 8,000 families from the inter-Andean valleys and the altiplano on 150,000 hectares over a period of three years. The project began in 1966, but at the end of the year only 3,200 families had been settled, 19 percent of which had deserted. By 1970 this desertion rate had increased notably; the reason given was that the Andean people had difficulty adapting to the forest environment.

In the 1960s and 1970s Peru had been confronted by a disorganized occupation of its forests, particularly the high forest, by thousands of Andean peasants. Their low standard of living led to the degradation and destruction of forests and soils. To protect the forests' resources the country initiated four planned settlement projects: Tingo Maria-Tocache - Campanilla (in the future, simply Tingo Maria) and Pichari in the high forest, and Jenaro Herrera and Marichin-Rio Yavari in the low forest. In addition, Saispampa was also begun in the subregion by an agricultural association dating from the 1969 Agrarian Reform. In three projects the settlers came from the mountains, while the settlers of Jenaro Herrera and Marichin chiefly came from the local forest regions to escape flooding problems and to become better incorporated into the market economy (Martínez, 1976).

These projects have not yet settled as many families as they had hoped. Only 59 percent of the lands have been adjudicated (142,413 hectares), of which only 30 percent have been actually used. Similarly, only 59 percent of the projected number of families have been settled, but high desertion rates would make the figure much smaller (Table 8-6).

All these settlement efforts have essentially failed to make significant inroads in resettling people and in intensively exploiting land; they have not succeeded in reducing demographic pressure on land in the Andean region, or reorienting the Andean-coastal migrations; increased sustained agricultural productivity and transformation of riverside subsistence economies into market economies has not taken place. These settlers have also suffered living and working standards as low as those found in spontaneous settlements.

Reasons for the failure of the planned colonies range from human error and inexperience to disastrous confrontation with natural hazards. In the absence of a coherent and determined settlement policy, the colonies were located far from important markets for their products, rural and regional development plans were not coordinated, and not enough money was invested to make them a success. Other problems included the total reliance on agriculture and livestock to provide income, the slow establishment of communication and service infrastructures, individual adjudication of land parcels where crops required a great deal of care, and finally the colonists' lack of knowledge about their new endeavors.

Technical assistance - human resources, materials, and financing - was inadequate. All agreed that the number of extension workers was insufficient to train a dispersed and inexperienced colonist population in agriculture and soil management: cars and boats were too scarce for rapid mobilization, and obtaining adequate loans to maintain the colonists while their crops were growing proved difficult (Miller and Martinez, 1981).

The National Development Plan of 1971-1975 (INP, 1971) recognized this reality. Noting the failed development attempts in what it called the "economic frontier zones," it stated that it would encourage efforts to incorporate lands and make complementary investments strictly to established agriculture and livestock interests.

Livestock operations in the colonies frequently replaced failed agriculture, but were never very successful themselves. The technology used to raise cattle in the rain forest was the same as that of the temperate regions, with their extensive natural grasslands. But grazing pastures previously forested rapidly compacts the delicate soils and suffers from the regrowth of woody vegetation. This forces the farmers to clear new forests, and so ranching becomes an itinerant activity. Additionally, the animal breeds used (Brown Swiss, Holstein, Cebu, Criollo), are selected according to the availability of breeding stock and are introduced in the absence of adequate knowledge about their care. After a long journey from distant localities, the animals generally arrive in poor condition. Further, in Tingo Maria in 1974 only one veterinarian was available to cover 1,200 square kilometers, Finally, delays in obtaining loans and price fluctuations prevent the purchase of large numbers of high-quality cattle.

Table 8-6
BASIC INFORMATION ON COLONIES PLANNED BEFORE 1974

Colony	Regional Locality	Distance to (KM)	Years of Establishment	Colonized	Land Area Adjudicated	Developed	To be Established	Families Established	Cost[b] in Soles (in millions)
Tingo Maria T.C.	Selva Alta (Huallaga)	Lima: 630	1966	140,000	122,685	39,458	4,680	3,794	2,104
Pichari	Selva Alta (Apurimac)	Ayacucho: 200	1961	18,710	7,890	1,710	500	360	100
Jenaro Herrera	Selva Baja (Ucayali)	Iquitos: 300	1965	47,500	6,842	1,328	1,400	418	20
Marichin-RY	Selva Baja (Ucayali)	Iquitos: 500	1971	10,000	5,000	400	100	50	22
Saispampa[a]	Selva Baja (Ucayali)	Lima: 840	1972	26,000	-	200	1,500	30	15
Total				242,210	142,417	43,096	7,180	4,252	2,261

a. 20-year duration.
b. Dollar = 43.58 soles.

Natural Hazards

The capricious courses and unexpected flooding of large rivers, the abrupt changes in temperature, the mudslides in the high forest and the rapid spread of diseases all threaten human settlements in the humid tropics. They can destroy a lifetime's savings or make the investment of large amounts of resources to combat them useless. For example:

- Iquitos is the most important city in eastern Peru, founded, along with Manaus, Brazil, during the rubber boom of the last century. Because of bank erosion and flooding, Iquitos suffers annual buffeting by the Amazon river, which has seemed to condemn the city to eventual disappearance. All possible solutions have proved useless, from constructing expensive retaining walls to letting nature take its course.

- The Huallaga river unexpectedly flooded a wide sector of Uchiza, an old town of colonial origin, destroying homes, crops and roads and killing hundreds of animals and human beings in 1982. Many residents lost all of their belongings; some were forced to migrate to the coast to live with relatives.

- In the early 1950s the unanticipated great floods of the Ucayali caused considerable destruction of crops and livestock on lands usually flooded sporadically and lightly. This flood forced people to found another town on higher ground, which is now being gradually eaten away by the same river as its course continues to change.

- Floods caused by the rising Amazon river led to the 1970 settlement of Choro Yacu on the road between Iquitos and the Brazilian border. Some 30 families came together from various hamlets to form the town. These same floods led to the failure of the planned colonization livestock project of Marichin-RioYavari, while flooding by the Tambopata and Madre de Dios rivers constantly threatens the town of Puerto Maldonado.

- In the early 1950s the settlement of Pucaramayo in the high jungle of Sandia Province in Puno was almost totally destroyed by landslides originating in the surrounding hills. At the same time unexpected temperature decreases in the high jungle valley of Tambopata (Sandia, Puno), while coffee plants were maturing caused financial ruin to many, leading some to abandon the valley. Strong *surazos* (winds originating in Patagonia) caused considerable damage in Puerto Maldonado in the 1960s, tearing off the roofs of most of the houses, while falling temperature caused crop and fruit losses.

- Finally, pests, such as the *broca* (a coffee borer), and diseases, such as papaya fungosis, are potential dangers in extensive parts of the Central Selva that threaten the livelihoods of colonists, cause great economic hardships, and lead to high desertion rates in planned colonies.

Planning Problems

The natural phenomena that continually affect human settlements in the humid tropics can disrupt the most well-intentioned plans. Planners must consider such factors as the steep slopes in the high forest and the meandering courses of the great rivers. They must also deal with changes introduced by human activity.

Adequate planning fundamentally relies on knowledge of all the factors that planning is expected to affect. Knowledge of the high and low forests is scarce, however, as is revealed by what has happened to past colonization efforts. Insufficient understanding of forest characteristics and the physical properties of woods, of the capacities of soils or the seasonal flows of rivers, of the effects of river course changes, of human activity, of fish behavior and more, all severely restrict the capacity to plan properly.

Human factors are also important. The functioning of the economy of riverbank populations is hardly understood. We only know the types of their settlements and that their economies are multi-faceted. Studies concerning this area are fewer than those describing some native populations. Managing the forest is based more on supposition than on careful empirical observations, and the circumscribed knowledge gained in some communities needs to be applied to others. The commerce system imposed by the *rescatistas* is scarcely known, and harmful to most if not all producers. The manner in which spontaneous colonies organize communal labor to accomplish concrete tasks is poorly understood. The power structure within one small region is almost completely unknown. How colonists actually take part in planning is little understood, notwithstanding the widespread realization that people need to participate in planning development projects. In short, the changes planned for these populations are based more on our own preconceptions than on knowledge stemming from analysis and investigation.

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Chapter 9 - Agriculture

Because farming is the principal means of support of most of the people living in the Central Selva, and because feeding its growing population has become a matter of critical concern for Peru as a whole, questions of land use for agriculture go to the very heart of the problems encountered by those who would transform the humid tropics. It is not enough to cut and burn trees, plant seeds, and expect to have a harvest. Agriculture in the Central Selva as elsewhere in the humid tropics requires a process of integrated and coordinated activities at the farm level and their interaction with regional and national economies and with other development sectors.

Natural goods and services

Soil

Peruvian Amazonia has a limited supply of soils that are well-suited for continual agricultural production. According to ONERN (1981) only 6 percent of the soils in the Selva, or 4.6 million hectares out of a total of 75.7 million, are suitable for annual and permanent cultivation; while 7.5 percent (5.7 million ha), are potential pastures. More than 84 percent (63.5 million ha) of the total land area is classified as being best suited for forest exploitation and protection. Unfortunately, little information is available concerning human settlement patterns on these lands, the amount of land being abandoned or left fallow because of soil and pasture deterioration, and on the underutilization of these soils through extensive livestock grazing.

The best soils are found on terraces near rivers and most of these areas are already planted in annual crops (corn, manioc, beans, and vegetables) and permanent crops (citrus fruits, bananas, papaya, and avocado). Some cleared forest lands yield harvests once or twice a year through the traditional system of cultivation, which takes place until crop yields diminish from the lack of soil nutrients and competition from weeds and pests. Once the lands become infertile, they are abandoned and new farmland is cleared from the forest. This system of "shifting agriculture" is practiced by native communities and also by the majority of colonists in Peruvian Amazonia.

Farmers with access to capital have established perennial crops, such as citrus, coffee, cacao, and other tree fruits, which maintain soils on slopes by providing continuous plant cover. Although permanent agricultural production such as this requires extensive management and investment in fertilizer and pesticides, its yields are higher than those of shifting agriculture. Permanent agriculture is not only an efficient use of land, it also helps stabilize rural populations by producing continual employment, and food that can be consumed domestically or sold in regional markets.

When good agricultural soils are scarce, and the existing soil resources underutilized and badly managed, soil erosion and reduced agricultural production inevitably occur. For example, grazing livestock on fertile alluvial soils is a low-intensive land use when compared with cultivation of high value crops. Equally inefficient is the system of planting annual crops on steeply sloping land, which will produce diminishing yields, eventual abandonment of the site, and a search for new lands to clear. But conflicts over the use of such lands are not easily resolved, being related to regional socioeconomic factors that are influenced by land tenancy patterns, market conditions, and access to roads.

Many of the soils in the humid tropics have little agricultural potential because they are highly acid and contain toxic quantities of aluminum and low levels of phosphorus, potassium, and organic matter (Sanchez, *et al*, 1982). What nutrients they do have are obtained through burning of vegetation and decomposition of organic matter. The nutrients are used up when fast-growing annual crops are planted and when pastures are established in recently-burned areas (Figure 9-1).

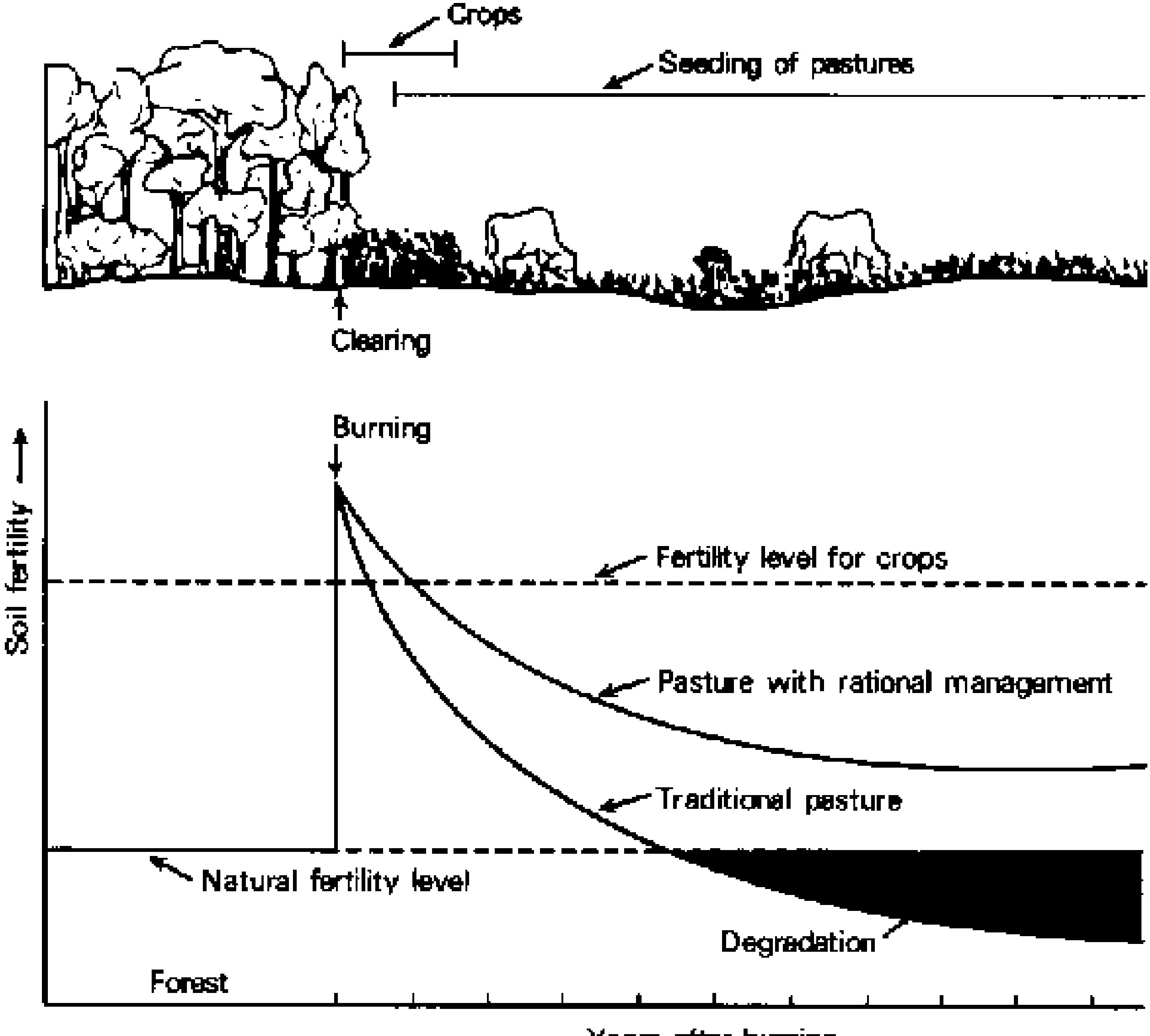
The mechanisms governing nutrient cycling in humid tropical forests are located in the upper soil levels and in the biomass. When organic material in the soil decomposes, its nutrients are absorbed and recirculated through the natural vegetation (Table 9-1). Under continuous vegetative cover or with systems of permanent cultivation, few nutrients are lost. But if the vegetation suffers continuous disturbance, as in annual cropping, nutrient levels are reduced by leaching, soil erosion and the harvest itself, making the addition of fertilizers necessary.

If production is to be maintained in the humid tropics, therefore, crop rotation and new cropping systems will be required. Examples of these systems are those that use nitrogen fixing legumes to help sustain production, including annual crops such as beans and peanuts in association with rice, corn and manioc, tree legumes (*Inga sp.*) in coffee and cacao plantations; and forage legumes (*Calopugnium sp.*) with natural pasture (*Paspalum natatum*).

Water

Water excess is often as detrimental to plant growth as is water scarcity. Water excess results in reduced oxygen levels in the root zone and water deficiency creates problems for plant metabolism, poor nutrient circulation, high temperatures, and dehydration. Both sets of conditions reduce growth and potential yields. In the humid tropics, only crops with a high market value (unhusked rice, bananas for export, oil from African palm) are mechanically irrigated and drained. For the rest, the most successful cultivation systems are adapted to water regimens dictated by climatic and soil factors.

FIGURE 9-1 - TENDENCIES IN SOIL FERTILITY UPON CONVERSION FROM FOREST TO PASTURE



Source: Toledo-Serrão (1982)

For example, natural marshes serve as buffer zones for adjacent agricultural lands, regulating water levels and absorbing rising waters. In these flood plains the sediments that are annually deposited along the banks of the large rivers are excellent for growing such short-cycle plants as rice, corn, beans, or jute (Table 9-2). When annual crops are grown on these fertile soils, they can be planted and harvested between normal flooding cycles.

Lesser Forest Products

Although lesser forest products are not actually agricultural products, the forest ecosystems adjacent to many cultivated fields provide various natural supplements to rural economies. Thus, native fruits, resins, natural pigments, medicinal plants, and natural palm and reed fibers are collected in great amounts and are sometimes processed during times of little agricultural activity. Historically, Peruvian Amazonia has supplied international markets with products such as rubber, bar-basco, zarzaparillo, and rosewood. The demand for these products varies according to cost increases due to increasing distances between forests and shipping ports. Demand may also vary because of competition from other parts of the world where transport costs are less and communication is more efficient. The social value of these products is difficult to estimate since native communities and colonists that gather and process them are dispersed throughout a large area for which commercial data are not available.

Agriculture today

In 1980 the total amount of cultivated land and pasture in the agrarian districts of San Ramon and Satipo was estimated to be 70,426 hectares, with an agricultural production value of 15,276,63 thousand soles (Table 9-3). This figure represents a 25 percent increase over 1973, as a result of road construction in the Perene Valley. Moreover, preliminary sectoral comparisons between the Central Selva and the rest of Peru give an idea of the Central Selva's importance in the national economy (Table 9-4), but tell nothing about the area's production potential nor about predicting the reductions in yield and land use efficiency if agroecosystems are improperly managed.

Table 9-1
NUTRIENT CYCLES IN TROPICAL AGRICULTURAL AND FORESTRY SYSTEMS

Function	Temperate Forests	Amazonian Forests	Implications for Tropical Forest and Agricultural Lands
Location of nutrients, cycle mechanisms	In the soil	In biomass covering the soil	When the biomass decomposes or when it is continually exploited, yields diminish.
Nutrient cycle index[3]	Not available	High (0.7)	Few nutrients are lost when there is continuous plant cover as exists in forests or in permanent cultivations.
Cation exchange	High	Low	The majority of soils in the humid tropics cannot support sustained production without fertilization. Soils with high CEC experience less severe nutrient loss because of leaching and a better response to fertilization.
Nutrient cycle duration	The processes are slow because of limited humidity and/or temperature	Successional plants rapidly absorb nutrients after forests are cleared	If soils remain continually covered with fruit or wood-producing trees, few nutrients will be lost.

Length of seed dormancy period	Long	Short	Natural reforestation depends on seed sources close-by, since seeds will not be transported over long distances.

a. This index compares the quantity of "recycled" nutrients with the total quantity circulating through the system. A high cycle index (around 1.0) means that all of the nutrients in the system are "recycled" and are not lost.

b. A low CEC means that there exist few negative changes in the soil capable of retaining nutrient cations such as calcium, potassium, and magnesium.

Source: Jordan, C.F. (1982).

Table 9-2
SUGGESTED ANNUAL CROPS TO BE PLANTED ON FLOODPLAINS

Common Name	Scientific Name
Cereals	
Corn	Zea *maiz*
Rice	*Oryza sativa*
Legumes	
Beans	*Phaseolus sp.*
Soybeans	*Glycine max*
Chick-peas	*Cicer arietinum*
Peanuts	*Arachis hypogaea*
Fibers	
Ramie	*Boehmaria nivea*
Jute	*Corchorus capsularis*
Urena	*Urena sp.*
Tubers	
Manioc	*Manihot esculenta*

Almost all farms, regardless of size, are labor-intensive. Such a practice is probably the most appropriate technology for these hilly areas with a high percentage of permanent cultivation. In 1976 fertilizers were used more in Chanchamayo (62 kg/ha) than in Satipo (35 kg/ha) and Oxapampa (33 kg/ha), primarily because the citrus plantations are older and more numerous (Table 9-5). This indicates not necessarily "progress," but rather a vigorous fertilizer industry, dating from the 1950s (Recharte, 1982).

Today coffee is the principal income crop: the Central Selva produces 25 percent of the coffee of Peru. Coffee production has remained stable in recent years despite fluctuating market prices. Yields vary from 400 to 600 kg/ha, although they could increase with better management. Diseases affecting coffee plantations, such as *broca* (*Hypothenemus hampei*) and roya *amarilla* (*Hemileia vastatrix*), can be caused by large extension or excessive density of the crop; intensive cultivation can also be counterproductive to obtaining high yields. Coffee is planted on all types of land, and little erosion or soil loss occurs because the coffee trees simulate natural forest conditions, providing shade and fixing nitrogen.

Citrus fruits - oranges, tangerines, and grapefruit - are the second most important crop in the area. Yields vary from eight to 13 metric tons per hectare. In spite of relatively intensive management, fertilization and disease control, losses from pests have forced farmers to replant in affected areas. Fresh fruit is sent to markets in Lima, while surpluses produced during periods of abundance are locally distributed.

Other important fruits, in terms of area planted, include avocados, papaya, and pineapple. Avocado production is limited because of the pest *Phytophthora*, which attacks the roots and flourishes in poor drainage conditions. Papaya is grown to provide income while citrus trees are being established. In the last two years, however, the total area planted has diminished because the pests have shortened productive tree life to less than two years. Chemical control is expensive and ineffective, and genetic resistance to pests has yet to be developed. Some farmers replant papaya plantations every one or two years as a practical solution to the pest problem.

Recently, small-scale plantations of a crop called *carambola* (*Averroha carambola*) has been planted near Satipo. This fruit is unknown outside of Peru, but it is being well-received in Lima markets and its future appears promising. Bananas, breadfruit, passion fruit, and chirimoya are usually produced for local and international markets.

A major fruit-processing plant near La Merced enables local farmers to sell their fruits, and connects the regional agricultural economy to national and international markets (for example, passion fruit juice concentrate is shipped in quantity to Europe). Production increased from 2,029 tons in 1976 to 7,836 tons in 1980. Its capacity has been estimated to be 9,000 tons a year. Farmers also benefit from several small citrus fruit packing plants in the Chanchamayo area which wash and pack the fruit before sending it to Lima. The presence of these establishments has encouraged the development of permanent fruit plantations by both large and small farmers. Because fruit trees are one of the few species in the humid tropics that can be cultivated on slopes, it has been possible to grow them relatively near the fresh produce markets and Lima processing centers.

Central Selva Land Use

Present land use patterns reflect soil and climate limitations, available capital, proximity to markets, transport facilities, tenancy patterns, and regional cultural traditions. Four general types of land use and human settlement patterns are found in four development axes in the Central Selva (Table 9-6).

Table 9-3
ESTIMATED AGRICULTURAL PRODUCTION IN THE SAN RAMON AND SATIPO AREAS IN 1980

Permanent Crops	Area (ha)	Production (ton)	Yield (Ton/ha)	Price at the Farm[a] (soles/kg)	Gross Value of Production[a] (thousand of soles)
Coffee	38,100	18,570	0.49	544	10,109,460
Citrus Fruits	4,697	44,345	9.4	22	968,760
Cacao	201	40	0.2	385	15,400
Avocado	1,355	7,569	5.6	38	288,430

Other Fruits	140	335	2.4	40	13,360
Mango	25	140	5.6	30	4,200
Annatto	139	48	0.35	167	8,000
Sugar Cane	87	792	9.1	10	7,920
Passion Fruit	175	875	5.0	35	30,625
Cocona	69	345	0.2	25	8,625
Others	48	93	1.9	20	1,850
Totals	45,046				11,456,630
Annual Crops					
Corn	4,003	9,152	2.3	39	357,970
Bananas	4,374	25,549	5.8	14	352,340
Manioc	1,295	15,819	12.2	22	348,018
Rice	490	578	1.8	62	36,120
Tobacco	278	2,803	0.1	30	84,090
Beans	258	243	0.9	135	32,860
Papaya	1,705	27,940	16.4	20	544,960
Soybeans	91	112	1.2	108	12,200
Taro	82	333	4.1	10	3,330
Pineapple	1,577	25,123	15.9	15	380,170
Tubers	72	577	8.0	58	33,620
Ginger	84	478	5.7	35	16,730
Vegetables	4	41	10.3	20	820
Totals	14,313				2,203,228
Grasses					
Elephant Grass	5,888	362,280	61.5	2.5	903,840
Molasa Grass	1,695	101,700	60.0	3	305,100
Jaragua	1,888	113,280	60.0	2.5	283,200
Kudzu	27	810	30.0	2.5	2,025
Others	1,361	40,830	30.0	3	122,490
Totals	10,859				1,616,655
TOTAL	70,218				15,276,513

a. In sales of 1980.
Source: MAA, Peru (1982).

Table 9-4
ECONOMIC COMPARISON BETWEEN THE CENTRAL SELVA[a] PERUVIAN AMAZONIA,

AND THE ENTIRE COUNTRY OF PERU

	Selva Central	Peruvian Amazonia	All of Peru
Cultivated area (hectares)[b]	70,426	666,724	2,470,718
Estimated Value of Agricultural Production[c] (thousands of soles)	15,276,513		39,883,600
Estimated value of forest production[d] (thousands of soles)	3,927,091	35,777,387	38,311,153
Estimated value of lesser forest products	26,768	2,087,918	2,511,570

a. Data for the Central Selva only include the San Ramon and Satipo agrarian districts.
b. MAA, 1980.
c. MAA, 1982 (annual and permanent crops, grasses, and forests).
d. Lesser forest products include resins, fibers, pigments, medicinal plants, oils, and native fruits.

Table 9-5
CENTRAL SELVA FERTILIZER CONSUMPTION IN 1976

Region	Area Planted (ha)	Fertilizers (ton)			Average Fertilizer Application
		N	P_2O_5	K_2O	
Chanchamayo	33,225	695	497	881	62
Satipo	20,743	245	239	234	35
Oxapampa	12,981	151	141	140	33

Source: Recharte, 1982

Development in the San Ramon - *La Merced axis in the Chanchamayo Valley* was based historically on large coffee plantations and on one sugar refinery. During the 1969 agrarian reform, however, a large portion of these lands was abandoned or expropriated. Today, while still producing some coffee, they are principally planted in fruit trees. The few alluvial terraces with the most fertile soils support large plantations of citrus fruits, avocados, papayas, and other tree fruits that are often harvested on hillsides. Pineapples, another commercial crop, are generally planted on poor sloping soils. Corn, beans, peanuts, and manioc, as well as bananas and other tree fruits, are also planted on small plots for subsistence purposes.

At present, there are few conflicts over the use of forest lands for farming, since most of the valuable timber has already been extracted and the harvest of secondary native trees and shade trees for firewood and charcoal is not detrimental to agricultural interests. The 30 percent of the land planted in pineapple, annual crops, and pasture is removed from agricultural production when exhausted and can be either reforested or left as permanent protected areas to prevent erosion and sedimentation and to ensure continued water supplies.

Table 9-6
AGRICULTURAL ACTIVITIES AND THEIR POTENTIAL SECTORAL CONFLICTS IN THE

CENTRAL SELVA

Development Axis	Land Resource Base	Availability of Agricultural Lands	Agricultural Activities	Conflicts with Other Sectors
Chanchamayo Valley (San Ramon-La Merced)	Alluvial Terraces gently sloping to hilly.	Poor	Fruit production, coffee distribution, shipping.	Sloping terrain should be reforested or managed as protected watersheds.
Villa Rica-Oxapampa	Steep to hilly terrain.	Moderate	Coffee, livestock, permanent cultivation, limited forest exploitation.	Intensive horticulture needs to be carried out on fertile soils, where grazing is the predominant land use.
Pichanaki-Satipo	Undulating topography, hilly to level terrain.	Moderate	Small farms, shifting agriculture, coffee, livestock, forest exploitation.	Intensive agriculture can threaten downstream ecosystems. Regenerating natural forests rarely have time to produce harvestable sizes of timber-producing trees because peasants cut them down first.
The Ene, Tambo, Pichis, and Palcazu river valleys	Seasonally-flooded soils.	Moderate to high	Scattered colonies and native settlements that practice shifting agriculture, extensive livestock enterprise in the Palcazu valley, small-scale livestock production elsewhere.	A large percentage of the alluvial floodplains are, at some time, occupied by permanent cultivation and extensive livestock operations.

Since fruit grown in the Chanchamayo Valley is sold in Lima, it is difficult to imagine how alternative land uses such as grazing or cultivation of annual crops would compete economically with present practices.

The Villa Rica-Oxapampa region has rolling land with scattered terraces well-suited for agriculture, especially coffee and livestock. Although coffee prices fluctuate widely, the favorable growing conditions and efficient management by the descendants of German and Peruvian colonists produce high yields. Coffee and livestock operations demand much capital investment, but they are successful and well-established because neither coffee nor livestock compete much with similar land resources. On the other hand, the use of flat land near Oxapampa for grazing can compete with papaya production, while level ground planted in pasture is controlled by stockmen who have developed their own markets for livestock and milk products.

The construction of roads from La Merced to Pichanaki and Satipo has been a principal factor in determining land use patterns in the *Pichanaki-Satipo development axis.* Since the topography is gently undulating, the area offers promising agricultural potential when compared with that of the Chanchamayo Valley or the narrow valleys in the Villa Rica-Oxapampa region. A few medium-sized farms on level terrain raise livestock, fruit trees, and coffee, although semi-permanent agriculture, including shifting agriculture, is much more prevalent. Shifting cultivation meets its constant need for new land by timber harvest, although when more land is planted in permanent crops, the need for clearing forest should diminish and conflicts related to forest exploitation should be resolved. But a long-term problem may arise from the increasing use of pesticides as lands are converted to semi-permanent agriculture.

The Central Selva river valley regions (*The Ene, Tambo, Pichis, and Palcazu rivers*) are wild areas characterized by subsistence agriculture and small-scale animal production for domestic use. Native communities of Campas and Amueshas and some colonists live here, often without legal title to their property. The fertile soils of the alluvial floodplain make this area well suited for cultivation of certain permanent and annual crops. The land is more commonly cleared for grazing, however, because of the strong market for livestock products. A private airline owned by the larger producers has several airstrips in the Palcazu and Pichis valleys to transport fresh beef to San Ramon.

Proposed road construction in the region can alter market preferences in favor of other products and land uses. Since sparsely populated land still exists in the Ene and Tambo valleys, conflicts related to forest and livestock production, and to protected land, can be resolved through land use planning. Soils of these valleys are poor and, in some areas, dry, and not suited to either sustained yield forestry or agriculture.

Expansion of Arable Lands

If Peru hopes to keep pace with population growth in the next few decades, it must increase its agricultural production by at least 2.6 percent annually. The country can do this by intensifying production on existing agricultural lands, expanding the amount of land under cultivation, and using land to produce food for internal consumption rather than for export. Considerable differences in production potential characterize the three principal regions in Peru. The non-coastal areas are less productive because of climate and soil limitations, inadequate transportation and commercial infrastructure, and lack of appropriate technology (this comparison, however, is based only on agricultural suitability and not on land tenancy, actual use, and availability). For example, one hectare of cultivated land on the coast roughly equals the production of 2.3 mountain hectares and 1.8 forest hectares (Table 9-7). These conversions show that land suitable for agriculture is concentrated along the coast (41.7%) and in the mountains (33.5%), with a smaller percentage being found in the forest (24.8%). Although the total area of cultivated land varies little, there has been a tendency to cultivate new lands in the forest, because of the ease of doing so and because of the long periods of drought in the mountains.

For example, in the 1960s, the Marginal Highway was begun in response to social pressure for broad agrarian reform and to provide access to lands in Peruvian Amazonia. The highway led to spontaneous migration to scattered areas, and the limited agricultural potential of such land produced questionable economic success for the migrants, conflicts with local communities, and destruction of forest resources. In the 1970s attempts were made to expand the agricultural frontier by installing irrigation in coastal areas. Very few of these large-scale irrigation projects (Chira, Piura, Tinajones, and Majes-Siguas) can be considered successful, however, because of the high costs per hectare, the long-term financial commitment required, and deficiencies in project management. Indeed, one reason to expand the agricultural frontier in Peruvian Amazonia is that the cost of irrigating new coastal areas is extremely high - more than US$7,500 per hectare (Table 9-8) compared to the US$4,000 per hectare cost of developing forest lands (Table 9-9). These costs include access roads, credit, and commercial infrastructure.

Table 9-7
GEOGRAPHIC DISTRIBUTION OF AGRICULTURAL LAND USE

Region	Ha.	%	Conversion to the Equivalent of Cultivated Coastal Hectares Under Irrigation	%
Coast	632,095	25.6	631,336	41.7
Mountains	1,171,899	47.4	505,909	33.5
Forests	666,724	27.0	375,832	24.8
Total of Cultivated Land	2,470,1788	100.0	1,513,077	100.0

a. An estimated 1.1 million hectares are left fallow each year.
Source: MAA, 1982.

Most likely, mountain lands could be used more intensively with irrigation and the use of technologies that take advantage of natural pastures and more stable soils. The result would be higher agricultural productivity that could feed more people and reduce migration to the coast and forest. An alternative strategy to incorporate additional areas into cultivation would be to rejuvenate the 153,000 hectares on selected coastal sites, improve the irrigation of mountain lands, and utilize suitable lands in the high forest.

Agricultural development limitations in the Central Selva

Limitations to agricultural development in the Central Selva come from various sources. Those related to the physical environment include the following:

- Long rainy seasons create weed growth in pastures, flooded lands, and conditions favoring the breeding of insects and other pests.

- The short-dry periods make pasture maintenance through burning of shrubs and weeds more difficult, increase the demand for seasonal labor, and affect the harvest, drying, and storage of some crops such as soybeans and peanuts.

- Low soil fertility and the high percentage of hilly terrain are not favorable to productive agriculture.

Other limitations are related to agronomy, commercial conditions, and to the availability of agricultural services:

- Most crops encounter problems with pests and weeds. Any new technologies employed to increase crop yields will also incur additional production costs.

- Agricultural extension services and the agrarian banks need to be more efficient in transferring technology to farmers.

- Marketing lesser forest products is a problem because of the rapid decomposition of tropical fruits, the lack of reliable supplies, competition with established tropical products harvested near markets and processing plants, and the shortage of marketing services, such as current price information for the growers.

And finally, limitations related to the lack of appropriate technology abound. Efforts have been made to transfer agricultural practices used in temperate regions to the country, rather than to apply techniques appropriate to the small farms typical of the mountains and forest. Sufficient evidence proves that land management practices successful in temperate regions do not work in the humid tropics (Nelson, 1973).

Table 9-8
ESTIMATED COSTS INCURRED BY COASTAL LANDS

Project	Lands Irrigated (ha)	Estimated Cost of Irrigation (US$ million)	Cost/ha of Lands Irrigated (US$)
Chaco-Viru	31,400	294.7	9,385
Olmos	80,717	563.0	6,975
Total	112,117	857.7	7,650

Source: Adler, 1980.

Table 9-9
STRATEGIES FOR EXPANDING ARABLE LANDS IN PERU

Region	Ha	Equivalent Cost of Coastal Irrigation (Ha)	Total Project Estimated Cost (US$ million)	Cost/Ha	Necessary Activities
Coast[a]	70,000	35,000	150	1,500	Recuperation of lands in affected saline areas.
Mountains[b]	25,000	8,500	21.3	850	Improved irrigation.
High Forest[c]	261,400	109,800	462	4,207	Access roads, credit, crop storage

a. Recuperation of lands affected by salinity.
b. IBRD.
c. The high forest includes three special projects: Alto Maya, Alto Huallaga, and Pichis-Palcazu.

Source: Adler, 1980.

Sectoral problems and conflicts

To give planners a quick orientation to the present situation in the Central Selva, some of the region's problems are briefly described below. Table 9-10 presents a summary of these conflicts.

1. The best agricultural lands are already occupied.

2. Poorly-planned roads provide access to lands unsuitable for agriculture.

3. The underutilization of agricultural lands has resulted in low production.

4. The intensified use of suitable agricultural lands will require greater investments in fertilizers and pesticides to maintain sustained production. If such investments are poorly managed, downstream ecosystems can become contaminated.

5. As more lands are abandoned and more pastures deteriorate, weeds become abundant and forests that act as barriers to the spread of pests disappear.

6. Urbanization and extensive livestock production utilize land suitable for agriculture.

7. Traditional agricultural systems increase resources, but are not sufficiently flexible to accommodate growing human populations. The short amount of time that lands are left fallow do not allow sufficient time for the soils to recover enough fertility for sustained agricultural production.

8. Native communities, which traditionally have practiced extensive use of the land, are now competing for their own land with colonists. The indigenous Campas and Amueshas intend to complete the process of obtaining land titles and to extend their domain to accommodate their growing populations. At the same time, national policy is to encourage emigration from overpopulated Andean communities. Conflicts between native communities, colonists, and Andean emigrants will increase when all realize the scarcity of soils capable of sustained production.

Table 9-10
ENVIRONMENTAL MANAGEMENT: CONFLICTS IN THE HUMID TROPICS

Agricultural Activity	Conflicts Within the Agriculture Sector	Conflicts with Other Sectors	Solutions

Utilization of fertilizers and pesticides for more intensive agriculture.	Loss of predator-prey equilibria; disease and insect resistance to pesticides require increasingly-expensive control.	*Fish/Wildlife* - Direct and indirect effects because of increasing levels of biocides in the water. *Water* - Potential contamination of drinking water. *Livestock* - Potential contamination of meat and milk products. *Forests* - Reduces the need to clean forests for agriculture.	Investigation of integrated pest management techniques. Establishing regulations controlling pesticide use with training, extension services, and enforcement. Evaluation of crop mixtures and agroforestry systems to increase production and to minimize problems with weeds and plagues. Pesticides need to be properly used for both economic and health reasons.
Increasing cultivation on marginal areas because of spontaneous cultivation.	Continued subsistence production levels and standards of living because of low yield.	*Fish/Wildlife* - Habitat loss because of forest destruction. *Water* - Accelerated sedimentation, increased water volumes in rivers, water quality is adversely affected by rapid runoff and reduced infiltration. *Forests* - Additional losses due to clearing. *Social Problems* - Rapid marginalization of small farmers near new settlements and limited development potential of occupied areas.	Encouragement of intensified agriculture on the best soils, evaluation of sustained agricultural production systems adapted to the humid tropics. Emphasizing the rehabilitation of abandoned fallow lands and of degraded pastures before new forest land is cleared.

Underutilization of land resources (planting of fertile soils in grass instead of more intensive uses).	Loss of profits obtainable from more intensive uses, need for utilizing marginal lands for intensive cultivation of annual or high-value crops.	*Fish/Wildlife* - Indirect loss due to continued clearing of forests. *Water* - Indirect conflicts due to continued agricultural activity on marginal soils in watershed highlands. *Forests* - Utilization of forest lands for agricultural use; loss of forest resources.	Evaluation of land use, considering climatic, soil and economic limitations, land tenancy, market conditions, and cultural characteristics.

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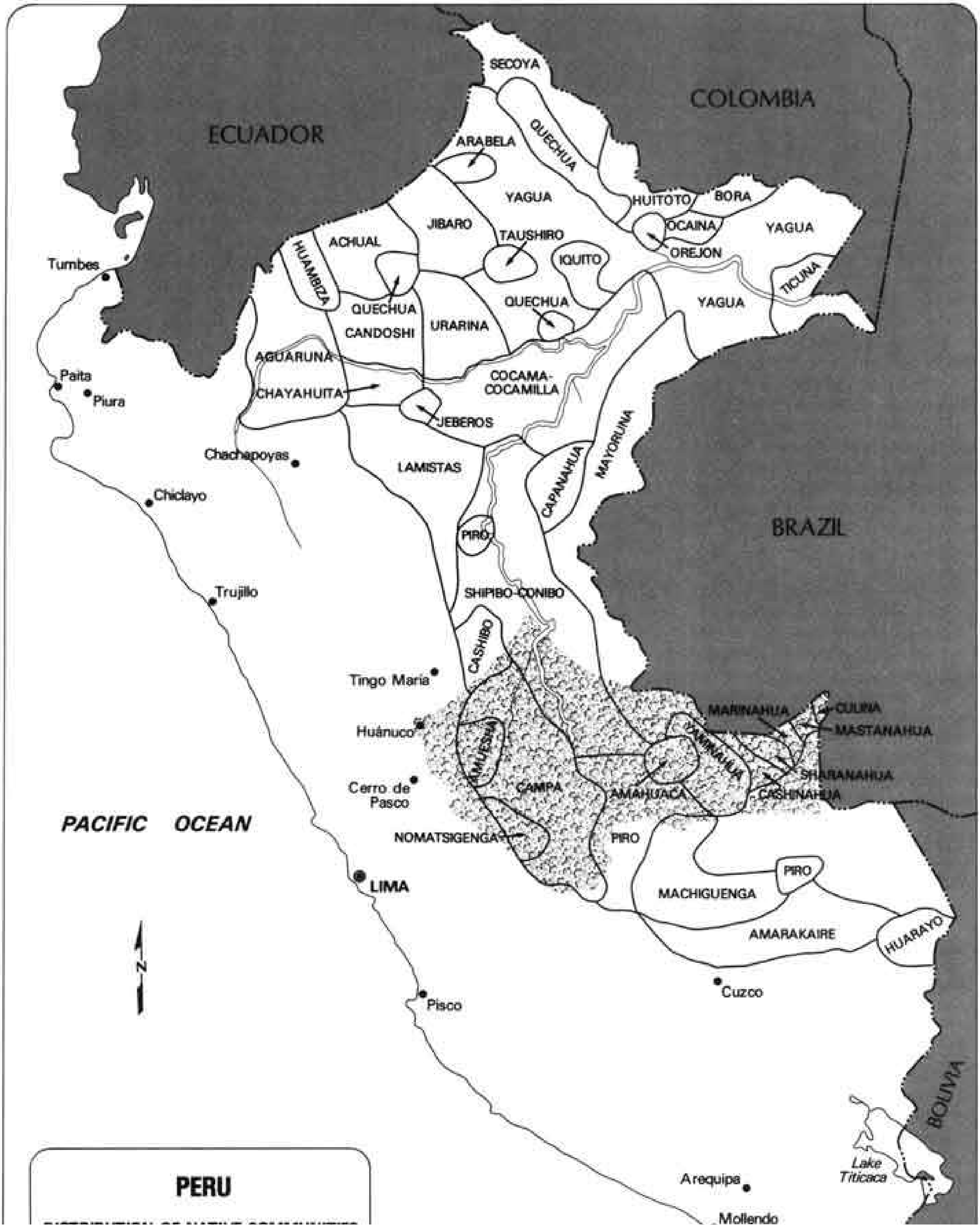
ECUADOR
COLOMBIA
BRAZIL
BOLIVIA
PACIFIC OCEAN
SECOYA
QUECHUA
ARABELA
YAGUA
HUITOTO
BORA
OCAINA
YAGUA
OREJON
JIBARO
TAUSHIRO
ACHUAL
HUAMBIZA
IQUITO
TICUNA
QUECHUA
QUECHUA
YAGUA
CANDOSHI
URARINA
AGUARUNA
COCAMA-COCAMILLA
CHAYAHUITA
JEBEROS
LAMISTAS
MAYORUNA
CAPANAHUA
PIRO
SHIPIBO-CONIBO
CASHIBO
MARINAHUA
CULINA
MASTANAHUA
AMUESHA
YAMINAHUA
SHARANAHUA
CAMPA
AMAHUACA
CASHINAHUA
NOMATSIGENGA
PIRO
PIRO
MACHIGUENGA
AMARAKAIRE
HUARAYO
Tumbes
Paita
Piura
Chachapoyas
Chiclayo
Trujillo
Tingo Maria
Huánuco
Cerro de Pasco
LIMA
Pisco
Cuzco
Arequipa
Mollendo
Lake Titicaca
N
PERU

Source: Map of Native Population compiled by Dr. Hugo Pesce. Institute of Summer Linguistics.

Chapter 10 - Ranching

Cattle, poultry, hogs, buffalo, and sheep are raised in the American humid tropics. Livestock raising has often been as controversial as agriculture, because of its negative side effects. On the other hand, countries in Amazonia need to use the humid tropics to feed their growing human populations (Peru for example must import meat and milk to satisfy national demand) (Table 10-1) and to increase their foreign exchange earnings by exploiting and exporting the goods and services obtained from tropical ecosystems. To this end livestock development policy in Peru has included strengthening livestock production and has given priority to activities that produce foodstuffs (INIPA, 1982).

All countries possessing Amazonian forests have indicated their firm intention to colonize and to encourage their exploitation (UNEP-MARNR, 1978; SUDAM, 1975; MAA, 1974). Nevertheless, these political decisions must now be accompanied by the technology to implement such policies.

Few concrete studies exist that describe how to establish stable livestock operations in the humid tropics. Stable production systems need to improve economic and social conditions and cause minimal damage to the land's capacity for providing quality environments to future generations.

Table 10-1
VOLUME AND VALUE OF MILK AND MEAT IN PERU (1981)

Product	Metric Tons (in thousands)	US$ (in millions)
Powdered milk without cream	23.4	29
Anhydrous milk fat	10.4	13
Powdered milk with cream	3.0	4
Beef	12.1	18

Source: Empresa Nacional de Comercialización de Insumos (1981).

The country must satisfy the demand for livestock products by exploiting its natural resources. Because of water scarcity and because it is more profitable to use irrigated areas for agriculture rather than livestock, animal production is difficult on the Peruvian coast. In the mountains, meanwhile, 70 percent of the livestock population is restricted to certain regions and, although production can be increased to some extent through improved management, only limited possibilities exist for expansion of livestock production activities. According to the Ministry of Agriculture (MAA, 1974), this leaves only the Selva as being capable of supporting major livestock development.

The American humid tropics have always been considered capable of supporting exceptional natural plant growth, because of favorable temperatures (averaging 24°C or more in the lowland jungle), and high levels of precipitation (over 1,500 mm) (Parsons, 1975). Minimal average monthly temperature (differences of less than 5°C exist) between the cold and warm months.

Further, much of the area is largely flat with ample water and a broad diversity of topographic, rainfall, and edaphic characteristics that, together, create a wide variety of regions that can be exploited. For example according to ONERN (1981), of the 75.7 million hectares in the Peruvian forest region, 10.3 million (13.6%) are suitable for grazing (Table 10-2). Even if livestock development is restricted to the lands best suited for grass (5.7 million hectares), an increase of some three million animals can be expected (Staver, 1981).

Another factor encouraging the introduction of livestock into humid tropical areas is the construction of access roads and trails, such as the Trans-Amazon Highway and the *Perimetral Norte* in Rodonia, Brazil that, together, include a total of 11,000 km of new roads. Ecuador and Colombia, because of their petroleum reserves, also have roads penetrating the jungle (Parsons, 1975). Peru, meanwhile, has reactivated its program to construct the Marginal Road (5,600 km) and has the support of neighboring countries.

Table 10-2
LAND USE APTITUDE IN THE PERUVIAN HUMID TROPICS

Classification	Land Surface Area	
	Hectares	%
Shifting Agriculture	2,421,000	3.21
Permanent Cultivation	2,191,000	2.89
Grass	5,718,000	7.55
Forests	46,432,000	61.35
Protection	18,924,000	25.00
Total	75,686,560	100.00

Source: ONERN (1981).

Whatever the purpose of the road being constructed, its immediate consequence will be spontaneous migration to the area accompanied by cutting, clearing, and burning of forests for cultivation of crops such as manioc and corn. In many of these cases, agriculture is a transitional step between forest and grassland. Thus, grasslands are expanding rapidly. It is hoped that, along with this expansion, introduction of improved grass varieties more appropriate to the tropics will bring increased production for the near future. For example, in the area influenced by the IVITA station in Pucallpa, 30 percent of the livestock lands are planted in various grass/legume combinations, and between 35 percent and 62 percent of the lands are planted in *Brachiaria decumbens, a* grass superior in quality to native and naturalized species (Riesco, *et al*, 1982). But there positive forces for livestock production must be weighed against conditions that will have a strong negative impact on the industry, such as unstable climate, poor soils, and cultural factors.

Factors detrimental to the livestock industry

In zones of 2,000-4,000 mm of rainfall/year, characterized by irregular rainfall distribution, grazing during the period of high rainfall causes severe leaching of nutrients and serious erosion of exposed soil (Tosi, 1975). Grazing in humid regions can also result in rapid decline of productivity due to soil compaction by livestock trampling clay soils saturated with water. Furthermore, as control of weeds through burning becomes impossible, ferns and other plants more tolerant than grass of acid and infertile soils begin to invade. For instance, in the Villa Rica area, rolling pastures which have been covered with *Melinis minutiflora* for the last 40 years are being invaded by ferns in the absence of measures to protect soil fertility. Because of the invasion of weeds and the natural low fertility of the soil, the land can support only around 0.7 animals/hectare. Eventually, the situation deteriorates to such an extent that people must emigrate from the area and find new lands for their livestock operations.

In regions and seasons of high rainfall drainage problems occur in the lowlands (*varzeas*) along the river banks. Epidemics and diseases increase, the use of mechanized equipment becomes more difficult, and the wear and tear on machines and agricultural equipment accelerates (Alvim, 1978). Heat and sunlight combine with the precipitation to create conditions inappropriate for livestock. For instance, in humid and very humid areas where temperatures do not fall below 20° C even at night, the cloud cover reduces photosynthesis and, thus, plant productivity (Tosi, 1975). The heat, meanwhile, makes cattle uncomfortable, reducing their food consumption and milk productivity and increasing energy expenditure to release excessive heat. Strong winds can reduce livestock productivity indirectly through their dehydrating effect on grass and soil.

Seventy-five percent of the Amazon riverbasin is characterized by acid and infertile soils, classified as oxisols and ultisols. These are deep, well-drained soils, red or yellowish, but with low pH and significant nutrient deficiencies (Sanchez, *et al.*, 1982).

Only 8 percent of the Amazon basin is covered by well-drained and moderately to highly fertile soils (Table 10-3). This figure, nevertheless, represents 37 million hectares. On the other hand, 67 percent of the basin (320 million ha) is covered by well-drained, acid, and infertile soils on land not exceeding 30 percent in slope. These soils are considered to have potential for agricultural, livestock, and forest exploitation.

Table 10-3
TOPOGRAPHIC DISTRIBUTION OF THE PRINCIPAL SOILS IN THE AMAZON BASIN (Millions of hectares)

Soil Group	Level Poorly Drained	Well-drained % Slope			Total	
		0-8%	8-30%	30%	ha	%
Acid, infertile	43	207	88	23	361	(75)
Alluvial, poorly drained	56	13	1	-	70	(14)
Moderately fertile, well-drained	0	17	13	7	37	(8)

Sandy,very infertile	10	5	1	-	-	(3)
Total	109	242	103	30	484	

Source: Sanchez, *et al*, (1982).

The principal obstacle, however, to employing Amazon soils in agriculture and livestock is their chemical, not physical, characteristics (Sanchez, *et al.*, 1982). As Table 10-4 indicates, 90 percent of the soils are deficient in phosphorus, with only 16 percent exhibiting a high capacity for fixing this element. Thus, phosphorus needs to be added to the soil or given directly to livestock, especially where grasses do not respond to phosphorus fertilizer because of high aluminum soil content (aluminum toxicity is the primary cause of poor grass growth in 73 percent of Amazon soils).

Finally, as Table 10-4 shows, 92 percent of Amazon soils are relatively resistant to erosion, due to the high proportion of lowlands and the gentle topographic relief in the Amazon region.

Table 10-4
PRINCIPAL LIMITATIONS OF AMAZON SOILS BENEATH NATURAL VEGETATION

Problem[a]	Millions of hectares	% of the basin
Phosphorus Deficiency	436	90
Aluminum Toxicity	352	73
Potassium Deficiency	271	56
Poor Drainage, Flooding	115	24
High Fixation of Phosphorus	77	16
Low Cation Exchange Capacity	71	15
High Susceptability to Erosion	39	8
Without Significant Limitations	32	6
High Degree of Slope (30%)	30	6
Laterite Formation when Subsoil is Exposed	21	4
Shallow Depth	3	0.6

a. Deficiencies of N, S, Mg, Zn, and occasionally other elements are widespread, but they cannot be quantified because of the lack of available data.

Source: Sanchez *et at.* (1982).

The low pasture density in the Peruvian Amazonia is chiefly due to the paucity of measures that replace soil fertility and to erosion in pastures located on steep slopes. Erosion is accelerated by animals compacting the soil, which reduce plant growth and cover. The magnitude of animal soil compaction can be inferred from the data on soil pressure that have been calculated for the Pucallpa region by Toledo and Morales (1979) (Table 10-5).

Table 10-5
RANGES OF PRESSURE ON SOIL APPLIED BY DIFFERENT COMPACTING AGENTS

Compacting Agent	Weight kg	Pressure on the Soil kg/cm²
Tractor, caterpillar, 180 HP	18,300	0.67 - 0.51
Tractor, Caterpillar, 270 HP	28,100	0.95 - 0.68
Tractor, Caterpillar, 385 HP	38,800	0.95 - 0.76
Tree-crusher, G-40 - 475 HP	45,000	1.03 - less
Tree-crusher, G-60 - 475 HP	65,000	1.37 - less
Horse	400	4.00 - 1.00
Cow	350	3.50 - 0.88
Human	70	0.47 - 0.23

Source: Toledo and Morales (1979).

Minimal soil erosion occurs when soil is covered by several strata of natural vegetation. On the other hand, any land use that exposes significant amounts of soil to direct wind and water action greatly accelerates erosion and produces the panoramas of denuded hillsides so common in the high forest region and along the eastern slope of the Andes. Raising livestock on steep slopes (more than 30%) can cause soil erosion problems; the paths they make can produce small pools of water, while overgrazing and annual cultivation expose the soil (Table 10-6). Clearly, livestock raising can be damaging. However, good grass and animal management can reduce erosion rates similar to those found under forest on rolling terrain (IVITA 1981). Given the close relationship between the weight of the compacting agent and the pressure that it applies to the soil, it would be expected that the smaller animals, such as swine and poultry, would be less damaging to the soil than cattle. Bishop (1980) points out that combining swine, poultry, agricultural and forest production in the Ecuadorian jungle is an economically attractive alternative, because these animals help maintain a stable nutrient cycle and they can be produced in harmony with the natural structure and function of humid tropic ecosystems.

Table 10-6
SOIL EROSION RATES IN THE HUMID TROPICS ACCORDING TO VEGETATION TYPE

Vegetation Type	Annual Erosion Rate	
	mm of soil	MT/hectare
Cotton Monoculture, Land Basically Flat	4	80
Rotational Cultivation, Land Basically Flat	1.6	32
Dense Pasture, Flat Land	0.1-0.5	2-10
Low Pasture, Flat Land	1-100	20-100
Cultivation on Newly-Cleared Slopes	30-60	600-1200
Virgin Forest, Rolling Terrain	0.01-0.5	0,2-10
Virgin Forest, Pronounced Slopes	0.5-2	10-40
Dense Forest Plantations, without Ground Cover	1-8	20-160
Thin Forest Plantations, with Ground Cover	0.1-0.5	2-10

Source: Bruning (1975).

Humid tropical soils require a continual return of nutrients for the vegetation to exploit, because of their low cation exchange capacity and because of the high amount of rainfall in the region. The nutrient cycle in forests includes the formation of a carpet of shallow rootlets, the extraction of nutrients, enhanced decay of leaves and branches, and the action of micorrhizae to transfer nutrients to the roots (Herrera, *et al,* 1978). In adopting cultivation, native populations used a system of shifting agriculture in which trees were felled, cleared, and burned, not only to prepare land for sowing, but also to fertilize the soil with the minerals in the ashes of burned vegetation. "Crop" plants, with higher nutritional requirements, could only produce for two or three years before the land became infertile where upon the lands were abandoned and left fallow for up to 20 years.

The coming of livestock brought two changes: grass, rather than annual crops, was planted immediately upon clearing the forest or, instead of being fallowed, the land was converted to grassland upon abandonment for agriculture purposes (Walters, 1975). Although livestock raising was begun by colonists, a growing number of indigenous inhabitants are now also active in livestock production either for economic reasons, or as Dickinson (1981) suggests, cattle imparts to man a sense of prestige. Nevertheless, neither the colonists nor the natives possess the minimum technology necessary to maintain cattle over long periods in one locality, and so must practice what may be called "migratory ranching."

New techniques are being developed to make livestock endeavors more efficient and stable. Selective and incomplete use of some of these techniques, however, can actually accelerate forest destruction. One such unbalanced technology is the use of new deforestation techniques which, for example, has reduced the cost of clearing forests in Costa Rica from US$450 per hectare to only US$127 per hectare (Parsons, 1975) and has stimulated the expansion of livestock operations in the absence of similarly improved techniques in animal production.

The above discussion primarily refers to cattle raising. Swine and poultry production, either shifting or sedentary, share many practices with annual cultivation and can help maintain the nutrient cycle in the soil. Sheep and goat enterprises are just beginning in the Peruvian jungle, but the same factors that affect cattle also affect these animals.

There is a tendency to believe that neither shifting nor subsistence livestock operations will ever attain a stable level in the humid tropics or produce enough food to satisfy the needs of growing human populations. It is felt that these systems, while providing for the needs of the people employing them, will not be capable of either providing the economy with a significant quantity of products, or of efficiently utilizing humid tropical natural goods and services. In addition, subsistence technologies, such as shifting agriculture, while being in harmony with certain ecological principles, also guarantee the continued poverty of their practitioners (Alvim, 1978). Demographic pressure has accelerated the cycle of clearing land and leaving it fallow, giving the impression that the system has become more efficient. In reality, however, it has led to an unproductive and unstable use of tropical ecosystems.

In a hot and humid environment animals suffer as much as humans from such problems as foot fungosis, parasites both external (ticks, worms) and internal (for example, lung worm *Dyctiocaulus*), and other diseases such as pneumonia, mineral deficiency, and malnutrition. In one five-year study of 1,703 calves in the Pucallpa region, the principal causes of death were found to be malnutrition (37.9%), pneumonia (8.3%), piosepticemia (7.7%), and clostridiocis (5.1%).

The ruminants best able to adapt to the humid tropical environment are the water buffalo and the cow. The tropical climate is also appropriate for such non-ruminants as swine and poultry; in fact, the intensive production of these animals can be economically more profitable in the tropics than in temperate areas because of lower construction and heating costs, for example (Payne, 1975).

Another serious problem confronting livestock operations in the humid tropics is the proliferation of weeds which sprout from large quantities of seeds in the soil, germinating when the clearing and burning of forests creates favorable fertility and light conditions (Toledo and Morales, 1979).

With both subsistence farming and extensive livestock enterprises, nutrients extracted from the soil have to be replaced, because they are indispensable to meat and milk production.

To illustrate, Serrao *et al,* (1978) cites results in Brazil in which 10 years of burning and cultivating grass produced an increase in pH, interchangeable calcium and magnesium, and potassium; a dramatic decrease in aluminum, and a notable increase in phosporus during the first four years followed by a decrease in phosporus to the original minimum virgin forest levels. Table 10-7 presents the data obtained from this study, which was carried out in the Paragominas region in Para state with ultisols. Similar results were obtained in Para and Mato Grosso with oxisols. Thus, it is evidently necessary to combine burning with phosphorus fertilization to maintain soil quality. Serrao *et al*, (1978), for example, announced that 13 years of applications of 137.5 kg/ha of phosphate (P_2O_5) *Panicum maximum* raised production from 3.5 MT/ha to 17.5 MT/ha. Toledo and Serrao (1982) recently reported similar results, adding that one factor limiting production and affecting fertilizer imports is the use of grass and legume species in the humid tropics that are not the best suited to local conditions.

Other goods and services required by livestock operations include wire for fences, herbicides, insecticides, antibiotics, fungicides, insect repellents, medicines, castration equipment; and milking, dehorning, veterinary, transport, extension, and commercial services. All of the goods must be brought from other regions, and some, such as vaccines, do not retain their effectiveness in tropical temperature and humidity. The investment required for these necessary services and imported goods mentioned above represent an obstacle to successful livestock enterprise in the Selva.

Ranching's interaction with other sectors

Livestock raising interacts with other activities of development in the humid tropics. These interactions can be positive and complementary (synergism), or negative and conflicting (antagonism), often depending on which category of livestock activity is under consideration: migratory livestock meat production (unstable system); sedentary livestock meat production (stable or potentially stable system); intensive livestock meat or milk production (stable system); swine and poultry production.

Livestock and Aquaculture

Peasants and indigenous people raising livestock today are increasingly using marginal lands. The cutting and clearing of forest areas to establish livestock operations can cause changes in river regimens and negatively affect fish production and growth. On the other hand, sedentary and intensive livestock operations tend to protect downstream areas where fish are abundant. Another advantage of intensive livestock operations (especially milk production) is that they use the manure they produce as fertilizer;

when this organic material is transported to rivers and lagoons during the rainy season, it can benefit fish. However, too much fertilizer can lead to excessive algal growth that can reduce the oxygen supply of lagoons and other small bodies of water and hinder pisciculture.

Swine and poultry production does not now conspicuously interact with fish culture in the humid tropics, but in China, the Philippines, and India synergistic interactions have increased when poultry and swine production is associated with pisciculture. In these situations poultry and swine are bred in confined conditions (intensive systems), which facilitate the collection of manure, which is then placed in chambers where anaerobic fermentation converts it to methane gas. This gas, in turn, is used to heat, refrigerate, produce light, and provide heat for poultry and swine broods.

The solid residue (sludge) remaining in the biogas production tanks is applied directly to fields as fertilizer, while the liquid residue (caldo) is used for cultivating nitrogen-fixing algae that produce a protein-rich food for swine and poultry. The Asians also breed fish that can be fed on this enriched food; and, they build enclosures for chickens and ducks above the ponds with floors made of open grating, so the waste is dropped into the ponds.

Table 10-7
THE CHEMICAL COMPOSITION OF ULTISOLS UNDERLYING FOREST AND GUINEA GRASS (Panicum maximum) DURING 10 YEARS IN PARAGOMINAS, PARA, BRAZIL

	Organic Material	Interchangeable Cations						Saturation
	%	N	pH	(CA+Mg) meg/100g	Al	K	P	Al
Forest	1.2	0.05	4,2	0.30	0.9	20	3	70
Grass								
Established	1.0	0.06	7,1	3.05	0	27	12	0
Grass								
1 year	1.0	0.05	6.7	2.31	0	70	9	0
2 years	1.3	0.06	6.5	2.65	0	59	8	0
4 years	1.2	0.05	6.7	3.56	0	51	10	0
5 years	0.9	0.05	6.2	2.13	0	20	2	0
6 years	1.4	0.06	5.8	1.98	0	39	3	0
7 years	1.3	0.06	6.0	1.75	0	98	3	0
8 years	1.1	0.06	6.0	1.92	0	23	3	0
9 years	1.2	0.06	6.4	3.18	0	43	3	0
10 years	0.9	0,04	6.3	2.33	0	20	2	0

Source: Serrão *et al.* (1978).

Livestock and Hydroenergy

Regulating water supplies with dams can either obstruct or assist livestock operations. For example, dams can reduce the amount of gentle slopes for cattle grazing when mud is deposited by rivers rising behind dams. Poorly managed shifting and sedentary upstream livestock operations, meanwhile, create soil erosion that increases the amount of soil entering reservoirs. Reducing and regulating water supplies with dams can also threaten continued water buffalo operations by drying areas that were formerly periodically inundated.

On the other hand, both sedentary and intensive livestock operations benefit from hydroelectric works that ensure continual water flow, reduce flood risks, assure availability of water for livestock throughout the year, and provide water for rangeland irrigation during drought periods. In particular intensive dairy farming is assured of water for cleaning installations, equipment, and animals, and for the electrical energy required to operate milk storage facilities and milking machines.

Livestock and Agriculture

Except for competition for space, neither intensive cattle ranching nor swine and poultry raising are antagonistic to agriculture. Indeed, they quite often complement each other, as when crops are partially or totally dedicated to feeding animals. Such an arrangement is seen in the high forests of Peru, where manioc, corn, rice, and regional wheat (*Coix lacrima*) *are* used to feed poultry (Blasco, *et al,* 1977). Another example is the use of forage crops, such as sorghum, corn, sugar cane and tropical root crops to supplement the diets of milk cows in the Pre-montane humid tropical climate at Oxapampa.

A growing interest exists in finding other ways to combine livestock with tropical agriculture, the most important using tropical crops, crop residues, and agricultural by-products. For example, livestock periodically fed manioc, can triple the yields of protein-rich forage (20% protein) without affecting the production of manioc (Ruiz, unpublished). Potato may be used in similar fashion to provide 600-700 grams of weight gain daily (Backer, *et al,* 1980). Use of crop residue and other by-products are described in various publications, which describe how sugar cane shoots, molasses, and urea can sustain intensive meat production at 800-1,000 grams per day (Ruiz, 1976). Ruiloba and Ruiz (1978) have also found that chaff from rice plants can be used in meat production, producing up to 1,000 grams of daily weight gain.

Livestock production is not as complementary with permanent cultivation as it is with annual cultivation. Nevertheless near Veracruz, Mexico sheep production is associated with citrus growing. The sheep feed on low plants in the orchard, thus saving the expense of manually or chemically controlling the plants that can obstruct fruit harvest. Further, the Animal Science Department of the University of Florida (USA) has developed techniques of using pulp from citrus fruits to nourish animals which would be useful in the humid tropics, where industrial processing of citrus and other tropical fruits produces significant quantities of potentially usable residues.

Associating legumes with annual and perennial crops is another method of combining agriculture and livestock. Reviewing this subject, Sanchez *et at.,* (1982) points out that the use of kudzu (*Pueraria phaseoloides*) *as* a fertilizer results in crop yields similar to those obtained using comprehensive fertilization but the cost of harvesting, transporting, and applying kudzu limits the extent to which this technique can be used. However, a legume not only provides a protein-rich forage, but also fixes nitrogen in the soil through its rhizobia and thus can be used to feed ruminant animals, and the resulting animal feces can then be applied as fertilizer.

Growing corn along with forage legumes is being investigated in Costa Rica and could provide legumes and corn residues that would be more nutritious than corn residues alone. Such methods can triple the available protein in animal forage and increase by 50 percent the energy quality of agricultural residues.

Nourishing animals with crop residues, however, also increases the risk of erosion, since their removal from land reduces the cover protecting land from rain and wind.

Livestock and Forestry

Land that has been cultivated for two or three years is frequently converted into grassland, instead of being allowed to lie fallow. It is obvious then that livestock operations can hinder forest regeneration. Livestock grazing increases soil erosion on hillsides exceeding 30 percent in slope, thus, when grazing on these slopes conflicts with forest regeneration, the forest sector should take precedence. On more gentle slopes, however, resolution of the conflict depends on edaphological considerations. Both activities can be combined in silvopastoral systems. But major conflicts exist between livestock and forest interests when both sectors can profitably exploit the same land.

Initiating sedentary and intensive livestock operations conflicts with forest interests by clearing forest areas to establish pastures and to provide wood for livestock facilities such as fences, corrals, stables, gates, beams, workers' cabins, landowner homes, crates, and others. Another negative interaction stems from the conviction of many stockmen that livestock do not require shade in pastures. Thus, these stockmen prefer rangeland completely cleared of trees, because they believe tree shade impedes grass growth. This generalization is not always true, however, precisely because of the variability of tree and grass species, soil types, and livestock.

Another conflict between livestock and forestry enterprises occurs when livestock enter forest areas and trample and browse seedlings. Kirby (1976) describes New Zealand experiences in which sheep and calves have grazed under close supervision in areas reforested with *Pinus radiata* when saplings had reached one meter in height. Young bulls and heifers, meanwhile, can graze in such areas if the trees are taller than 2-2.5 meters.

Livestock and forestry operations are more frequently observed in association than in competition. For instance, it is common to find ranches in which various living trees (such as *Erythrina* sp., *Gliricidia sepium*, and *Leucaena leucocephala*) serve as fenceposts. Trees also provide livestock with shade and wind protection while various forest species provide forage to ruminant animals. Such plants include *Erythrina glauca, E. poeppigiana, Glyricidia sepium, Leucaena leucocephala, Guazuma ulmifotia, Psidium guajava,* and *Cecropia.* In Costa Rica *Erythrina poeppigiana* is used to provide shade in coffee plantations, at a density that can yield approximately 4 MT of *Erythrina* forage (dry weight) every six months. Other studies in Costa Rica have illustrated this plant's richness in protein (20-24%), digestibility (around 65%), and palatability to goats and sheep (3.1-3.5% of the living animal's weight) (CATIE, 1978). In summary, then, data illustrating the nutritional value of forest species indicate that it is technically feasible to develop efficient systems that integrate silviculture with livestock endeavors.

Livestock and Wildlife

Native fauna of the humid tropics, of course, intimately depend on forests. Thus, livestock operations compete with wildlife interests as they do with forest interests. Further, stockmen wish to prevent livestock from coming into contact with wild animals. Felines, such as the jaguar, and serpents, such as the bushmaster, can decimate herds. Herbivorous insects can greatly reduce rangeland biomass. Data detailing the significance of this phenomenon in the humid tropics do not exist, but in a sheep-raising region in the United States it has been estimated that up to 50 percent of an area's grass can be lost to insects. I n addition, armadillos, some rodents, and snakes consume chicken and duck eggs. Forests also harbor vectors of the eggs of the parasitic worm *Dermatobia*, and vampire bats feed on the animals' blood and expose them to infections and infestations. Thus, the stockman has no interest in having his livestock live alongside wildlife. His zeal to control wildlife is not restricted to his own land but is also manifested outside it.

On the other hand, some cases are known of livestock associating with wildlife. One example is the appearance in tropical America of the cattle egret that follows livestock to feed on insects and ticks and other acarids that live on, or fall from, the animals' loins, thus reducing parasitism and the incidence of livestock diseases. Young chicks raised around households almost always are permitted to roam freely outside the houses, at which time they encounter a large variety of insects that they consume voraciously.

Livestock and Human Settlements

Four categories of inhabitants, as classified by Dourojeanni (1979), live in the high forest of Peru: mountain people, coastal people, European immigrants, and Asiatic immigrants. In the low forest, another group can be recognized: river people, descendants of the first white colonists, who intermarried with natives. Natives, river people, and mountain people practice shifting agriculture and are workers for other groups. Mountain people and other groups also practice other types of agricultural activity, as well as livestock, forest, mining, and commercial pursuits.

Even in the absence of detailed studies illustrating the interactions between human settlements and livestock, some observations can be made. First, it is evident that, of all agricultural pursuits, natives, jungle dwellers, and mountain people have had the least exposure to tropical livestock raising. Natives seldom raised livestock until they learned how to do it while working for the colonists. Mountain people, on the other hand, had some knowledge of raising sheep for wool production. Thus, it should come as no surprise that these groups tend to practice unstable livestock enterprises caused by lack of basic technical knowledge and, in so doing, cause rapid destruction to the soil and other natural resources of the forest.

The other groups practice sedentary, extensive, and semi-intensive livestock activity. People from the coast have brought such practices with them as confining livestock and feeding them with cut forage. The descendants of immigrants tend to settle in the highlands and produce both meat and dairy products where the topography permits, breeding the stock with European races.

From this, it can be surmised that people engaged in livestock activity without the knowledge of fundamental technology can cause problems affecting man and the ecosystems which support him. The only solution is to educate people in animal production and to establish commercial channels that will enable them to break the cycles of poverty, make a profit from their efforts, and thus insure their continual and consistent interest in their work.

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Chapter 11 - Forestry

The world's closed tropical forests total 1,160,000,000 hectares; 53.6 percent of them are found in Latin America and include 506,500,000 hectares of exploitable forests and 147,500,000 hectares of non-exploitable forests. Peru, with 74,000,000 hectares, has the second largest expanse of tropical forests in Latin America, behind only Brazil which has 400,000,000 hectares (FAO, 1982). Nine and 1*12* million forested hectares are in the Central Selva, of which 43 percent show good production potential; 27.9 percent show medium to low production potential; 18.2 percent need to be left intact; and 8.4 percent have already been cleared for agriculture and livestock (UNA, 1980).

Tropical forests can be classified according to climate, use, or accessibility, although the broadest classification system used in tropical America is that of Holdridge (1967). Forests can also be classified according to their successional stage: climax (virgin forests); partially disturbed; mature second-growth; young second-growth; and lands deforested to be used for farming and ranching.

When the Central Selva is classified according to use, 802,356 hectares have been cleared for agriculture and livestock production, although only 25 percent of these are actually under production; the rest lie abandoned and fallow.

Humid tropical forests are highly productive, with average biomass exceeding 400 m^3 per hectare of which 40 percent is exploitable wood. These volume figures for the Central Selva are given in Table 11-1 and include all commercial forest species as well as a large number of species not yet commercially exploited because of certain negative qualities (silica content, difficulty in drying, hardness). When only presently-exploited species are considered, the volumes are reduced by almost one half.

The total commercial volume is 51.5 m^3 per hectare, or 43 percent of the volume available given present-day technology and markets, and 23 percent of the volume being used (27.7 m^3/ha). This figure is much higher than the 2 m^3 per hectare average currently being obtained through selective harvesting.

Table 11-1
CUBIC METERS PER HECTARE OF BIOMASS (M^3/HA) PER ZONE IN THE CENTRAL

SELVA

Zone	m^3/ha
Pozuzo	136
Oxapampa-Villa Rica	109
Pichis-Palcazu	115
La Merced-Satipo	123

Source: UNA (1982a,b,c).

Vegetative composition also keeps trees off the market. Of the more than 2,500 tree species in Peruvian tropical forests, many do not contain sufficiently valuable wood or are not common enough to be exploited commercially. Forest inventories in Peru have recorded 250-400 species per region, with the most abundant species being represented by 10-15 individuals per hectare and the least abundant by 0.01 trees per hectare (Table 11 -2). But while tropical forests seem to have many different kinds of trees, some are much rarer than others, and only a few species comprise most of the total volume (Malleux, 1982).

Table 11-2
TREE SPECIES PER ZONE

Zone	Number of Species Recorded	Number of Trees per Hectare Most Abundant Species	Number of Trees per Hectare Least Abundant Species
Pozuzo	222	10.2	0.015
Oxapampa-Villa Rica	280	14.0	0.02
Pichis-Palcazu	350	12.5	0.01
La Merced-Satipo	270	8.0	0.01

Table 11-3 shows the close mathematical correlation between volume percentages and numbers of species, with the 10 most abundant species accounting for 44 percent, the 20 most abundant accounting for 62 percent, and the 50 most abundant accounting for 75 percent of the total volume. The more important tree species in the Central Selva are given in Table 11-4.

Use of wood and other forest products

Even though wood is an abundant resource in Peru, its forest industry is not well developed - largely because of limitations on the numbers of species utilized, the low prices paid for logs, and problems with the chain of commerce (the various "middlemen") (MAA, 1980).

Table 11-3
WOOD VOLUME OF MOST ABUNDANT SPECIES

Zone	Total Volume	10 Most Abundant Species	20 Most Abundant Species	50 Most Abundant Species

	m^3/ha	m^3/ha	%	m^3/ha	%	m^3/ha	%
Pozuzo	136	60,7	37	82.6	51	115.4	71
Oxapampa-Villa Rica	109	48.3	44	68.5	62	81.1	81
Pichis-Palcazu	115	46.0	40	69.0	60	87.4	76
La Merced-Satipo	123	67,3	54.7	92.2	75		

Table 11-4
THE MOST IMPORTANT CENTRAL SELVA TREE SPECIES

Common Name	Scientific Name	Common Name	Scientific Name
Pashaco	*Albizzia* sp.	Moena	*Ocotea sp.*
Shimbillo	*Inga sp.*	Manchinga	
Moena	*Ocotea* sp.	Requia	*Garea trichilioides L.*
Mashonaste	*Clarisia* sp.	Quinilla	*Chrysophyllum* sp.
Cumala blanca	*Virola decortinane* Ducke	Machin sapote	
Cachimbo caspi	*Couratari* sp.	Mashonaste	*Clarisia racemosa*
Marupa			*R. et P.*
Shiringa	*Hevea* sp.	Chimicua	*Pseudoemedia*
Huamansamana			*multinensis M.*
Almendro	*Caryocar sp.*	Shimbillo	*Inga sp.*
Machimango	*Eschweilera* sp.	Catahua	*Hura crepitans* L.
Caimitillo	*Sideroxylon* sp.	Tornillo	*Cedrelinga*
Lupuna			*catenaeformis* Ducke.
Sapote		Yauchana	*Poulsenia armata*
Espintana	*Duguetia* sp.	Nogal	
Copaiba		Pashaco	*Schizolobium excelsum*
Chimicua	*Perebea* sp.		*Ducke.*
Copal	*Protium* sp.	Cedro	*Cedrela odorata*

National timber production is approximately 4.5 million m^3/year. Of this volume, around 1.5 million m^3 are used in industry, while the rest is consumed as firewood. In 1978 and 1979 national lumber production averaged 400,000 m^3, of which approximately 15,000 m^3 were exported (eight thousand m^3 were imported). Industrial lumber production has focused on some five species, which represented 71 percent of the national production in 1978 (Table 11-5). Other species were used only in very small amounts.

Table 11-5
LUMBER PRODUCTION BY SPECIES

Cedro	88,000 m^3
Eucalyptus[a]	78,000 m^3
Roble corriente	43,000 m^3
Tornillo	39,000 m^4
Caoba	23,000 m^4
Moena	14,000 m^4
Total	285,000 m^4

a. Harvested from mountain plantations.
Source: MAA (1982)

Today the Central Selva contributes 41 percent of the lumber produced in Peru. Factories in the region produce parquet, broom handles, and crates, rather than the more profitable planking and plywood. Firewood consumption in the region is greater than 1 million m^3/year. Native communities also exploit the forests. Those in the Central Selva have for generations used such products as leaves, fruit, roots, and vines (Table 11-6).

Present and future forest use

Natural forest in the Central Selva is subject to strong human pressure because it is near the crowded Central Sierra. Confronted by high population densities and the need for land, large numbers of people from this area continually migrate to the high and middle Selva areas. This human flow, incited and promoted by official policy and projects, has resulted in the clearing of 800,000 hectares for agriculture and livestock, establishing farming operations on soils that are inappropriate for this use.

Soil Use Classification

Soils in the Amazonian region are normally unproductive for agriculture. For example, ONERN (1982a) estimates that an average of 4 percent is suitable for clean cultivation, 2 percent for permanent agriculture, 14 percent for grass, 38 percent for forest exploitation, and the remaining 42 percent for being left alone. Research conducted in the Pichis-Palcazu and Oxapampa-Villa Rica regions by the National Agrarian University (UNA, 1982a, b, c) classified soils according to their most appropriate use (Table 11-7), while according to the Peruvian land use classification map (ONERN, 1982b), the Atlantic Slope (Amazon basin) has the land use capabilities described in Table 11-8.

Land use classification for the Central Selva is given in Table 11-9 where two-thirds (66.1 %) is classified as being best suited for protected forest, 14.2 percent as being best for forest production, and 19.7 percent as being most appropriate for agriculture and livestock (grass, permanent cultivation, clean cultivation). Never-the-less, according to the Peruvian Forest Map (Malleux, 1975), more than 800,000 hectares in the region have been cleared for agriculture and livestock. Of this land, scarcely 25 percent (200,000 hectares) is presently being used; the remaining has been abandoned and is either lying fallow or is covered by second-growth forest.

According to the Ministry of Agriculture, 63,159 hectares were cleared in the San Ramon-Villa Rica and

Satipo agriculture districts in the 1979-1980 growing season. Each year, 5 percent more of the area, or 40,000 hectares, is cleared of forests. This trend indicates that over 1,000,000 hectares will have been cleared by the end of the century; added to the present amount of cleared land, this will total 1,800,000 hectares, or more than the combined total area of lands used for forestry, livestock, and agriculture.

Table 11-6
FOREST SPECIES THAT PROVIDE PRODUCTS OTHER THAN WOOD

Common Name	Scientific Name	Product
Huito	*Genipa americana*	Fruit
Marañon	*Anacardium occidentale*	Fruit, seed
Guanabana	*Anona muricata*	Fruit, seed
Arbol del Pan	*Artocarpus communis*	Fruit, seed
Achiote	*Bxia orellana*	Extract
Almendro	*Caryocar* sp.	Fruit
Palmito	*Euterpe precatoria*	Palm hearts
Aguaje	*Mauritia flexuosa*	Fruit, oil
Sapote	*Matisia cordata*	Fruit
Uvilla	*Pourouma cecropiaefolia*	Fruit
Ungurahui	*Jessenia batata*	Fruit, oil
Oje	*Ficus authelmintica*	Latex
Jebe	*Hevea brasiliensis*	Latex
Yarina-lrapai	*Phytelephas microcarpa*	Leaves for roofing, fibers

Table 11-7
LAND CLASSIFICATION IN THE PICHIS-PALCAZU AND LA MERCED-SATIPO REGIONS

	Pichis - Palcazu		La Merced - Satipo	
	Ha	%	Ha	%
Total Area	1,350,811	-	630,098	-
Protected Forest	1,022,000	75.66	343,466	54.51
Agriculture and Livestock	53,542	3.97	74,541	11.83
Agro-forestry	86,549	6.41	-	-
Permanent Forest Production	150,393	11.13	212,091	33.66
Forest Reserves	38,327	2.83	-	-

Source: UNA, (1982),

Table 11-8
LAND USE CAPABILITY ON THE ATLANTIC SLOPE

	Ha	%

Total Area	95,675,100	100.00
Forest Production	47,960,800	50.13
Protection	30,867,700	32.26
Grass	11,376,400	11.89
Clean Cultivation	3,259,500	3.41
Permanent Cultivation	2,210,700	2.31

Source: ONERN(1982b).

Table 11-9
USE CLASSIFICATION OF SOILS IN CENTRAL SELVA WATERSHEDS[a] (Thousands of hectares)

	Pachitea[13]	**%**	**Perene**	**%**	**Ene**	**%**	**Tambo**	**%**	**Total**	**%**
Protection	1,595	55.6	1,340.2	72.92	810.3	86.48	263.7	60.92	4,007.2	66.1
Forest Production	631	22.02	137.7	7.39	72.6	7.75	24.9	5.75	866.2	14.2
Grass	368	12.84	236	12.84	1.2	0.13	94.8	21.80	700.0	115
Permanent Cultivation	140	4.89	83	4.52	31.2	3.33	36.6	8.45	290.8	48
Clean Cultivation	131.1	4.65	43.2	2.34	21 6	2,31	12,9	2.98	209.8	34

a. Does not include the Atalaya Forest District.
b. Includes the Pichis and Palcazu valleys.
Source: ONERN (1963). (1966a,b). (1970). (1981).

Timber Harvest

Timber harvest, another significant economic activity in the region, is carried out through contracts on land tracts of variable size (from 200 to more than 20,000 hectares) within such declared areas as freely-accessible forests. Selective harvest focuses only on commercially valuable species (cedro, caoba, ishpingo, tornillo); normally, only 5 m^3 per hectare are harvested, so the forests are not significantly altered.

Five units of freely-accessible forests in the Central Selva occupy 1,761,000 hectares. Figures from 1980 indicate that 280 harvest concessions were issued for 100,000 hectares which, according to the Ministry of Agriculture, produced 165,000 m^3 of lumber and some 30,000 m^3 of other wood products.

According to the forest development plans of the Pichis-Palcazu Special Project and the National Forestry Institute, the Central Selva is to become the most significant source of wood in the country (MTC, 1981 a). These efforts are projecting forest harvests beginning in 1985 (Table 11-10). To this can be added the volume harvested from the Alexander Von Humboldt National Forest for a total of 447,000 m^3 of logs and 200,000 m^3 of lumber.

Timber harvest in the Central Selva began 60 years ago in the Oxapampa-Villa Rica region, at first to supply the wood needed for home construction and public works, and later to supply industry. The Oxapampa-Villa Rica region has developed harvest techniques that have not been used in other areas, including dragging the logs with oxen and mules, using skidders on slopes and hills, harvesting a large number of species that produces large average volumes per hectare, and intensive harvest of essentially homogeneous stands of *Podocarpus oleifolious* and *P. montanus* (ulcumano and diablo fuerte)(JRB, 1981).

Table 11-10
PROJECTED WOOD PRODUCTION IN NEW CENTRAL SELVA FOREST DEVELOPMENT PROJECTS (m^3/year)

	Sawlogs	Lumber
Valle del Pichis	223,000	101,000
Valle del Palcazu	109,000	49,000
Valle del Perene	35,000	15,000
Total	367,000	165,000

Source: Proyecto Especial Pichis-Palcazu (PEPP), personal communication.

Today there are 29 sawmills in Oxapampa-Villa Rica with a lumber capacity of 78,000 m^3/year. Forty-five percent of these operations participate directly in harvesting their raw material. None of them, however, are self-sufficient; they all must obtain additional timber by contracting colonists and middlemen.

The average distance from forest to mill is 40-50 km and can be as long as 90 km in Oxapampa. Felling and trimming are done by chainsaws provided by the industries. Tractors have not yet been introduced into this region; trucks with winches and cable are used instead. In the Alexander Von Humboldt National Forest timber is hauled by road and river, and tractors are frequently used, The timber harvesting methods employed in the country may be separated into four different categories: clear-cutting, individual harvesting on private parcels, semi-intensive industrial harvest, and selective industrial harvest.

Clear cutting is not precisely a management method, but simply describes the clearing of forests for agriculture and livestock. The most valuable trees harvested are sold to middlemen or industry, but this process provides less than 10 percent of the logs utilized as raw material by industry. Nationwide, it is estimated that 300,000 hectares of natural forest are cleared annually, which theoretically should produce more than 1,000,000 m^3 of commercially-valuable wood. Not only is this wood lost, but a great amount of less valuable wood is also destroyed because the indiscriminate cutting is carried out on small and scattered parcels, by a farmer who lacks the technical knowledge, infrastructure or equipment to get the wood to the market.

Once the farmer is settled near a logging road and sawmill, and has acquired some working capital and basic tools, he may *selectively harvest trees from his parcel* or sell them on the stump. He regularly harvests a small percentage of wood for domestic purposes (home construction, firewood, fences) using palm leaves for roofing and other materials. At the same time, he continues clearing the forest for agriculture. Each year approximately 460,000 m^3 of wood harvested by this system are used for domestic purposes and 250,000 m^3/year, or 25 percent for industry. In the Central Selva, this system should supply 120,000-150,000 m^3 of saw-logs per year.

The *semi-intensive industrial harvest* system is based on planning and investment, and its objective is to supply industry. The area being exploited remains relatively stable. Forest product industries organize and execute the harvesting, using such heavy equipment as tractors, truck loaders and winches. Some companies are contracted by industries to harvest wood, leasing from 5,000 to 50,000 hectares of land from the industries. This system is most developed in the Iquitos and especially the Pucallpa regions.

An increased number of species is beginning to be harvested with mechanized harvest techniques in order to reduce costs. A 20 m^3 per hectare volume increase in harvested wood has been achieved in Pucallpa, although in most of the territory the increase has only been 5-10 m^3 per hectare. This is above the national average increase, which is under 5 m^3 per hectare. Yet because this system is still not widespread, it supplies no more than 15 percent of the sawlogs consumed by industry.

Selective industrial harvesting is traditional and widespread in the country. Small-scale harvesters (200-800 hectares) are contracted by middlemen who provide some tools and working capital. During the *zafra* period, when rivers are rising, trees are cut, trimmed, and dragged to riverbanks or roads, where the contractor or middleman buys the logs at a price that varies according to species, scaling the log in board feet (assuming 200 board feet/m^3). This system supplies approximately 50 percent of the wood used in industry.

The timber industry

The national timber industry has improved significantly in the last few decades, but its progress is limited by several variables, including limited production directed at a high-income population; poorly-diversified industrial production; deficient product quality control; a poor system of harvesting and supplying raw material; and poorly developed wood technology and the use of a limited number of tree species.

Sawmills utilize 83 percent of the sawlogs cut for industrial purposes, followed by the plywood industry which uses approximately 9 percent of the wood. Seven tree species provide 75 percent of the lumber produced: cedar, 15 percent; eucalyptus, 18 percent; roble corriente (Moena), 11 percent; tornillo, 14 percent; mahogany, 6 percent; other moenas, 8 percent; and copaiba, 3 percent. Three principal species are used in parquet production: hualtaco, oreja de leon, and guayacan. Other species used include huayaruro, chonta, quinilla, and mashonasta. Laminated wood is made chiefly with lapuna (*Chorisia* sp.).

These data show that more than 80 percent of the national timber industry depends on some 12 species, with cedar, mahogany, and tornillo providing more than 35 percent of the lumber produced nationally. Even though these species usually occur in low densities, together they provide an average volume of 5 m^3 round wood per hectare nationally, 3.5 m^3 round wood per hectare of recoverable wood, and 2 m^3 per hectare of lumber. Thus 83,000 hectares of forest annually produce 166,000 m^3 of lumber from these three species.

In the Central Selva foresters are able to use more species than in the country as a whole, because of the logging roads and the intensive harvesting carried out in the Oxapampa and Villa Rica regions, where a grouping system lumps a large variety of species under one name. Species are grouped under four commercial names: ulcamanu (*Podocarpus utilior*); diablo-fuerte (*Podocarpus oleifolious*), roble (*Ocolea* sp.); and roble corriente, which includes a number of species belonging to the Lauraceae family.

In other areas in the country, each species is marketed under a different name.

In 1980, 1,380,000 m^3 of sawlogs were used by the wood industry, producing 700,000 m^3 of lumber for all industrial purposes. This indicates that 50 percent of the wood received by industry is lost. The installed capacity of the wood industry in Peru is 1.06 million m^3/year, which shows that only 66 percent of the capacity is being used.

There are 620 forest industries in Peru, the large majority of them producing less than 5,000 m^3/year (MAA, 1980). Average production is 5-10 m^3/day of the following products:

Lumber. 456 sawmills have an installed capacity of 900,000 m^3/year. The Central Selva produces 42 percent of the total, followed by the eastern region producing 40 percent, the south producing 15 percent, and the north producing 3 percent.

Laminated Wood. Three factories in Iquitos, with an installed capacity of 50,000 m^3/year, use lupuna, *Chorisia* sp., to produce laminated sections 2.4 m long, 1.2 m wide, and 4 mm thick.

Plywood. Seven plywood factories in Iquitos and Pucallpa have an installed capacity of 105,000 m^3/year. The species most used is lupuna, *Chorisia* sp; the products' dimensions are the same as those of laminated wood.

Chipboard. This product is manufactured in Pucallpa and Iquitos, using chips obtained from sawmills and the residual cores from peeling plywood logs. *Parquet.* Seventy-one parquet factories have an installed capacity of 3.2 million m^3/year and produce 470,000 m^3/year, or 12 percent of capacity, restricted by poor supplies of raw material, and obsolete equipment.

Veneer. Four plants produce veneer, three in Lima and one in Pucallpa. An installed capacity of 4,000 m^3/year produced, in 1980, 1,800 m^3.

Forest production, although fundamentally comprised of wood, also includes a small number of different products that are sold without being industrially processed (except for palm hearts). The markets for these products vary greatly, both nationally and internationally. Table 11-11 presents non-wood forest product production data from 1980 and 1981.

The installed capacity of Peru's national forest industry, therefore, greatly exceeds its annual production because of problems at every stage of the process by which a tree moves from forest to mill to factory.

Lumber marketing

The sale of forest products, particularly wood, is without a doubt the culminating and most complicated problem facing the industry. The harvesting and processing of forest products are controlled by the marketplace and must conform to its conditions. While the problems are more social than technical or economic, some technical problems can be identified.

Each piece of wood is marketed twice, first between the forest and the industry (to produce sawlogs), and second between the industry and the consumer. Both routes feature, on the one hand, uncontrolled price increases based on artificial supply-demand relationships, and, on the other, limited production and technological development.

Selling the wood from forest to industry is the more traditional and complex system. Before the Forestry and Wildlife Law of 1975 (Peru, 1978), the *habilitación* system was typical, although not formally legalized. In this System, a middleman pays, in money or tree species, a series of smaller middleman and retailers who, eventually, buy the wood from the small-scale harvesters (natives and farmers) who cut trees and transport them to rivers or roads. The process causes the price of wood to rise four to five times before the wood arrives at the processing plant or sawmill.

Table 11-11
NATIONAL PRODUCTION OF PRINCIPAL NON-WOOD FOREST PRODUCTS 1980-1981

PRODUCTS	1980 Kilograms	1981 Kilograms
Carob beans	9,723,960	11,178,816
Brazil Nuts	4,321,205	1,211,772
Quinine	160,000	25,000
Barbasco	679,592	750,000
Tar	1,726,198	3,074,102
Curare	16,712	1,874
Latex	10,000	52,114
Palm hearts	501,769	1,906,564
TOTAL	17,139,436	18,200,322

Source: MAA, 1982.

The 1975 Law legally abolishes the *habilitación* system, which nevertheless continues in practice. Now, for example, money is lent or prepaid to small-scale harvesters (those who own logging contracts on less than 1,000 hectares, more than 90 percent of those contracted nationwide) and the chain of commerce is the same.

Commerce between industry and consumer is more visible and open, although no less damaging than the system described above. Generally, industry, which provides the capital, controls the product until its final destination (the consumer) and establishes a series of steps that artificially increase product prices two or three times. Between factory and consumer, the process usually includes a principal middleman, transporters, warehouses (in Lima), lesser middlemen, retailers, and craftsmen.

Nationally, the sawmills acquire 65 percent of their logs from middlemen and 35 percent from directly harvesting their own parcels or parcels owned by others. They sell 85 percent of their lumber to middlemen, 10 percent through markets, and 5 percent through distributors. Twenty percent of the volume goes to such large-scale consumers as mining operations, furniture factories, and transportation concerns. Ten percent is sold in the markets by merchants, who advertise in newspapers and other media, and 70 percent is sold retail and wholesale (Figure 11-1).

The principal consumer sectors are civil construction (55% of the total), furniture and handicraft concerns (25%), mining (10%), transportation (5%), and others (5%). The principal products competing with wood in both construction and furniture-making are iron and aluminum. Wood was generally preferred over these two high priced products in 1981, even though wood prices were also very high, and even though other problems continue to plague the wood industry.

For example, the sawmills concentrate on producing wood for those people who can pay for mahogany, cedar, tornillo, ishpingo, and other expensive woods from which the industries and merchants obtain maximum profit. Meanwhile, consumers have become accustomed to associating wood with cedar and mahogany and are reluctant to accept other species (which, in any case, industry is not enthusiastic about promoting). People have only accepted other woods in the marketing system in Oxapampa and Villa Rica, where these woods are called roble and roble corriente.

Further, industry has little interest in technology that can increase the use of species not presently considered commercially valuable such as drying, preservation, classification, quality control, and particleboard manufacturing technologies, all of which could enable new species to be marketed at lower prices.

Wood accounts for only 10 percent of the material used in home constructions. Even the people in the forest are accustomed to using such materials as cement, iron, and bricks, which are called "noble materials," despite the exhorbitant cost of importing them by air freight.

Peru's involvement with international wood commerce is limited and has considerably diminished in the last few years. In 1978 and 1979 31,400 m^3 of processed wood were exported (exporting logs and unprocessed wood is prohibited by law). In 1978 the export value was US$5 million, in 1979, US$7.54 million. Exports in 1980, diminished to 23,500 m^3 and a value of US$6.26 million, and, in 1981 they decreased to 13,657 m^3 with a value of US$6.27 million (MAA, 1982).

Figure 11-1 - THE LUMBER MARKETING PROCESS IN PERU (1980)

Forest management alternatives

Neotropical humid forests in their natural state are relatively complex. While they are heterogeneous floristically, they are homogeneous with respect to volume. Some 10 species (3% of the species to be found in a given area) account for 44 percent of the volume, 20 species account for 62 percent of the volume, and 50 species account for 78 percent of the volume (Dourojeanni, 1982).

Considering only the 20 most abundant and the commercially most valuable species (cedar, mahogany, ishpingo, tornillo), an average volume of 80 m^3 per hectare of commercial-sized trees (more than 30 cm DBH) is attained. Of this volume, an estimated 40 percent, or 32 m^3 per hectare, can be used immediately which, when trimmed, is 25 m^3 per hectare of marketable volume. Thus, the problem mostly involves the remaining 60 percent. Intensified research must look into the remaining 48 m^3 per hectare and its physical-mechanical properties, industrial uses, and drying and preservation problems. Considering just the woods that have proven useful, 32 m^3 per hectare can be cut, providing an average minimum of 25 m^3 per hectare of wood.

Forest development and colonization experiences in the Central Selva

Colonization

Colonization and rural settlement efforts-spontaneous, directed and planned - have been carried out in the Central Selva for several decades. All these settlements have focused exclusively on agriculture and livestock, however, and no planned forest settlements have been developed. Some forest settlements arose spontaneously when colonists, merchants, and harvesters realized that forest exploitation could be profitable. But, for the most part, people have concentrated on agriculture and livestock and left timber commerce in the hands of a few industrialists and investors.

For example, Pucallpa was colonized for agriculture and, in particular, livestock enterprises (Tournavista, San Jorge). These colonies, however, later directed more than 70 percent of their economic activity toward forest production but have exhibited no interest in managing the forest, reforesting, or protecting the forest from damage. The person who works with timber is almost always a farmer who clears and burns the forest to establish crops or grasses. He is practically indifferent to the steady retreat of the timber-producing areas.

One devastating experience with massive deforestation occurred in the Huallaga Central region where the colonies of Tingo Maria-Tocache, La Mejorada-Campanilla, Juanjui, Tarapoto-Yurimaguas, and Biabo River region, all cleared hundreds of thousands of forests to establish grasses, subsistence crops, and industrial crops such as oil palm, rice, bananas, cacao, and rubber (MTC, 1981 b). At present, cacao and rubber have been abandoned, and timber production is minimal. Such efforts have moved, in large part, to the Bajo Huallaga and Perene-Satipo regions, again with no effort made at reforestation and forest protection.

During the 1970s, especially following the implementation of the Agrarian Reform Law and the Forest and Wildlife Law, some initiatives began to develop forestry projects, although not necessarily colonization or forest settlement schemes. Thus, The Jenaro Herrera Integral Rural Settlement Program which was initiated near Requena in the 1960s to encourage livestock and agricultural production, eventually became increasingly oriented toward forest production. During this project, with support from the Swiss Government, the first serious effort to rationally manage natural forest was developed. A program of basic research focused on the ecology of forest species and silvicultural techniques; and the project established a well-managed arboretum, permanent growing plots, wildlife investigations, and experimental parcels of native species, such as *Chorisia sp.*, *Virola* sp., *Cedrelinga catenaeformis*, *Jacaranda*, *Copaia*, and *Simarouba amara.*

Another type of forest settlement, although still poorly developed, is the forest corporation. Such enterprises belong to the laborers who attempt implementation of integrated forest-industry production systems. In the Iparia National Forest in the Pachitea region, 66,000 hectares were transferred to a corporation and significant timber extraction, reforestation, and management of natural regeneration have taken place. Commercial woods, such as mahogany, cedar, ishpingo, tornillo, copaiba, and cumula are being harvested.

The Alexander von Humboldt National Forest is well-known because of its ambitious plan of forest research, management, and production. With assistance from FAO, important efforts of scientific and practical significance were made in the 1970s in understanding basic forest inventory, developing volume tables, and studying the physical-mechanical properties of native goods, drying and preservation techniques, reforestation, management of natural regeneration, and agro-silviculture. Today this national forest located near Pucallpa covers 645,000 hectares, and is the largest and most important forest in Peruvian Amazonia (Dourojeanni, 1976). Consequently, nearby areas are highly coveted and are now almost entirely divided up by timber concessions.

Also, in 1974 rural settlements established in the area took the initiative of establishing a center of forestry, livestock, and agricultural operations 35 km from Pucallpa. The Center now has a sawmill, and at present, work is focusing on forest, livestock, and agricultural production.

The model of the Social Property Corporation (EPS) adapted best to forestry enterprise in the 1970s, in part because the Forest and Wildlife Law promised the corporation priority in forest harvesting contracts and in part because the labor system and forest production were both more suited to this model. Such corporations are dedicated to forest, agriculture, and livestock production. One such effort located near Pucallpa uses 8,629 hectares for forest, agriculture, and livestock production and 8,065 additional hectares for forest exploration and evaluation. In one forest area, the principal product is parquet; another is currently being established in Cuzco and is to focus on lumber and railroad cross-tie production on 20,000 hectares. Others make dried and preserved lumber, crates, and posts.

The private forest corporation is almost exclusively an industrial enterprise not concerned with forest management. For this reason, the traditional private corporation, as opposed to the Social Property Corporation (EPS) has not established permanent or stable forest settlements.

Special Projects

As described in Chapter 3, special projects are integral development programs, most of which are located in the forest region and along the Marginal Road. Their objective is to establish settlements oriented around agriculture, livestock, and forestry in accordance with government policy. Practically all colonization programs have been converted to special projects, which have acquired increased autonomy and flexibility in operations and administration.

Problems that these projects must confront include:

- indiscriminate clearing of forests;

- organized and unorganized invasion of public and private lands;

- the erosion and destruction of road banks, rivers, and highland watersheds;

- the granting of lands lying within protected areas, forested areas belonging to native communities, and private property;

- the disorganized registering of lands, granting of land titles, and awarding of timber concessions;

- the absence of forest nurseries;

- the lack of immediate action to manage National Parks and Protected Forests;

- the lack of training and equipment for colonists.

The principal project in the Central Selva is Pichis-Palcazu, which includes urban and rural settlements. Approximately 40 percent of the project's total area is considered to be best suited to forest production.

Among the more novel concrete actions planned for this special project is the forest settlement projected for the San Alejandro-Puerto Victoria area, specifically within the Alexander von Humboldt National Forest. Along a strip 63 km long and 2 km wide, 70 household forest plots of 360 hectares each have been laid out. Production is to be managed through cooperatives, which will provide necessary tools, infrastructure, services, and training.

The Madre de Dios Project contains 7,840,000 hectares with natural forests covering some 90 percent of the area. The objective of this project is to formulate a regional development plan and to establish micro-regional development programs. Within these micro-regional programs forest evaluation studies will be carried out on 240,000 forested hectares which have been designated for forest production to be completed in two phases. Forest settlements are to be based on managed forest product harvest and processing, and to incorporate family and multi-family units and businesses to supply forest products to the country's southern region.

Special projects are an important way to highlight the dangers posed by indiscriminate forestation, in Peru and throughout the world, while at the same time working to solve the problem as concretely and completely as possible.

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Chapter 12 - Fisheries

Fish resources in Peruvian Amazonia are valuable economically, socially and culturally. The fishing industry did approximately US$56 million worth of business in 1981, with fish, an important nutritional component of the Peruvian's diet - and the Peruvian's imagination (Piazza and Vildoso, 1967). Abundant myths refer to aquatic resources and a surprising variety of names are given to the same fish in different indigenous languages. Fish have crucial roles in trophic structure, energy flow, nutrient cycling, and seed distribution, and some species show good potential for aquaculture.

The aquatic ecosystem

The Amazonian aquatic ecosystem is characterized by water with low mineral content and scarce nutrients (although with great local variation). It also exhibits profuse and complex relationships with the broad flood-plains and has a rich biota, particularly fish (around 2,000 species), that show a high species diversity at higher trophic levels. But this ecosystem, so stable in its natural state, is easily threatened when confronted with external disturbances, especially those caused by man (Bonetto, 1979).

The Amazon river basin drains more than 6.5 million square kilometers and has no rival in area drained and volume of water transported to the ocean (an average of 220,000 square m^3/s). Approximately 2.5 million square kilometers lie less than 200 meters above sea level, with the majority of this territory being covered by a dense forest (Lowe-McConnell, 1975). This area is influenced by annual inundations that are very important to Amazon life cycles. The basin is drained by innumerable rivers of variable magnitude that flood extensive wooded areas and form marshes, lagoons, bays, and floating meadows. Often, these water bodies are interconnected (Bayley, 1981).

According to their origin and composition, waters in the larger rivers have been catalogued as "white," "clear," and "black," illustrating that the rivers and environments are different (Sioli, 1968).

White Waters, considered the richest in salts and nutrients, originate on the Andean slopes. They are turbid, with neutral pH, and their actual color is a light grey. The sediments causing the turbidity impede primary production in the river and settle along principal channels, flooded areas, and, especially, lagoons. As these sediments settle, they contribute nutrients that are important to natural productivity.

Clear Waters are poorly to moderately productive and originate from the archaic rocky zones of the

Brazilian Shield and from areas of red and yellow tropical soils that do not have large wetland areas. They are more or less transparent in color, with yellow or green tones, and with a lightly acid pH. They play an important role in fish production in rivers with bays. Where the current diminishes, a type of highly productive river-lake forms, which sustains downstream fish populations.

Black Waters are of low biological productivity. These waters lack inorganic ions, have almost no nutrients, and are strongly acid. Originating in the lowest Amazonian terrain and wetlands that generally are dominated by podzol soils, they are loaded with organic material in colloidal suspension that give them their dark color.

As can be seen, the chemical and physical composition of the rivers depends upon their origins, sediments, and bottom types. They are secondarily influenced by human activity, chiefly mining, agriculture, and deforestation in the highlands. Thus, excessive sediments resulting from erosion cloud the water, modify the composition of river and lagoon bottoms, cause digestive problems in microphage fishes, and clog fish gills. Furthermore, the decomposition of large amounts of organic sediments can cause a decrease in the dissolved oxygen content of water, and dramatic phyto-plankton blooms, both of which are lethal for many fishes. Many sediments are toxic, especially those mixed with mine wastes, which are abundant in the Andes.

As the rivers descend from the highlands into the Amazonian plain, their temperature, volume, sediments, and nutrient loads all increase, while their current velocity decreases as does their grade. Meanwhile, the variety and abundance of fish species increase.

Throughout the Amazon region, particularly on the low plain, significant floods are produced during the period of high water (December-May) which recede during the period of low water (July-September). Because of this cycle, the height and volume of the rivers vary enormously (at Iquitos, the water level varies 12 meters), influencing trophic and reproductive cycles. During flooding, the amount of territory available to fish dispersion can increase more than 10 times. The majority of fish species begin reproducing when flooding begins and find places with abundant food and refuge in the flooded areas. The ecosystems of highest biological productivity are ox-bow lakes along large and medium-sized rivers, river bays, floating pastures, and seasonally-flooded forests (Torax, 1967).

Ox-bow Lakes or Cochas

In low areas the rivers form innumerable meanders with branches more or less filled with water that, when cut-off from the rivers, form lagoons (*cochas*). Each cocha displays different characteristics according to the river water from which it originated, and that flow into it during floods, as well as according to its own shape, size and benthic composition. Generally, primary productivity of the cochas seems to increase with frequent blooms of cyanophytes. Cochas filled with white water are usually the most productive and provide sediments and stored nutrients to rivers during floods. Afterwards, the sediments settle and permit light penetration which, combined with the high temperature, yield rapid plant growth that is exploited directly and indirectly by fish populations.

River Bays (*Mouth-bays*)

Certain clear water and black water rivers contain stretches that behave limnologically more like lagoons than rivers. They form a continuation of the sedimentation zone (a type of restricted floodplain formed by river alluvium), constituting a strip of open, clear, and very slow water, that often has plankton blooms. The phyto-plankton produced is generally consumed downstream in areas where fish are abundant, particularly at the mouths of major tributaries. This formation is typical of tributaries of the middle and lower Amazon (Soili, 1968).

Floating Pastures

During periods of rising water, aquatic vegetation proliferates and forms dense mats that cover the water's surface, giving the appearance of islands (*camalones*). Floating pastures are common in rivers and cochas with white water (such as the Amazon), and in areas of sedimentation in clear water rivers. Their constituent plants exploit the nutrients carried by the water, development generally being limited by a pH of less than 5 (Sioli, 1968). Most of the plants which make up these islands belong to the genera *Paspalum, Panicum, Echinochloa, Cyperus, Pistia*, *Eichornia*, *Marsilea, Salvinia*, and *Lemna*. Camalones can completely cover some bodies of water, and obstruct navigation in rivers and major channels. They are perhaps the most productive bio-topes in Amazonia. Among their roots an abundant and varied fauna uses them for support, refuge, and food. A major limiting factor of camalones is that their oxygen content is often too low for certain species of fish.

Flooded Forest

The Amazon region's vast flat areas, gentle gradients of its rivers, and annual water level fluctuation contribute to widespread flooding of the lowland forest. Numerous populations of aquatic organisms invade these flooded areas to find food and refuge in both the surface humus and vegetation now covered with water and periphyton. Because of the low nutrient content of the waters and the low light penetration, indigeneous food productivity is low - principal sources of food, in fact, are forest flowers, pollen, fruits, and invertebrates that fall into the water. This food is critically important to the reproduction and development of many species, so some fish biomass is sustained in these areas. When the water recedes, the fish become confined to rivers and lagoons and are more susceptible to capture. Some authors believe that the fishing potential of entire Amazon regions can be evaluated by investigating flooded forest areas.

Fish and Fishing Productivity

Most Amazonian fish species are disbursed throughout river environments. In general, fish shoals are small in the principal rivers, becoming larger along beaches and in lagoons and channels with slow current, although fish frequently move between distinct environments during floods. More varieties of fish live in the Amazon basin than anywhere else in the world because of several factors: the size and age of the basin, the many kinds of habitats offered by the winding rivers, the diversity of niches in the low jungle rivers and adjacent lakes, and the high proportion of the river basin lying in the lowlands, offering comparatively stable conditions capable of supporting large numbers of fish (Lowe-McConnell, 1975). Maintaining this rich and diverse fish population depends on species that feed on organisms and organic material in ingested mud, for example, the clearly dominant genus *Prochilodus, a* typical forage fish. The largest fish species to be found in tropical freshwater environments - individuals of the genera *Arapaima, Zungaro,* and *Pseudoplatystoma* - *can* exceed two meters in length and 200 kilograms in weight.

Amazonian fish can be categorized by origin and salt tolerance. Fresh water species are the most abundant in the basin and belong to the Caracoid, Siluriform, Osteoglosid, Gimnotod, Simbranchid, and Lepidosirenid groups. Secondary fish, confined to fresh water but capable of tolerating some salinity, are represented by Cichlids and Poecilids. Some 50 species of fresh water fish are derived from marine families, including the commercially-exploited fish *Plagioscion,* Sciaenidae, *Pellona*, and Clupeidae.

Finally, some groups of marine origin, such as certain sharks, move into fresh water. Caracoids predominate in species abundance (43%), followed by the Siluriformes (39%) (Smith, 1979).

The importance of each fish species as a food source in the Peruvian Amazon can only be imprecisely determined. Capture data are available only from the large fishing enterprises, and do not include the great amounts of fish brought in by individual fishermen (Chapman, 1979). "Species" described in this data pertain to the common names of fish, which frequently encompass several species, genera, or even families. For example, the data from Iquitos describe only 20-25 species captured, when in reality, the number of species caught is much greater. Nevertheless, it is possible to realize the importance of the boquichico (*Prochilodus nigricans*), which makes up 48 percent of the registered catch. The paiche (*Arapaima gigas*) is also valuable and in great demand, constituting 10 percent of the catch, although it does not form schools or exist in large numbers. The Siluriformes, not counting the carachama (Loricarudae), make up 11 percent of the catch (Hanek, 1982).

The Peruvian Amazon fishery

Fish are the traditional food for people living along rivers, providing them with at least 60 percent of their animal protein. It is estimated that small-scale and commercial fishing in the Peruvian Amazon yields between 60 to 80 thousand metric tons per year. Fifty percent of this catch is consumed directly by humans, with a value of US$60 million per year. Figure 12-1 shows catch size estimates of fisheries in the Peruvian Amazon and their value. Figure 12-2 illustrates the commerce of fresh, dried and salted fish.

Figure 12-1 - PERUVIAN AMAZON FISHERIES: SIZE AND VALUE OF THE FISHERY INDUSTRY

Figure 12-2 - FLOW OF SALES OF FRESH (___) AND SALTED-DRY FISH (- - -) IN THE PERUVIAN AMAZON

Three types of fisheries can be distinguished in the Peruvian Amazon: artisan, commercial, and ornamental. Individual fisheries are widely dispersed, and the small boats used in this type of fishery restrict the fishermen to areas near their villages. Simple fishing gear is generally used, and the catches are consumed primarily by people living in villages along the riverbanks. Commercial fishing, based in the larger towns such as Iquitos, Pucallpa, and Yurimaguas, use gear designed to snare large numbers of fish at a time. The relatively large boats permit trips that last up to 30 days. Ornamental fishing is a specialized endeavor and varies according to the changing demands of the market.

Minimal Peruvian legislation regulates Amazon fisheries and is limited principally to the following areas: controlling harvesting techniques, (dynamite and other explosives, barbasco - *Lonchocarpus nicou* - and venomous substances); protecting aquatic turtles; creating protected areas in the Pacaya, Samiria, Pastaza, and Mazan rivers; and protecting the paiche, *Arapaima gigas,* while it breeds from October to February and limiting its capture to specimens at least 1.40 meters long. In the near future it will be necessary to develop regulations controlling fishing in bodies of water adjacent to settlements that, claiming exclusive rights to exploit these waters, come into conflict with native populations and commercial fishermen (Hanek, 1982).

Artisan Fishing

Nearly every man, woman and child who lives in a riverbank settlement fishes at least part-time. They keep what they need for their families and sell the remaining fresh fish to local markets; or dry and salt it for sale to merchants from the large towns.

Artisan fishing methods are simple and inexpensive. Equipment includes poles, hook and five meters of nylon line; arrows with several types of arrowheads, usually steel, used either with or without bows, farpas or arrows with detachable points, harpoons and lances, throw-nets (the most commonly-used gear), hoop-nets or honderas used by three or more fishermen in lagoons and backwaters, drag-nets operated by four or more fishermen and two boats, explosives, and tapajes or hoops of sticks forming traps placed across cocha outflows.

Since the fishermen are also farmers, they easily combine fishing and agriculture. The flooding cycle, fish behavior, and the seasonal requirements of agriculture all impose a sequence of activities on riverbank communities (Figure 12-3). During high. water, there is little activity, but as the water recedes, fishing increases. Later, as flooded areas dry, crops are sown in muddy areas and during low water, fishing increases.

Figure 12-3 - ARTISAN FISHING ACTIVITIES IN RELATION TO THE FLOOD CYCLE

Commercial Fishing

The commercial fishing fleet of the Peruvian Selva has an estimated 476 boats and is based in the larger towns of the region (Hanek, 1982). Some of the same methods and equipment are used in commercial fishing as are used in artisan fishing (throw-nets, honderas, and drag-nets) although they are of greater size and number. In addition, commercial fishing uses agallera nets, which are constructed according to the characteristics of the fish being sought and the places where the fishing will take place. Among the best known nets are the menudera for small fish, the gamitanera for the genus *Colossoma* and the paichetera for the paiche.

Commercial fishing catches, and to some extent small-scale fishing catches, are processed simply, with 74 percent of the fish being eaten fresh or frozen, 12 percent dried and salted, 11 percent salted, and 3 percent smoked.

Ornamental Fishing

Ornamental fish have been captured and exported from the Peruvian Amazon since 1951. Since 1977, however, the catch has declined somewhat because of over-fishing, competition from other producer countries and regulations. Domestic use of ornamental species is almost negligible (0.5%), although it is increasing. During the 1970s, more than 155 million fish worth US$6.5 million were exported.

The fisherman, the aquarist who receives and stores the captured fish, and the exporter all share the profits of this industry which generates work for more than 3,000 people. Various fishing methods are used: the malla which is a net of very small openings operated from shore by two individuals, the pusahua a type of hand net with a circular mouth and a fine mesh; and, the tarrafa a casting net made of minute mesh. The capture and sale of these species are economically important around Iquitos.

Table 12-1
COMMONLY USED GROUPS OF ORNAMENTAL FISH

ORDER	FAMILY	NUMBER

		GENERA	SPECIES
Rajiformes	Potamotrygonidae	1	1
Osteoglossiformes	Osteoglossidae	1	1
Cypriniformes	Characidae	19	36
	Anostomidae	3	5
	Chilodidae	1	1
	Gasteropelecidae	3	6
	Hemiodontidae	1	1
	Parodontidae	1	1
	Lebiasinidae	3	14
	Apteronotidae	1	1
	Gymnotidae	1	1
	Electrophoridae	1	1
Siluriformes	Auchenipteridae	1	1
	Doradidae	2	2
	Pimelodidae	6	6
	Asprendinidae	2	2
	Callichthyidae	5	16
	Loricariidae	5	7
Atheriniformes	Cyprinodontidae	1	3
	Belonidae	1	1
Perciformes	Cichlidae	8	14
	Nandidae	1	1
Tetraodontiformes	Tetraodontidae	1	1
Pleuronectiformes	Soleidae	1	1
TOTAL 8 orders	24 families	70 génera	124 species

Source: Hanek (1982).

Nearly 125 species of ornamental fish are captured (Table 12-1) but these are classified commercially into four groups:

- the "neon tetra" or "piaba" group, represented by one species, *Hyphessobrycon innesi.* This was the primary commercial species until 1977 and constituted an average 45 percent of the total fish exported during the 1960s;

- the shirues, carachamas, and doras group that includes approximately 30 species in the family Callichthydae;

- a miscellaneous group consisting of approximately 70 species of the family Characidae;

and

- the rare fish group, which includes fish of high commercial value on the international market, such as the discus (*Synphysodon discus*), the angelfish (*Pterophyllum sealare*), the pacu (*Metynnis sp.* and *Myloplus* sp.), the arowhana (*Osteoglossum bicirrhosum*), and the pirarara (*Phractocephalus hemiliopterus*).

Ornamental fish are captured in ravines, *cochas*, and springs in Amazonian rivers and tributaries. Some species are caught only in certain localities. For example, *Osteoglossum bicirrhosum* is found in the Tapiche river (a Ucayali tributary); *Symphysodon discus* is found in the Putumayo and Nanay rivers; and, *Pimeloduspictus*, *Pimelodella cristata*, and *Pimelodus maculatus are* caught in the lower Ucayali river (Pucallpa region). Most ornamental fish are captured when waters are retreating (Hanek.1982).

Aquaculture Development

While fish populations can still sustain current fishing levels, possibilities for increased exploitation do not appear promising - especially in certain regions. For example, Bayley (1982) estimates that the Palcazu river fishing region, which extends to the river's confluence with the Pachitea river, allows a catch of 590 tons annually. However, these stocks cannot sustain a population significantly larger than the current 12,000 people at the present level of individual consumption of 122 grams of fish per day.

Prospects of increasing fish production through aquaculture, appear favorable. Two methods are most promising: managing lagoons in the low jungle region; and extensive and semi-intensive aquaculture in the Selva Alta and the Central Selva. Management of lagoons and cochas in the low jungle involve creation of feeding and refuge areas similar to the acadja system of Africa, accompanied by monitoring of fish populations and perhaps introduction of important species. This method, discussed in more detail later, is a possible solution to certain conflicts between small-scale and commercial fishermen. In the highlands extensive aquaculture is, at the moment, limited by the scarcity of appropriately modified bodies of water.

Semi-intensive aquaculture can be carried out in harmony with agriculture, as described in Figure 12-4. Generally, in tropical countries this method is considered a likely possibility for providing employment and low-cost food while, at the same time, requiring little investment of money and other resources. In Peru, particularly in the last 10 years, experimental stations at Pucallpa, Tarapoto, Satipo, Iquitos, and Moyobamba have initiated research into developing this type of aquaculture, while the private sector has also shown increasing interest. Although results have not yet been published concerning species introduced into the zone, it is estimated that semi-intensive production and production associated with other rural activity would not be less than four tons per hectare per year, with two annual harvests and with fish averaging 300 grams in weight (Schuster *et al*, 1955). Additionally, efforts to breed large numbers of fish fry and to improve techniques for their cultivation are increasing, especially with the genera *Colossoma* and *Brycon.* Yields of these fish in experimental ponds, using natural breeding and requiring only the investment of animal manure and some agricultural wastes, have exceeded 3.5 tons per hectare per year, with some operations producing over 5 tons per hectare per year (Guevara *et al*, 1981; Pedini, 1981; da Silva, 1981).

Significant relationships between fishing and other development activities

Fish harvesting methods, particularly those used in artisan and commercial fishing, have begun to have a negative impact on the fish supply. Most detrimental have been habitat destruction and indiscriminate fish harvest, which not only take large fish and adults appropriate for consumption, but also innumerable young. While various Amazonian species show excellent potential for cultivation in ponds, the natural environment must still be the source of these fish; they are difficult to breed in captivity, and fall pray to caiman, fish eating birds and otter which can invade ponds and prey on the cultivated fish or complete with them for space and food.

Forestry, agriculture and cattle breeding all interact negatively and positively with fish, fishing and aquaculture. Because fish and flooded forests interact symbiotically, with the forest providing food and refuge and certain fish species distributing seeds, deforestation for agriculture can negatively affect fish in several ways: modifying habitat through deforestation and erosion; polluting water with pesticides and excessive amounts of fertilizer; and impeding the migration of certain fish species by dam construction. Harvesting the forest for wood can modify the aquatic environment as well. Sawmill wastes are toxic; when they cover the bottoms of lagoons, they decrease the amount of dissolved oxygen.

Agriculture that causes flooding can provide food and refuge to fish while fertilizer in less than toxic amounts can provide nutrients to increase fish production. On the other hand, some fish can invade and damage poorly-managed rice farms.

Generally, livestock grazing negatively affects fish in the same way as agriculture. Some fish, in turn, are dangerous threats to livestock. On the positive side, many fish species control livestock disease vectors when they are in their aquatic stages, and livestock feces, washed by the rains, contribute to the fertilization of natural water bodies.

Figure 12-4 - INTEGRATION OF TROPICAL FISHERY AND AGRICULTURE - LIVESTOCK ACTIVITIES

Water weeds originating from cleaning of the pond that could be used to feed livestock.

Water weeds originating from cleaning of the pond that could be used to feed livestock.

Fish interact with land animals through predation and competition for food. Examples are also known in which the excessive hunting of caiman, capybara, and zambu-Ilidora has caused a decrease in fish populations, because of the loss of fertilizing excrement and loss of control of more efficient fish predators, such as piranha.

Among the most important disturbances of fish and fish habitat produced by human activities are the destruction of seasonally-flooded forests, sedimentation, urban and industrial pollution, dam construction and the construction of other barriers. Further, in some areas population increase requires more food fish, especially when supply of wild animals diminishes (Berger, *et at.*, 1979). In addition, incorporation of western customs into the lives of native populations leads to the elimination of myths and customs that hold certain areas to be dangerous to fishermen and thus create fish refuges. By reducing religious holidays this process also increases the number of fishing days (Smith, 1979).

On the other hand, fish can cause problems for human beings; some fish are dangerous, while others transmit or are intermediate hosts for diseases. Poorly-managed ponds can encourage the spread of vectors of such diseases as malaria, encephalitis, and, in some neotropical areas, bilharzia (Eyzaguirre, 1979).

Dam construction is one of the activities that obviously can threaten fish populations, especially by interrupting water flow retaining sediments that contain nutrients; release of water that contains toxic substances and high oxygen demand; and forming barriers that impede fish migrating for reproduction. Measures to resolve such problems include evaluation of minimum water requirements in dammed watersheds and provision of minimum flow when dam reservoirs are being filled, the periodic discharge of retained sediments, and the avoidance of releasing toxic waters that generally accumulate at the bottom of reservoirs.

On the other hand, new reservoirs created by dams present new fish habitats that can be used in extensive aquaculture. Certain fish species also eat the plants that are damaging to turbines as well as control disease vectors that can multiply because of dams. Below the dam, ponds that use dam-regulated water can be constructed to provide fish fry for extensive cultivation in reservoirs. Road construction can negatively affect fish by filling channels, by limiting fish migration, and by causing erosion due to the destruction of riparian vegetation and by increasing the number of areas accessible to commercial fishing. The principal problem with mining, especially in Andean headwaters, causes downstream pollution by mine tailings - the severity of which depends on the type of tailing. This is a serious conflict, since mining in Peru is economically important and actively pursued. Storage and purification of tailings is difficult and such regulations are seldom complied with.

Petroleum extraction has two negative aspects: on site petroleum pollution where it is being extracted or transported (especially by pipeline); and formation of chemical barriers, especially saline water, formed by dumping oil wastes and formation water into Amazonian rivers. Snedaker (1977) has shown that the Corrientes river's dilution capacity in Peru is less than one third that required to accommodate the salt water being discharged into it. The result is that a salty stretch exists in its channel between Trompeteros and the Tigre River that acts as a chemical barrier for fish during the spawning season. Larval and juvenile fish are especially affected, particularly those belonging to strictly freshwater species, including the very important Caracids and Silurids. This is a difficult problem to solve, because petroleum is so economically important to the country. Nevertheless, it will soon damage an important food source for riverbank populations in parts of Peruvian Amazonia.

Conflicts of interest exist regarding the use of fish resources in floodplain lagoons and cochas during the dry season. On one side are riverside populations; on the other are industrial fishermen that enter these areas to fish for export to cities. Riverside populations use simple fishing methods and claim, not without reason, that industrial fishermen reduce the fish available to them. Conflicts also arise over the use of those species where the adult stage is used for food and the juvenile stage is exploited for ornamental purposes.

In both natural and artificially-created bodies of water, extensive aquaculture can produce significant fish populations that can sustain both small-scale and commercial fishing. These techniques can include the introduction of native and introduced species into reservoirs. Many native species that breed in still water environments can sustain fisheries or serve as forage fish, including the paiche or the tucunare (*Cichia oceltaris*). Equally, when introduced from artificial enclosures or natural sources, certain species become very productive in reservoirs (*Colossoma, Brycon,* and *Prochilodus*). Cultivated exotic species, however, can escape and destroy habitat (as has occurred with the common carp, *Cyprinus carpio*) and prey on and compete with native species. Some local species can also become nuisances when placed in ecosystems that encourage their proliferation where they are resistant to controls. Such is the case with the piranha, *Serrasalmus,* and the "jaraco," *Hoplias.*

Although semi-intensive aquaculture using naturally-produced wild fish species can reduce the availability of these fishes, little such activity is carried out, because of the costs and difficulties involved with transporting fry from spawning areas to areas where semi-intensive aquaculture is most profitable. Experimental techniques for the controlled cultivation of native species is applicable to the conservation and repopulation of these species in the low jungle as well as in producing ornamental species. Aquaculture will probably never compete significantly with fishing interests, because of its low production levels and because demand for fish still exceeds supply.

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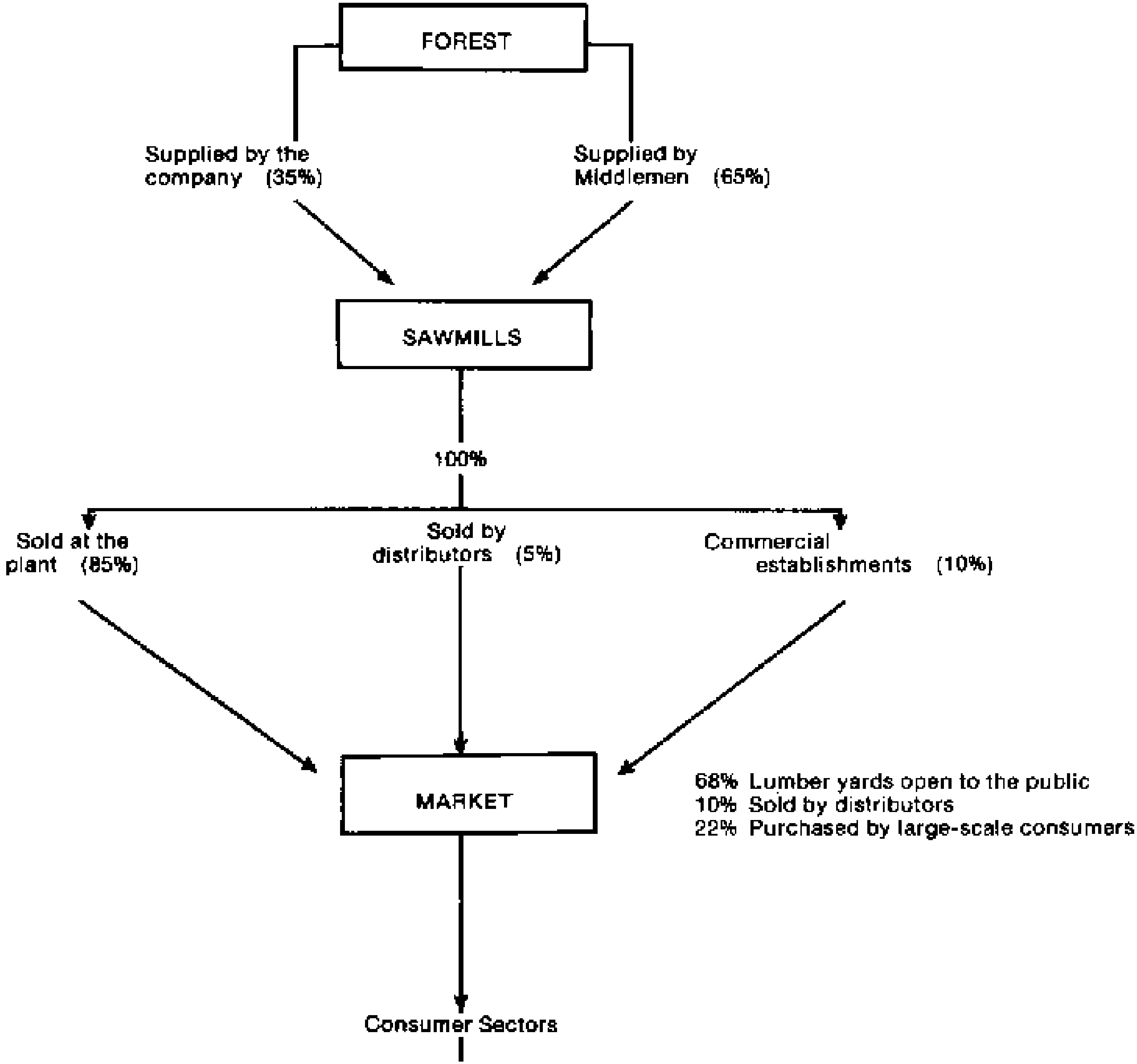
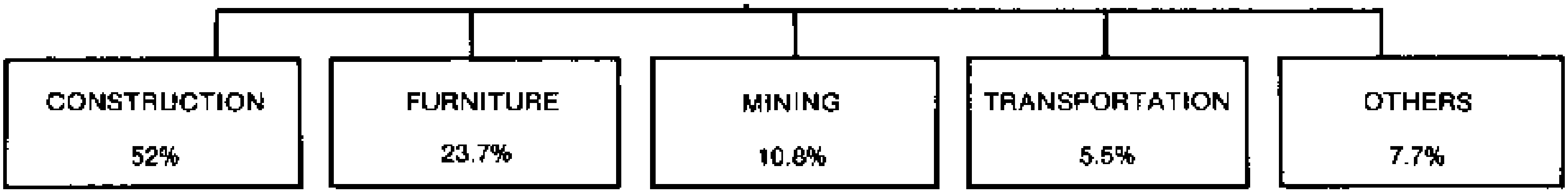

FOREST
Supplied by the company (35%)
Supplied by Middlemen (65%)
SAWMILLS
100%
Sold at the plant (85%)
Sold by distributors (5%)
Commercial establishments (10%)
MARKET
68% Lumber yards open to the public
10% Sold by distributors
22% Purchased by large-scale consumers
Consumer Sectors


CONSTRUCTION
52%
FURNITURE
23.7%
MINING
10.8%
TRANSPORTATION
5.5%
OTHERS
7.7%

Chapter 13 - Minerals and petroleum

Mining in the Central Selva

The diverse metallic and non-metallic deposits of the Central Selva region are concentrated principally in the Department of Junin (See Map 1-1). Silver (Ag), zinc (Zn), lead (Pb), copper (Cu), and lesser amounts of gold are found here, as well as non-metallic mineral deposits of clay and calcareous minerals. Many of these minerals are worked by the San Vicente mine, the most typical and most important of the region. The operations of this mine will be examined below as the model for mining activity in the Central Selva.

The San Vicente mine is located at an altitude of 1,500 meters above sea level. Discovered in 1935, it was accessible by way of the Puntayacu river. Although various mineral deposits are exposed on both sides of the ravine cut by the Puntayacu, it was not until 1960, that The San Vicente Mining Company was formed, to prospect and exploit the zone; production began in 1970. The company has built a road network for its mining operations as well as laboratories, administrative offices, a medical center, and other buildings. To supply energy for these support services and for the mines themselves, the company uses eight internal combustion engines installed in a power station with a potential of 4,500 KW. A planned hydroelectric plant will increase this potential.

Initially, ten lead-zinc deposits and one zinc-lead-copper deposit were identified in a 16 km stretch. The most common sulfur mineral is sphalerite or zinc sulfide followed by galena or lead sulphide, which is found as fine crystals. Secondary minerals are Smithsonite, cerussite, anglesite, and calamine. Gangue minerals are represented by calcite and dolomite. Previous mineral chemical analysis determined the presence of zinc in the form of zinc sulfide (60.41 %) and zinc oxide (5.83%). Later chemical analysis of the mine's minerals found a proportion of 11.52 percent zinc, 1.11 percent lead, and 0.98 percent iron.

The reserve is tabular, in that the minerals are found in the surface layer of the rock. Reserves in 1980 were calculated to be 5,256,000 metric tons of proven and probable deposits (zinc and lead minerals). The purity of the minerals was determined to be 13.6 percent for zinc sulfide and 0.8 percent for lead sulfide. Considering that 429,947 metric tons of minerals were produced from the mine in 1980, the company should be able to maintain continued production for the next 12 years. Thus, probably 5,256,000 metric tons of proven and probable mineral reserves exist; additional exploration and development will probably turn up additional reserves.

The minerals are extracted, by conventional cut and fill methods, tunnels, shafts, and strip-mining. A series of short tunnels is dug between the surface and the mineral vein, where chimneys are opened to facilitate ventilation of the working areas. Infiltration of large amounts of water requires the use of pumps and special drainage systems.

Minerals are transported by carts from the mine interiors, using decauville lines. At the surface, the minerals are loaded onto trucks that carry them to the concentration plant. The concentrated material produced is then transported by dump-truck 320 km to the port of Callao, from which it is exported to the international market. The road travelled by the trucks goes through rough terrain and crosses two passes of more than 4,000 meters high.

The mineral concentrating process consists of crushing and pulverizing the ore, and separating the component through flotation and filtering. To improve the purity of the minerals, the company uses a concentration plant employing methods based on floatation and gravity that have a theoretical capacity of 2,500 MT per day. In 1980, 429,947 MT of minerals were processed, yielding 75,129 MT of concentrated lead and zinc. Chemical analysis of the lead concentrations found a lead proportion of 64.01 percent, a zinc proportion of 5.91 percent, and an iron proportion of 1.14 percent. Meanwhile, zinc concentrations were found to contain a lead proportion of 1.28 percent, a zinc proportion of 56.48 percent, and an iron proportion of 1.94 percent. After processing, somewhat more than 72 percent of the lead and 0.64 percent of the zinc in the lead concentrations are recovered, and from the zinc concentrations, 20.17 percent of the lead and 85.85 percent of the zinc.

Unused metal in the processing plant's washings is dumped into the Puntayacu river, turning the river bluish-white until it meets the Tulumayo river. Beyond the confluence with the Tarma river, the water appears normal, but some rather dramatic phenomena have been associated with mineral wastes in these rivers. Among them are skin problems affecting people using river water, the lack of agricultural and livestock activity along the banks, and the absence of fish up to the Chanchamayo river's confluence with the Paucartambo. Proposals to increase the 1,000 MT of minerals processed daily to 4000 MT would significantly increase the pollution of these rivers.

Gold and Manganese Deposits

Gold deposits in the region are alluvial, produced by the mechanical action of the streams and rivers draining the region. Ancient granites existing in the region are the sources of gold and heavy minerals. The principal deposits are along the margins of the Perene, Unine, Anapote, and Urubamba rivers. These precious metals are mined entirely by rustic methods.

Manganese deposits are also rich in iron. They usually are comprised of oxides, such as pyrolusite, man-ganite, hausmannite, and hematite and are found in the Quimiri and Huatshiroki areas in Chanchamayo, Pampa Tigre, Pampa Silva, and Sachavaca along the left bank of the Perene river. Although large, they have not yet been exploited. Other areas have been identified which, with 97.6 percent pyrolusite and 68 percent hematite, are also potentially rich in manganese and iron. Reliable data, however, do not exist that give an idea of volume and potential value.

Non-metallic Mineral Deposits

Calcareous clays and construction materials are widely distributed in the region in different lithological horizons. For example, the salt domes are part of the Jurassic Sarayaquillo formation while the various types of clays are fundamentally Quaternary deposits lying along river banks. In addition, calcareous minerals are scattered throughout the region as stratigraphic components of different geological formations. Finally, sand and gravel for construction materials are widely distributed as part of the Quaternary formations exposed along the region's drainage network.

Petroleum activity in the Central Selva

Peru's gas and oil fields are believed to be primarily in the northeast and, in the Selva, lie north of the Marañon river and in the Central Ucayali. Because little is known about their potential yield, the Peruvian Government has divided the eastern region into sectors to be explored and eventually exploited.

The most significant hydrocarbon deposits in the Amazon basin, in terms of present production, are located in the northern forest region in the Department of Loreto while those of the Central Selva are the Maquia, Aguaytia, and Aguas Calientes deposits in the Department of Ucayali and in the Department of Huanuco.

Other indications of gas and petroleum have been detected in numerous forest localities. In the Central Selva they have been found along the Ucayali river, near Iquitos, and along the Marañon, and Santiago, Colorado and Alto Madre de Dios rivers.

Hydrocarbons are a mixture of thousands of different chemical compounds, varying from light gases to semi-solids, like asphalt, or solids like paraffin. Most of these hydrocarbons are found in solution in liquid hydrocarbons. Heavy petroleum that is not of the bituminous asphalt type has also been found in the Peruvian Amazonia, but because of its high molecular weight it does not have promising commercial potential. More exploration, however, has revealed the possible existence of commercially-exploitable petroleum in the region.

Exploration and Exploitation Activities

Exploration has been carried out throughout the Peruvian forest, especially in the area between the Urubamba, Tambo, and Ucayali rivers. Various methods have been used, the most important being seismic and exploratory wells.

Data from 1979 illustrate that the Amazon basin produced 67 percent of the nation's hydrocarbons. Four billion barrels of recoverable petroleum are estimated to exist in the country, 71.5 percent of which are believed to lie within the Peruvian Selva. Natural gas makes up 50 percent of the total reserves. Petroleum production from 1979 amounted to 70 million barrels, which means that, at the current rate, the reserves will last for approximately 57 years.

Petroleum activity in the region consists of exploration based in the Aguas Calientes camp, and petroleum extraction and transport in other parts of the region. The Aguas Calientes petroleum refinery has a 2,500 barrel per day capacity.

Transport of Petroleum and its Derivatives

The equipment used in hydrocarbon exploration and exploitation is primarily transported by planes, helicopters, boats of medium tonnage, and barges. The Ucayali river represents a portion of the most economic route for transporting products and materials between the Selva and the coast, which of course encourages settlement of the region (Faura Gaig, 1962). It also encourages the exploration of the region's natural resources because the Ucayali river crosses land where large deposits of bituminous substances have been found.

Petroleum from the northern Selva region of Peru is transported by a pipeline 856 km long that extends from Saramuro to Bayovar and from the branches of each production center. In addition, barges called *chatas* transport both unprocessed petroleum and its derivatives, principally diesel fuel.

Petroleum By-products

Normally, petroleum and brine are not entirely separated, and some petroleum, organic compounds, and dissolved gases are discarded along with the saline formation water. Concentrations of these substances vary; they usually constitute 0.1 -3.0 percent of the water volume. Considerable amounts of petroleum are also lost through spills, leaks, equipment and accessory washing and repair. Fumes from petroleum combustion, from the burning of petroleum and aromatic vapor gases in storage tanks and wells are discharged into the atmosphere. Generally, the gases burned during petroleum refining contain hydrogen, methane, ethylene, ethane, propylene, and propane. The impact these substances can have on humid tropical ecosystems is not known, but data from elsewhere suggest that dumping them into the region's streams could lead to serious consequences for the entire Amazon basin (Ossio, 1979).

Factors limiting mining and drilling in the Central Selva

Approximately 37 million hectares in the Amazon basin (8% of the total) cover wet, loose soils, which makes it very difficult to construct adequate access roads. Even if a road network can be built to provide access to different facilities and production locations, the work must be complemented by the use of helicopters, planes, and barges, since the roads deteriorate easily in heavy rains.

The climate in the humid tropics, meanwhile, is characterized by prolonged wet and dry seasons, which encourage erosion and landslides in areas where human activity has eliminated plant cover. Further, mechanized equipment deteriorates rapidly under such conditions. The human factor is important too. The scarcity of native workers with specialized skills means that people must be brought in from outside the region to work the mines and oil fields.

Interactions between the mining and petroleum industries and others

The mining sector plays an important role in the country's economy. Mining exports bring considerable capital into Peru and, therefore, accelerate development in the country. Mining creates jobs, and those working in mining are among the best paid workers in Peru.

Mining and mineral processing require the construction of physical and social infrastructures, such as road networks, schools, health services, and homes. At the same time, mining produces a multiplier effect in the other sectors. Agriculture must produce more food and the livestock sector more meat and milk to meet mining settlements' demands. More forest products are also used in the construction of houses, offices, and mines; and more firewood and livestock forage are consumed. Mining increases consumption of water resources for domestic use, metallurgical processing, energy generation, navigation, fire control, contaminant dilution, and sediment transport.

But mining practices can also have a detrimental effect on other activities, especially those affected by water. While the presence of small quantities of such elements as zinc, manganese, and copper can be beneficial in both soil and water, large amounts can be toxic. Concentrations of these elements in soil can increase because of atmospheric action and the dumping of mine tailings and waste water. This has, in fact, occurred in the vicinity of the San Vicente mine. The accumulation of such heavy metals as lead, zinc, copper, and mercury represents a problem for certain crops, especially lettuce and tomatoes, where concentrations become toxic.

The more soluble a component is, the more toxic it becomes. Zinc for example, is easily released from zinc sulfate in soil and carried away by surface and ground water. Thus, zinc ions are quite mobile and are found in a form between soluble cations and hydrolized elements. Zinc is an essential element in the biosphere and is fixed in the soil, partly by microorganisms. Small concentrations stimulate plant growth, but large quantities are toxic.

Manganese and copper also are essential elements found in all plants, in concentrations that vary with soil concentrations. Manganese affects plant growth and contributes to nitrate reduction in both higher plants and green algae. Like zinc, small amounts of both manganese and copper stimulate plant growth; large quantities are toxic.

The human resources of Peru are also profoundly affected by the mining industry. Mining and petroleum operations use labor brought in from outside the region. In general, Andean people work the mines, and coastal people the oil fields. How well these individuals adapt to forest conditions varies: some remain for years, others quickly return to their places of origin. Desertion rates are large because the workers are separated from their families and because the work is tedious. Moving from one area to another also involves certain health risks, notably the danger of encountering such diseases as dysentery, amoebiasis, and malaria. Furthermore, mine workers can become exposed to toxic gases, such as carbon monoxide, hydrogen sulfide, acetylene, methane, and carbon dioxide.

Petroleum activity, like mining, encourages the development of other sectors, since it contributes indispensable energy to them. In the vicinity of a working oil field, support industries develop, such as forestry to provide wood for homes and offices; agriculture to provide food, ornamental plants and medicines; and hunting to provide meat. Formerly, the company encouraged indiscriminate hunting to obtain sufficient meat, but this was found seriously to threaten the wildlife population, which was also reduced by explosions, and noise from helicopters and airplanes.

Extracting and desalinizing petroleum in the Selva region produces an average of two or three barrels of formation water (brine) for each barrel of processed crude (varying from almost 0 to 100 barrels or more per barrel of processed crude). The amount of saline water varies according to geology, locality, and age and type of well. Often the saline water is discharged into water courses. This is the least expensive dilution method (Ossio, 1979), but the river's dilution capacity, the brine salt content, how the river water is used, and the characteristics of its aquatic life all need to be considered because high salt levels can greatly damage fresh water ecosystems, especially during breeding seasons and when larvae and juvenile stages are present. One sudden and appreciable change in salinity can kill fish, but, given time, fish can either adapt to, or escape, saline water. The major problem is that sections of salt water act as barriers to migratory fish, preventing them from traveling up or downstream where they need to breed (Snedaker, 1977).

If the average chloride content in Amazonian rivers is 7 mg/l, it can be estimated that the volume of water required to dilute the salt to this concentration will be 323,960 m^3 per day or 3.75 m^3 for every 1,000 barrels processed. Table 13-1 compares the ion content of this brine with sea water. Brine also contains sulfates, magnesium carbonates, calcium carbonates, and lesser amounts of such substances as oils, organic compounds, and dissolved gases.

Table 13-1
ION CONTENT OF FORMATION WATER COMPARED WITH THAT OF SEA WATER

Ion	Sea Water ppm	Brine ppm
Na^{+1}	10,600	12,000 - 150,000
K^{+1}	400	30 - 4,000
Ca^{+2}	400	1,000 - 120,000
Mg^{+2}	1,300	500 - 25,000
$C1^{-1}$	19,000	10,000 - 250,000
Br^{-2}	65	50 - 5,000
I^{-1}	0.65	1 - 300
HCO_3^{-1}	-	0 - 1,200
SO_4^{-2}	2,700	0 - 3,600

Source: Reid G., *et al.* (1974).

Saline wastes can also contaminate aquifers, which can be detrimental to agriculture. The petroleum in brine wastes will form a film over water surfaces that interferes with oxygen transfer essential to aquatic life and that damages the plumage of birds.

Water in the vicinity of Central Selva ports and embarkation points also becomes contaminated from the waste of boat crews and from spilled fuel. This is an especially serious problem during low water periods. Oil spill accidents are difficult to prevent, except by continual surveillance of storage facilities and pipelines. Accidents caused by rupture of the latter are of two types: minor spills that are hardly perceptible but which may have a cumulative effect, and major spills caused by total or partial pipeline ruptures. The economic impact of spills is considerable and includes cleanup costs and damage to fisheries, agriculture, recreation, and tourism.

Both the volatile compounds of low molecular weight and the dissolved gases in petroleum present risks of explosion, especially when combined with atmospheric oxygen. When gas concentrations are either low, as in well-ventilated areas, or much higher than explosive levels, risk exists and it can be very dangerous to work under such conditions.

The workers themselves can have an impact on the surrounding areas unforeseen by the company's planners. Unplanned and disorganized settlements tend to develop in the vicinity of petroleum camps. Often the community is made up of relatives of the petroleum workers, who were not able to be accommodated by the petroleum company's facilities.

Regulations governing the use of Amazonia's national parks are frequently ignored by mining interests. For example, hunting, fishing, and petroleum activities have been carried out in the Pacaya-Samiria National Reserve for the last 10 years without consideration of reserve regulations; "gold fever" in Madre de Dios Department caused a major immigration of miners, merchants, and others into the region and into the department's Manu National Park, as well.

Guidelines for mining and petroleum planning in the Central Selva

A large part of the Pacaya-Samiria Reserve, where petroleum activity has been extensive, is plagued with pollution of synthetic materials (plastics and techno-port), while the riverbank fauna - capybara, monkeys, and birds - are made increasingly nervous by the noise created by helicopters and boats. In addition, the nesting beaches of paiche, turtles, taricayas, and cupisos are eroded by boat wakes.

To eliminate the dumping of noxious wastes, a technique has been proposed for U.S. mines in which concrete and asphalt are used to hermetically contain the pollutants. Remaining material can be left exposed or covered with soil, depending on the material and the way the soil will be used in the future. Figure 13-1 schematically illustrates this technique.

The wastes generated from desalinizing petroleum are usually disposed of through direct discharge, evaporation lagoons, and subterranean injection. Figures 13-2 and 13-3 illustrate how to control such contamination.

The Water Law prohibits pollution of water resources, and it is the responsibility of the mining and petroleum companies to comply. One suggested preventive measure is to prohibit the construction of facilities that do not use effective filters, anti-pollutant devices, and purifiers and to inspect the pollution control equipment of all new mining and petroleum enterprises. Drainage and other hydraulic works also need to be inspected to ensure that water containing pollutants does not enter natural drainage systems (Table 13-2).

Mining and petroleum companies can treat, store, and eliminate harmful wastes to minimize conflicts with other activities. One report recently published by the Committee on the Challenges of Modern Society, listed the following seven options, in order of priority, for effective management of dangerous wastes.

Figure 13-1 - REDUCTION OF SURFACE WATER INFILTRATION

Figure 13-2 - ALKALINE NEUTRALIZATION

FIGURE 13-3 - DIAGRAM OF THE NEUTRALIZATION PROCESS UTILIZING LIME

1. Reduction of waste quantities at the source; for example, utilization of wastes in the hydraulic support at the San Vicente mine, or injection of salt water into petroleum wells, or

treatment of settlement wastes.

2. Separation and concentration: the separation of liquids from solids to facilitate treatment.

3. Changes in dangerous wastes: research can be conducted into finding less toxic material to be used in recovering minerals.

4. Recovering materials: for instance, wastes can be used directly to provide energy, or they can be transformed into useful products.

5. Destruction through incineration and energy recuperation.

6. Detoxification and neutralization.

7. Reduction of volume.

Each option can be effectively applied alone or combined with others in order to retain mining and drilling as principal economic activities in the nation while lessening the damage to the natural resources and ecosystems on which they depend.

Table 13-2
WATER QUALITY STANDARDS FOR FISHING AND IRRIGATION

Parameter	Peru mg/l	OMS mg/l
Suspended Solids	Absent	80
Oils, Fats	Absent	-
Phenols	0.001-0.002	0.001-0.002
Lead	.10	0.05-0.10
Fluoride	1.5 - 2.00	3.4
Arsenic	0.20	0.05
Selenium	0.05	-
Chromium^{+6}	0.05	0.05
Cyanide	0.01	0,05
Silver	0.05	N/R
Nitrates	100	45
Chloride	N/R	200-600
Manganese	0.1 - 0.5	0.50-0.50
Copper	1.0-1.5	0.05-1,50
Zinc	5.0- 15.0	5.0-15.0
Sulfates	400	200-400
Magnesium	150	30-150
Iron	0.30-1.0	0.1-1.0

Source: MAA, 1969.

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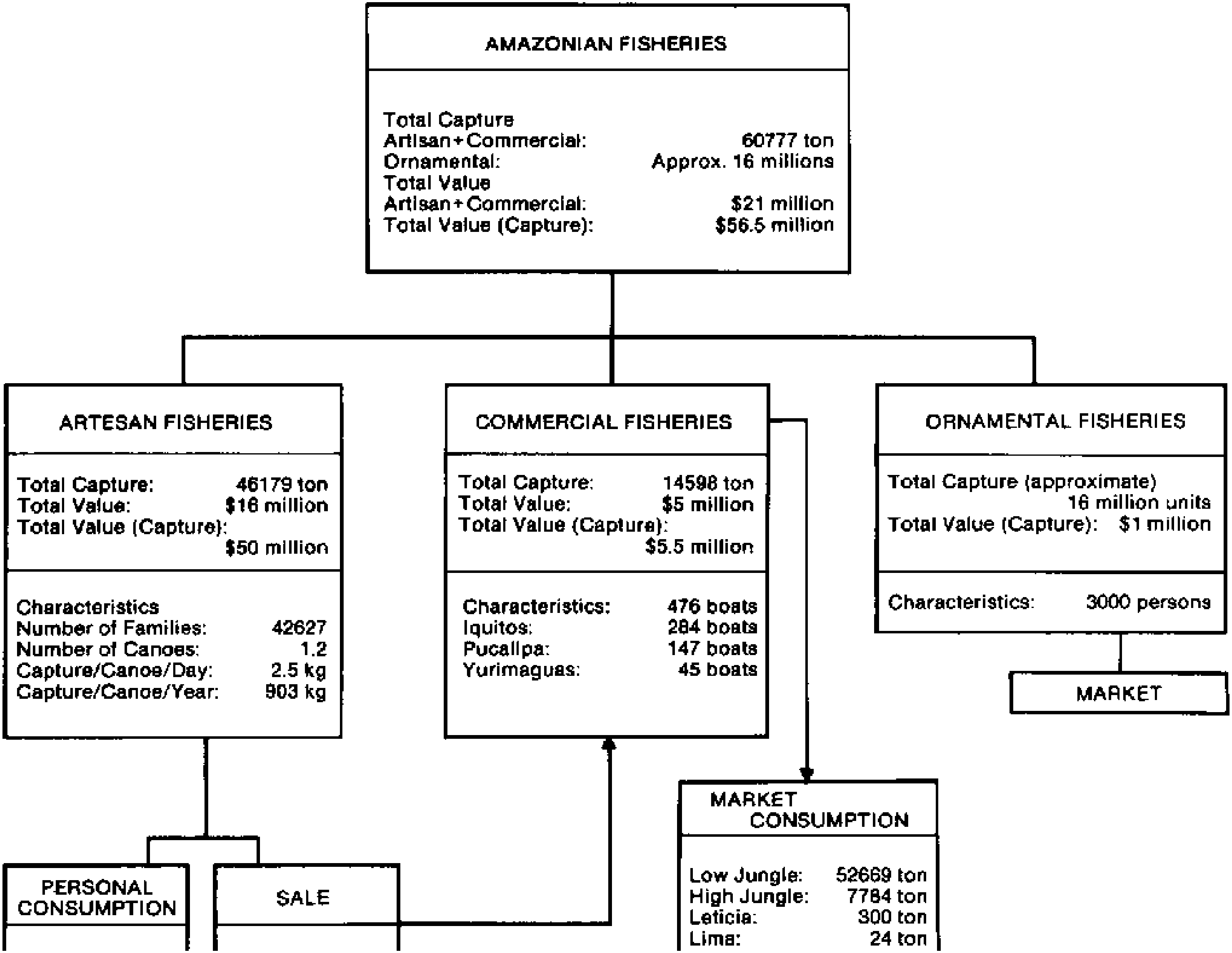
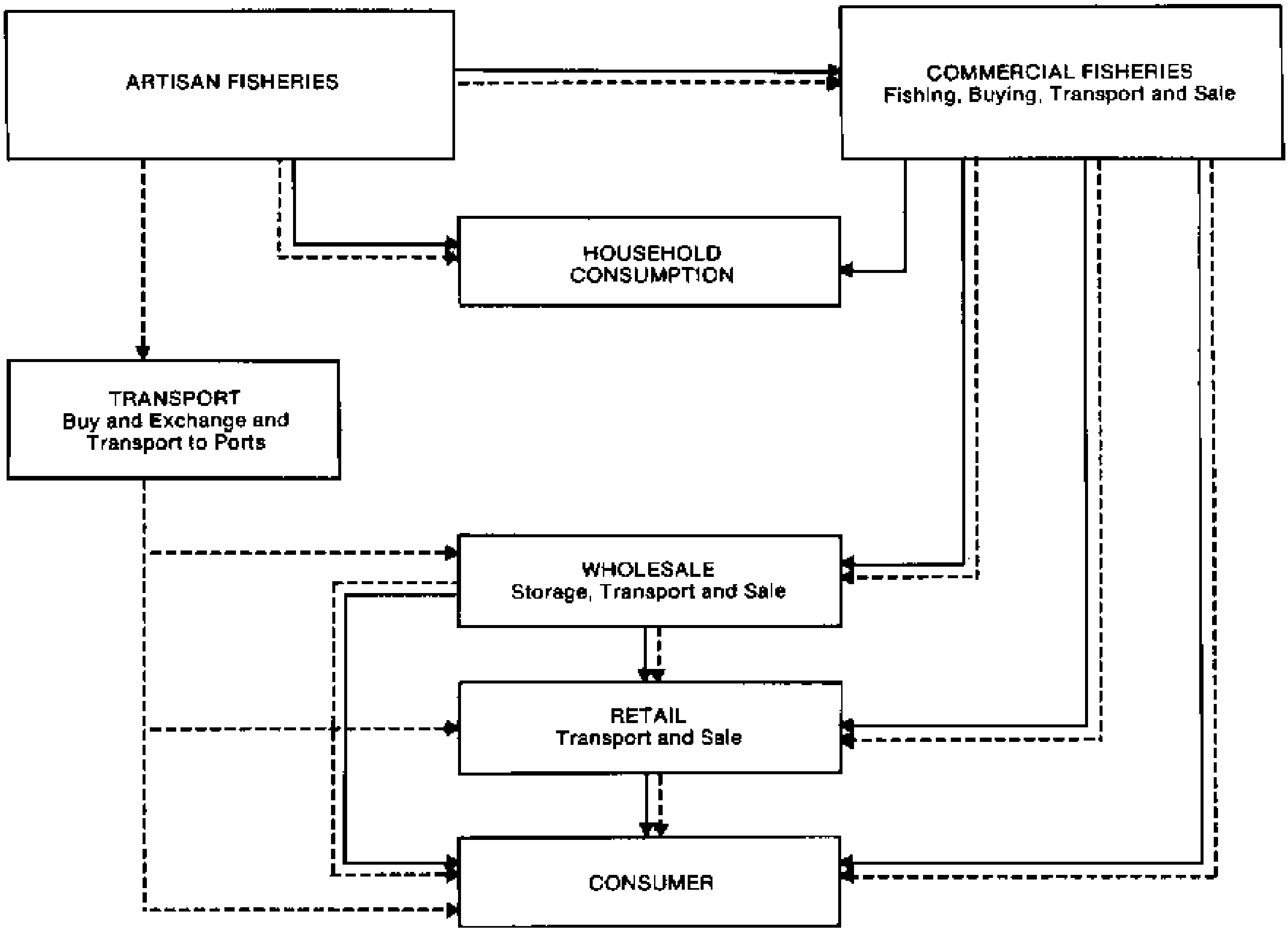
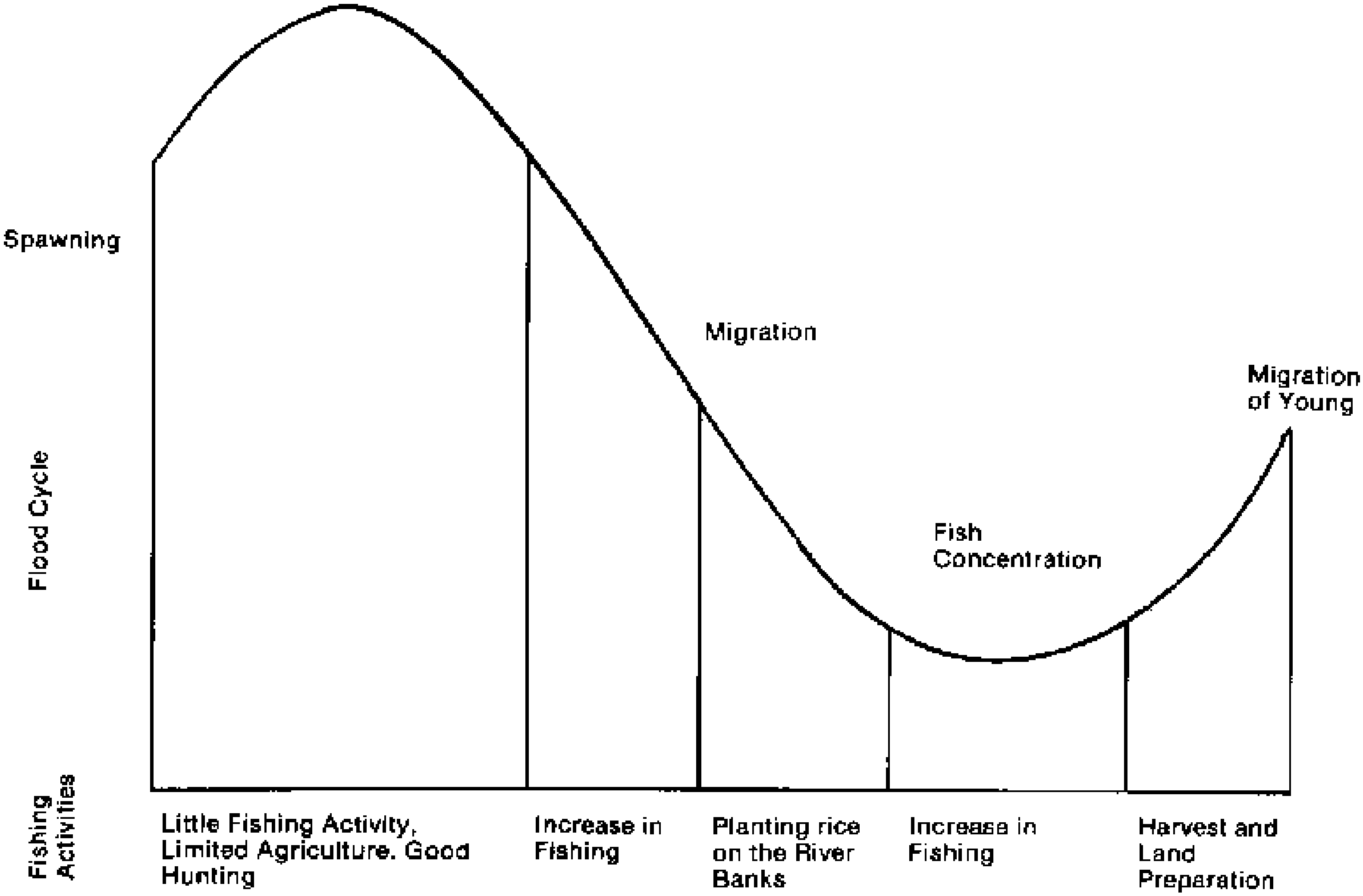

AMAZONIAN FISHERIES
Total Capture
Artisan+Commercial: 60777 ton
Ornamental: Approx. 16 millions
Total Value
Artisan+Commercial: $21 million
Total Value (Capture): $56.5 million
ARTESAN FISHERIES
Total Capture: 46179 ton
Total Value: $16 million
Total Value (Capture): $50 million
Characteristics
Number of Families: 42627
Number of Canoes: 1.2
Capture/Canoe/Day: 2.5 kg
Capture/Canoe/Year: 903 kg
COMMERCIAL FISHERIES
Total Capture: 14598 ton
Total Value: $5 million
Total Value (Capture): $5.5 million
Characteristics: 476 boats
Iquitos: 284 boats
Pucallpa: 147 boats
Yurimaguas: 45 boats
ORNAMENTAL FISHERIES
Total Capture (approximate) 16 million units
Total Value (Capture): $1 million
Characteristics: 3000 persons
MARKET
PERSONAL CONSUMPTION
SALE
MARKET CONSUMPTION
Low Jungle: 52669 ton
High Jungle: 7784 ton
Leticia: 300 ton
Lima: 24 ton

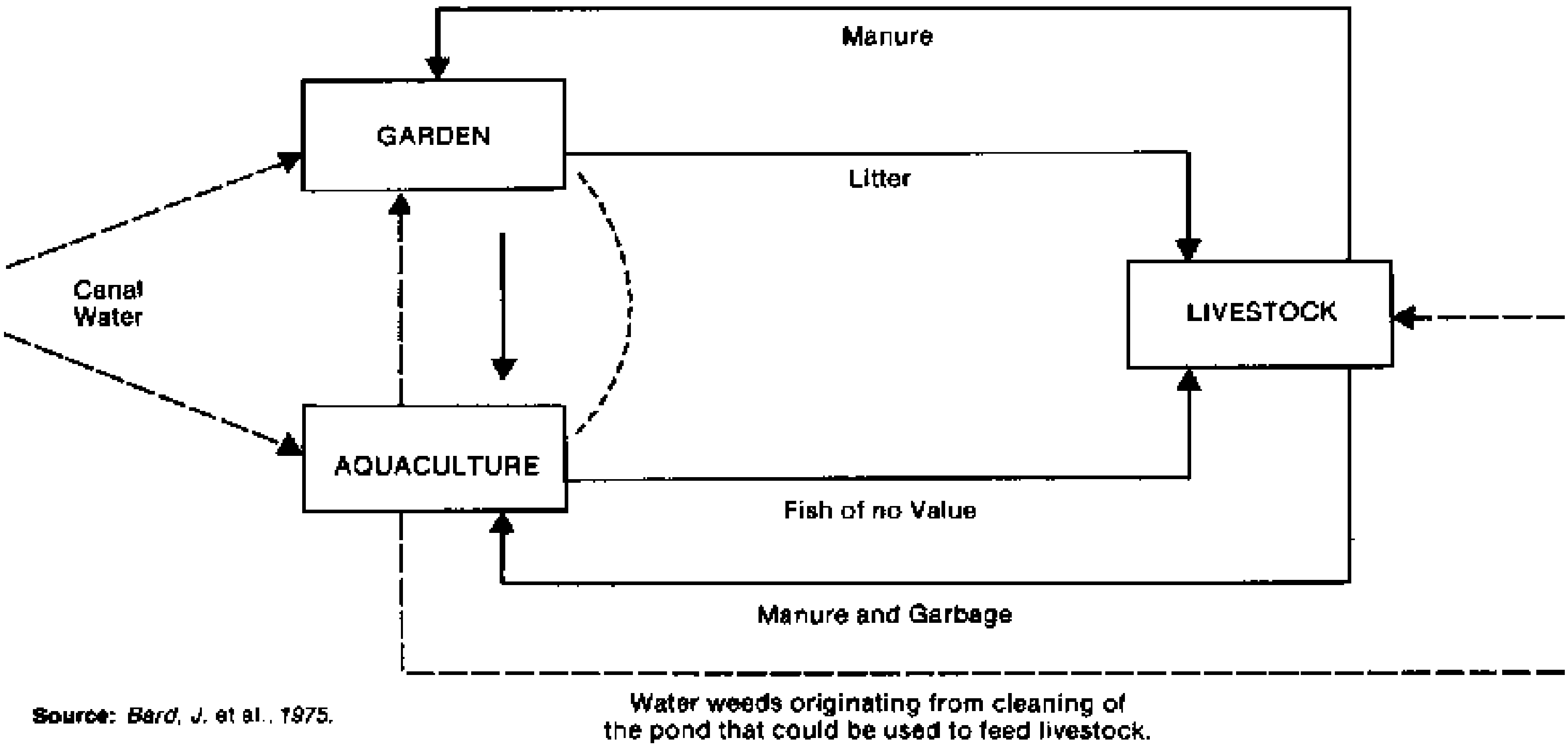
Source: *Hanek (1982)*



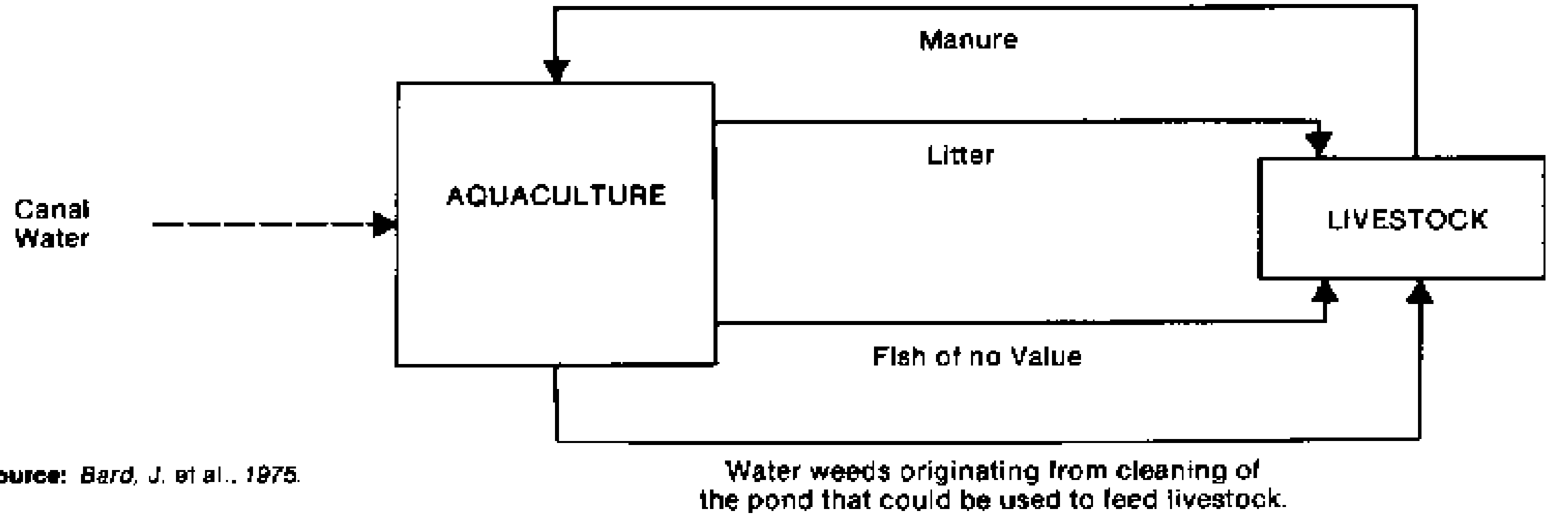
Source: *HANEK (1982).*



Source: *HANEK (1982).*



Source: *Bard, J.* et al., *1975.*



Source: *Bard, J. et al., 1975.*

Chapter 14 - Transportation in the humid tropics

Introduction

The paramount importance of transportation systems in community development is widely known. The objective of transportation is to carry people and goods from one site to another. Consequently, it is an important means of communication and an agent that can both induce favorable socioeconomic change as well as cause serious conflicts with other development activities. It can also immobilize and make unproductive large quantities of capital if it is not suitably used. Even though very little statistical information is available about the Central Selva, it is clear that road construction, maintenance, and vehicle traffic can conflict with other development efforts.

Road construction in the humid tropics in general, and the Peruvian Central Selva in particular, requires analysis of a complex series of factors, set in the context of both the historical evolution of transportation in these areas, as well as in the geography which imposes severe limits on the development of transportation systems.

Peru has been defined as a "terrestrial archipelago" because its inhabitants are grouped into dispersed isolated settlements at different altitudes. The most important barriers to communication between these settlements are coastal deserts, snow-capped peaks, frigid punas, deep canyons, wet tropical forests, and swamps. Production and consumer centers are dispersed throughout the country at altitudes ranging from sea level to 4,500 meters above sea level. Fifty to ninety percent of the prices of agricultural goods produced in the interior and sold on the coast are accounted for by transportation and marketing costs. Historically, roads have been inadequate for the burdens of commerce placed on them.

Evolution of transportation in the Selva

Four periods in the evolution of Selva transportation systems can be distinguished: Large Expeditions, Steamboat River Navigation, Air Transportation, and Terrestrial Transportation. A few years after the Spanish conquest of Peru, the rumored existence of El Dorado inspired various expeditions into the Selva, beginning with that of Gonzalo Pizarro in 1541. Fantastic descriptions of El Dorado and other such places persisted for more than 100 years, attracting adventurers, miners and missionaries. These expeditions left no road infrastructure, but they did increase knowledge of the region which later contributed to the selection of road locations.

The 19th Century saw a significant worldwide technological change in navigation, with the introduction of steamships. Notably faster on calm sea than sailing ships, steamships became widespread with the decrease in coal and metal prices and the substitution of steel for iron. The first English steamship "Peru" arrived in Callao in November, 1840 followed by the Brazilian ship "Marajo" which appeared in 1853 in Nauta, a settlement on the left bank of the Marañon river, near its confluence with the Ucayali river. At Peru's request the "Marajo" visited the Peruvian Amazon three times a year for an annual fee of 20,000 pesos. From that moment, commerce and development in the Peruvian Amazon depended on ships that came from the east, from Brazil, rather than from distant Lima.

The steamship allowed the Low Selva's natural resources to be exploited. Recognizing the Selva's strategic location, and to counteract its dependence on Brazilian craft, Peru's President, Ramon Castilla, ordered the construction of two steamships, two exploration vessels, and a floating dock capable of accommodating 1,000 ton ships. Operation began in January, 1864 and since then, the Peruvian river fleet has grown. A river port was constructed in 1901 at Iquitos; by the end of the 1970s, ports were also built at Pucallpa and Yurimaguas, replacing natural landings.

Since the steamship began operation, the most convenient way to enter and leave the Peruvian Low Selva was through Brazil via the Amazon river. The alternative was to travel by land for two difficult months over the Andes and through the High Selva on footpaths. In 1863 Raimondi wrote regarding the need to supply river settlements with potatoes imported from Portugal and France that arrived half-decomposed or germinated. Ironically, the mountains in Peru were at that time an important potato-producing region, but could not supply an adjacent area in the same country, because of the lack of transportation.

During this period, several incidents significantly affected the way of life of Selva inhabitants:

1. The production boom of the famous Moyobamba hats attracted international attention, and caused several foreign consulates to be established in that town. This business saw surprising growth until the middle of the 19th Century.

2. The rubber boom from 1870 to 1914 subjected the native population to continual plunder of land, property and person, and to epidemics of imported diseases to which they had no resistance (colds, flu, and measles). Brazilian cities (Manaus, Rio Branco, etc.), on the other hand, benefited significantly from the boom's profits.

3. Policies of the Peruvian Government at the end of the 19th and the beginning of the 20th Centuries gave considerable impetus to colonization in the region, but being landlocked and lacking roads the region was unable to support such colonization efforts.

The Air Transportation Period

With the construction of the Iquitos airport in 1930, air traffic began and Iquitos finally became more oriented toward Lima and the rest of Peru instead of to Brazil to which it had been tied physically and economically (Riccioni, 1965). Later, airports were constructed in other Selva localities, and by 1961, the largest volume of passengers and cargo in Peru, larger even than the volume at Lima Airport, passed through Tarapoto airport.

Large areas of the High Selva and Low Selva saw their isolation ended with the arrival of air traffic, but financial and technical limitations (freight, investment, etc.) restricted their social and economic integration into the rest of the country. Most service was provided by single-engine planes.

The terrestrial transportation period began late. "In the jungle area (Selva) no roads have been constructed. Only those localities that can be reached by boat are known and have been exploited. The rest of this vast area has not been exploited and is practically unknown," wrote Davalos and Lisson in 1902. In 1929 Diez Canseco wrote, "East of the mountains, in the forest region, the problem is still worse; in fact, to date, it is unsolvable. The amount of rough terrain and the abundance of rain causes the roads on the hillsides to be permanently threatened by landslides. Where the terrain is more level, the moisture retained by the vegetation converts all land into a quagmire, while bridges grow in number and dimension as the water descends until rivers are encountered that are practically impassable."

Roads rapidly spread through Peru between 1920 and 1930 with the passage of the "Road Conscription" Law by the Leguia government. This law required every citizen age 18-60 to dedicate 12 days per year to road work, which added thousands of kilometers of coast and mountain roads and which contributed to the beginnings of a road network in the Selva. During the 1930s the Chanchamayo Valley (San Ramon and La Merced) in the Central Selva became connected by land with the rest of the country through construction of the Lima-La Oroya-Tauna-La Merced road. After the 1930s, mountain localities were selected as starting points for crossing the Eastern *Cordillera* to incorporate new areas and settlements in the Selva into the national economy. Roads were built to Quince Mil (1942), Pucallpa (1943), Oxapampa (1943), Puerto Maldonado (1962), Pozuzo (1974), and Tarapoto (1978).

Despite these advances, however, road construction in the Selva has generally been slow and characterized by delays. There have been several reasons for this, including changes in government, economic crises, technical difficulties in construction and maintenance, and unrealized social and economic goals.

Other Methods of Transportation

In most of the country horse and foot paths have been and will continue to be crucial in supporting both new colonies and existing communities that are far from roads. Peru's vast network of paths has been constructed by the users themselves with neither technical assistance nor official financial support, this despite the fact that under the Incas, roads formed large networks and offered well-constructed suspension and floating bridges and roofed resting places (*tambos*) at regular intervals.

At the beginning of the present century a 580 km railroad line from Tambo del Sol to Pucallpa was planned. Tambo del Sol is located 4,112 meters above sea level along the railroad between Oroya and Cerro de Pasco. The road, passing through Huacho, Oxapampa, Pozuzo and Puerto Inca, was to expand the area influenced by the Central Railroad, so that Lima and the Central Sierra would be connected with the Amazon region. The rails were to reach the navigable rivers on the Atlantic slope, providing an inter-ocean route that would be an alternative to the Panama Canal. Its construction began in the 1950s, but after the construction of only 40 km, the project was abandoned.

Confronted with the expense of construction and maintainance of roads in the Selva, two recent studies considered the possibility of using dirigibles instead. The first analyzed the benefits that dirigibles could bring to the Urcos-Puerto Maldonado Road project area (Cahn-Hidalgo, 1982). The second looked at the Central Selva and concluded that dirigibles would be more efficient and economic than conventional plans (Mayer, 1982). Unfortunately, additional planned investigations comparing dirigibles with terrestrial transportation have not yet been conducted.

Transportation in the Central Selva today

All manner of motorized vehicles have been used increasingly in recent decades in the Central Selva to transport products to Lima, where they are most in demand. Increases in the price of forest products have also encouraged farmers to later convert their trails to cart roads.

Road Infrastructure

The Central Selva can be reached from Lima by two access roads: the Lima-La Oroya-Tarma-San Ramon road (295 km) and the Lima-La Oroya-Concepcion-Satipo Road (362 km). However, the latter road passes through rough terrain and is little traveled.

Map 14-1 illustrates the principal Central Selva roads and their connections with the rest of the country. Nearly 40 percent (521 km) of the Central Selva roads belong to the national network, of which less than 1.0 percent are paved, 63.2 percent are improved, 23.6 percent are unimproved, and 13.2 percent are cart trails (Table 14-1).

An appreciable length of local roads (725 km) has been constructed over trails cut for timber harvesting by private corporations or by communal efforts. These roads are characteristically straight, without shoulders or drainage ditches, and are often impassable in the rainy season.

Private Transportation Services

Buses and taxis for passengers and 8-12 ton trucks for freight are provided exclusively by private companies and individuals, which are regulated only according to demand and road conditions. Most of these intraregional transport lines originate in, or have as their destinations, La Merced and Satipo. In other parts of the Central Selva accessible by road, service is less satisfactory and more irregular. Passengers usually travel in specially prepared pickups or small trucks, or they can travel in the cab or on platforms of freight haulers. Where there are no roads, irregular service by small planes based in San Ramon or elsewhere outside the Central Selva fill the gap.

In 1982 the Regulatory Commission of Transportation Tariffs established a tariff of approximately US$35.00 per ton of truck-hauled dry cargo. Compliance by the fleet depends on road conditions and negotiations between suppliers and claimants. Generally, suppliers have more power in negotiation.

River Transportation

Air transportation and automobiles have notably reduced the importance of transport by river for both passengers and freight. The principal navigable rivers of the region are the Ucayali, Tambo, Pachitea, Urubamba, and Ene. The Pichis and Palcazu rivers are navigable by smaller boats from their confluence to Puerto Bermudez and Izcozacin, respectively. The Perene river is navigable from its junction with the Ene to Puerto Ocapa. No official infrastructure or port service exists for passenger and freight movement, although natural ports are used, depending on the season and height of the rivers.

River service is limited to areas lacking roads and to transportation over short distances. It is most important east of the Central Selva, in Puerto Inca, Puerto Bermudez, and Atalaya. In these areas rivers contain larger volumes of water, and they are the only means of large scale transportation. The most specialized service with the largest ships is provided by corporations based in Pucallpa. These distribute food, drinks, materials and equipment and transport logs to sawmills in Pucallpa. For small freight cargos, individual enterprises are available with a large variety of boats.

Air Transportation

More than 70 airstrips exist in the Central Selva, most of them without paved runways, appropriate lighting or other facilities. The San Ramon airport has the most air traffic and is able to accommodate DHC-5 planes. Its clay runway is 800 meters long and 40 meters wide (MTC, 1982). DHC-5's may also use the airstrips at Puerto Bermudez, Satipo, Atalaya, Puerto Ocopa, Mazamari, Cotivereni, Rateri, Iscozacin, and Puerto Victoria. Only small planes can use the other strips in the region. Most air traffic occurs in the dry season, from July to October. Users and local governments are largely responsible for maintaining the local air transportation infrastructure.

Five air-taxi companies operate in the Central Selva, offering irregular passenger and freight transportation service. In accord with the Civil Aeronautics Law, they can neither announce nor be subject to flight itineraries, nor can they travel the same routes as the regular air service companies. Fees are set according to trip length and whether passengers and freight will be found for the return flight. Most planes are single-engine, although one company based in San Ramon has 5-twin engine planes.

Road construction and improvement

Geologic and Climatic Characteristics

Central Selva roads traverse the forested foothills of the High Selva and the Amazon Plain. The foothills, outcrops of the *Cordillera Oriental,* are characterized by canyons, deep ravines, and narrow valleys. Its rivers flow over varied types of rocks which produce small falls, surface erosion, and occasional flash floods during the rainy seasons.

The Amazon Plain, meanwhile, is relatively flat. The pressure of heavy rainfall, the runoff from the highlands, and seasonal overflowing of riverbanks deposit combinations of organic and inorganic material on the land; the different layers of these deposits, which are usually called "incoherent" units, do not provide a good surface for road construction.

Population Distribution

Population density in the Central Selva is only 0.02 people per hectare while the national density is 0.12 people per hectare. The ratio of agricultural land to inhabitant is 11 hectare per person, while the national ratio is only 4.28 hectare per person. Almost 70 percent of the population is concentrated on 11.4 percent of the useful land located near access roads and on lands that are predominantly protected (stretches of the Chanchamayo, Oxapampa, and Satipo). Eighty percent of the populations are rural while the urban population is concentrated in San Ramon, La Merced, Satipo, Oxapampa, Puerto Bermudez, and Villa Rica, with populations that vary from 4,000 to 12,000. Other settlements contain 200-400 inhabitants. In roadless areas, settlements of both colonists and natives are generally located along riverbanks (INP, 1981 a).

MAP 14-1 - PERU - MAIN ROADS IN THE SELVA CENTRAL AND ITS INTERCONNECTION WITH THE REST OF THE COUNTRY

Table 14-1
CENTRAL SELVA ROAD NETWORK (January 1980)

	TOTAL			IMPROVED			UNIMPROVED			TRAIL		
	Km	%[a]	%[b]	Km	%[a]	%[b]	Km	%[a]	%[b]	Km	%[a]	%[b]
National Network	521	39.9	100.0	329	94.5	63.2	123	64.7	23.6	69	9,0	13.2
Departmental Network	59	4.5	100.0	9	2,6	15.3	29	15.3	49.2	21	2.7	35.5
Local Network	725	55.6	100.0	10	2.9	1.4	38	20.0	5.2	677	88.3	93.4

a. Structure according to the type of network (vertical).
b. Structure according to the road surface (horizontal).
Source: MTC (1980).

Road Investment and Planning

Building a road in an area of little economic activity and away from large population centers requires careful integration using micro-regional plans and multiple objectives. When planning for expansion or development in agriculture, mining or other production sectors, officials tend to forget that transportation costs are an important part of the expense that should be factored in from the beginning in order to increase the demand for transportation and thus justify the considerable investment in road-building.

The 1981 -1985 Central Selva public investment program for the transportation sector is a major part of the strategy and policies of the "Central Selva Development Plan" (INP, 1981 a) and the "1981 -1985 Medium-Range Investment Program" (INP, 1981 b). Transportation sector projects represent 82 percent of the total projected investment for the Central Selva; for the rest, 9 percent goes to support production, 4 percent for regional plans and support of micro-regional administration, 3 percent for social services, and 2 percent for baseline studies. Among the basic infrastructure projects the most important is the construction and improvement of the Selva Marginal Road, which accounts for 30 percent of the investment in the region.

Technological Design Standards

The "Peruvian Road Design Standards," developed in 1970 by the Road Infrastructure Office of the Ministry of Transportation and Communication, specifies how the slope, banking, and curve radius of the roads must be designed to suit the topography and the volume and speed composition of the expected traffic. These standards are adapted from studies conducted in the United States in 1965 by the Highway Research Board. Although these standards are based on traffic and road conditions in the United States, they have been adopted with few changes by almost all other countries because of the lack of local studies that allow site-appropriate projects to be developed. The current system is incompatible with the rough terrain and heavy vehicles (trucks) common to the Central Selva. Others (Holguin, 1980; the International Labor Office and the World Bank) have also pointed out that it is inappropriate to apply imported standards and techniques to road construction (Allal and Edmonds, 1977). While these standards may occasionally be suitable to the conditions in developing countries like Peru, in most cases they are inadequate economically and culturally.

Inappropriate standards and poor administration, meanwhile, have caused the number of automobiles in Peru to grow too large for the road infrastructure, while freight surveys conducted in 1978 and 1981 revealed that illegally large cargos are being carried on a high percentage of roads by almost 75 percent of double-axle vehicles. Excessively heavy cargos accelerate pavement deterioration and considerably increase maintenance costs. In addition, they threaten the majority of bridges, which are old and which were not constructed to support such cargos. (Urbina, *et at*, 1982).

Principal Construction Activities

To build a road, land has to be cleared of trees, plants and animals. The width of the area to be cleared varies according to topography and vegetation, but an average width is approximately 20 meters on each side of a road, to allow enough space for levelling and construction and also to serve as a buffer area to prevent the weight of large falling trees from damaging road banks and to prevent tree branches from falling on roadbeds.

Thus, a strip 40 meters wide is often left without plant cover and exposed to the elements for a considerable length of time. The mechanical force of rainwater can erode this land and carry off sediments and organic material to water courses, while the fauna that lived along the road site are forced out, or prevented from migrating across such a barrier.

Drainage and earth movement are the principal problems confronting road builders in the humid tropics. The function of drainage works is to capture and dispose of water as quickly as possible. Central Selva roads lack adjacent drainage ditches and thus they are subject to attack by water, which reduces soil resistance and causes the road base, sub-base and surfaces to wash out. Precipitation flows off the land's surface, filters through the soil, or evaporates. As surface runoff, it forms small channels that eventually meet to form rivulets and then streams, roads frequently impede this natural runoff. Without drainage works, large puddles form in the road way, and water infiltrating the subsoil tends to gush from the banks and road surface.

If the road is located on a slope, the water's mechanical action increases, but the resulting gullies are well-defined and thus can be controlled. If the road is located on flat terrain in tropical regions, drainage problems are much worse, because the channels are not well-defined. Alteration of the free flow of water affects the development of some plant species; affects migrations, reproduction, and feeding of fish; and increases sediment loads that fill river channels, eventually forming islands and changing river bottom configurations which can adversely affect river transportation and riverbank settlements and production. Consequently, a significant concern of planners in the humid tropics is to find suitable areas for roads to minimize drainage problems and, thus, the costs of road maintenance.

Much of the cost of road construction is incurred by levelling and excavating the road bed, and these costs are affected by topography, geotectonic conditions, height of the road bed, and the cost of moving earth. If the road right of way is flat, the road will be supported on a terrace, a structure made with material from the site or from elsewhere. However, not all soil material in the Low Selva is suitable for constructing terraces and often this material must be transported long distances. If the terrain is hilly, stretches can be built with on site material and on fill, but in montainous areas large scale earth-moving is required. If the slope is excessive, tunnels and retaining walls may have to be built. In some cases, the cost of levelling approaches 75 percent of the total and is increasing (Holguin, 1980).

The project engineer, for economic reasons, must compensate for excavated on-site material and avoid the excessive use and transport of fill materials from other localities. To this end, the engineer will try to alter slopes, and increase or reduce vertical curves to reduce construction costs.

In the Selva "incoherent" units (expansive clays and marshy areas) are frequent. Construction material is scarce. Increasing the amount of on-site excavated material to compensate for the scarify of material lowers the road closer to the water table. This will require additional drainage works and thicker pavement and, consequently, increased costs. At the same time, extracting material from alongside the construction site can significantly alter topography, vegetation, runoff, etc., away from the road site. Excavation of hillsides can disrupt their natural equilibrium and cause landslides that obstruct water courses with sediments, unless such preventive measures as retaining walls are employed.

The materials adjacent to the road and in quarries are an important factor in construction costs. The absence of material will require transporting rock and sand from distant localities, as frequently happens in the Peruvian Selva. In one project, for example, rock was transported to the Iquitos airport from a site (Aguaytia) 10 days distant by barge, and one more day by truck. Rocks and cement were transported to Inapari by cargo planes; cement from Lima was loaded on boats at the port of Callao, taken through the Panama Canal to Belem do Para in Brazil, and then carried up the Amazon to Iquitos.

The cost of moving earth, meanwhile, depends on the unit cost of each one of the following activities: excavation at the construction site; excavation at other sites; compaction of site material in the terrace; compaction of terrace material obtained away from the site; transport of site material to the terrace; transport of waste material away from the site; and transport of material obtained at other sites to the terrace.

Careful maintenance makes transportation more economical and inexpensive transportation is vitally important to Peru's commerce and regional integration. In spite of this, no clear road maintenance policy has been established to date, road maintenance budgets have always been insufficient, and the road network has seriously deteriorated.

Maintenance consists of routine and periodic activities. Routine activities are carried out throughout the year to correct small problems and ensure the efficient functioning of all parts of the road infrastructure. Periodic road sections that have deteriorated from traffic and weather conditions are repaired, with the most effort dedicated to drainage and support of the roadbed. Drainage works are cleaned before, during, and after the rainy season to prevent obstruction and structural damage.

Construction and Maintenance Costs

Road construction costs vary according to soil, climate, topography and the availability of local resources, such as labor and construction materials. Both workers and materials are scarce in the Selva. Even though there is plenty of wood, managers of large projects prefer to use traditional materials such as glazed concrete and corrugated pipes which they must import. Smaller projects, however, do use wood in drainage works, which significantly reduces the costs.

Extracting material from quarries widens the geographic area to be affected by a new road, and may require roads to connect the quarry areas with the road under construction. The construction of a new road in the humid tropics can threaten the stability or existence of ecosystems in the road's vicinity and make permanent changes in human and animal populations. Roads permit spontaneous immigration of the poor, who may immigrate to the jungle to feed their families on the wild flora and fauna there, and to harvest some forest products they can sell to acquire needed goods in the markets. Meanwhile, intense road traffic creates a practically uncrossable barrier to the migrations of some insects and animals. The few animals that do attempt to cross roads expose themselves to being run over or hunted, for the roads facilitate illegal trafficking in and exploitation of protected areas and wildlife. Only multi-disciplinary research can lead to an objective, detailed understanding of the possible conflicts and hazards of building a road system through a given area.

At present, feasibility studies are required to consider route alternatives. These studies should consider variables such as hydrology, meteorology, soils, geotectonics, and seismic hazards and should focus on natural resource potential. Technical and economical calculations need to be employed to determine the road's benefits. Such analysis should be complemented by anthropological and sociological studies, as well as investigation into the project's impact on flora and fauna. If a road project is well conceived, executed and maintained, and if road side settlements are planned, its negative impact will be significantly reduced compared to that caused by poorly-maintained roads and by the activities of spontaneous migrants along new roads.

Table 14-2
THE PERUVIAN ROAD NETWORK

Surface	National				Departmental				Local				TOTAL
	Coast	Mountain	Selva	Subtotal	Coast	Mountain	Selva	Subtotal	Coast	Mountain	Selva	Subtotal	
Paved	3,945	878	230	5,053	799	293	6	1,098	751	85	4	839	6,990
Improved	496	4,780	1,747	7,023	479	2,179	75	2,733	567	1,874	419	2,859	12,615
Unimproved	49	2,594	147	2,797	692	4,277	308	5,277	878	5,173	524	6,575	14,643
Trails	314	303	397	1,014	946	2,272	207	3,425	6,807	16,573	2,327	25,708	30,147
Total	4,804	8,556	2,521	15,882	2,916	9,020	595	12,532	9,003	23,705	3,274	35,982	64,395

Region	Paved	Improved	Unimproved	Trails	Total	%
Coast	5,495	1,542	1,619	8,067	16,723	26
Mountain	1,256	8,833	12,044	19,148	41,281	64
Selva	240	2,241	979	2,931	6,391	10

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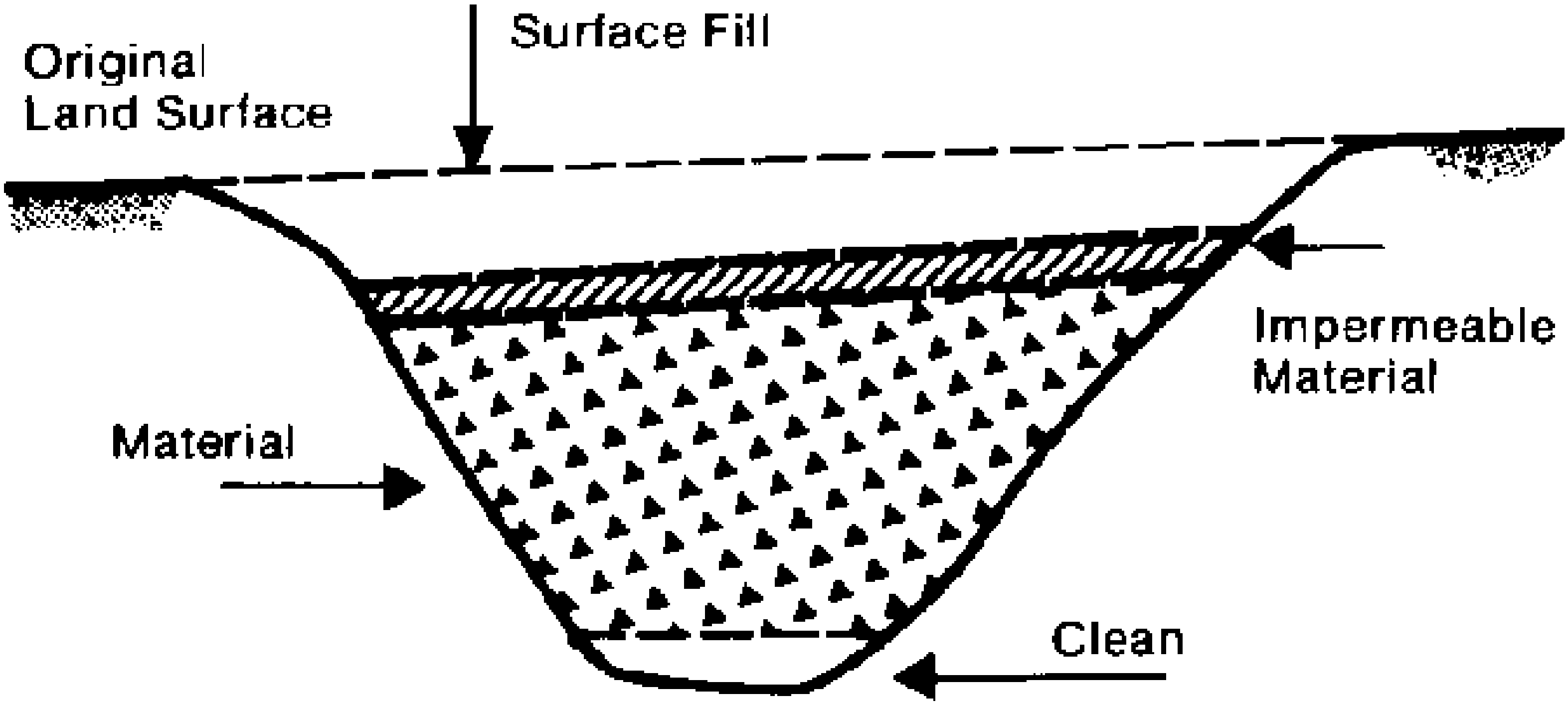
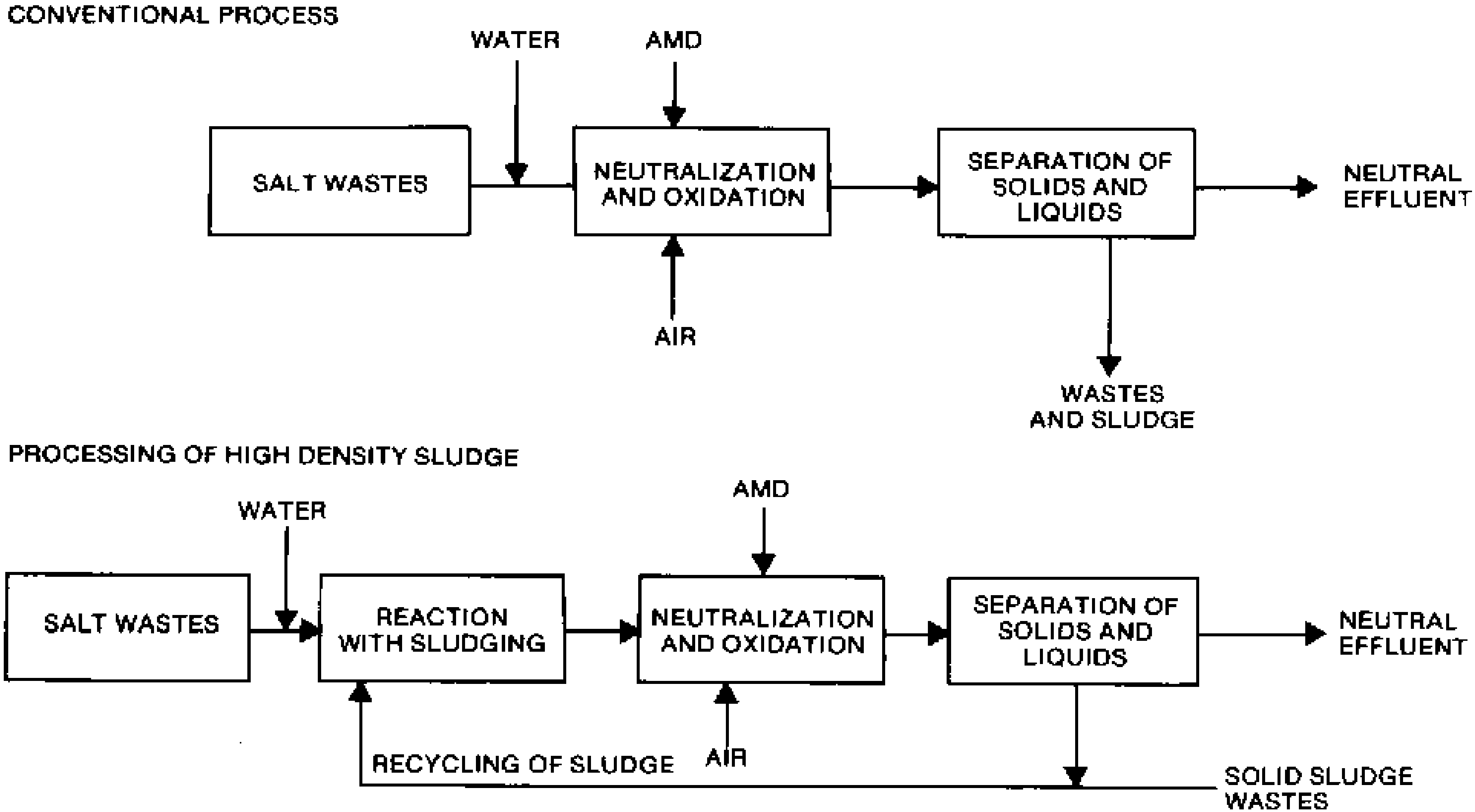
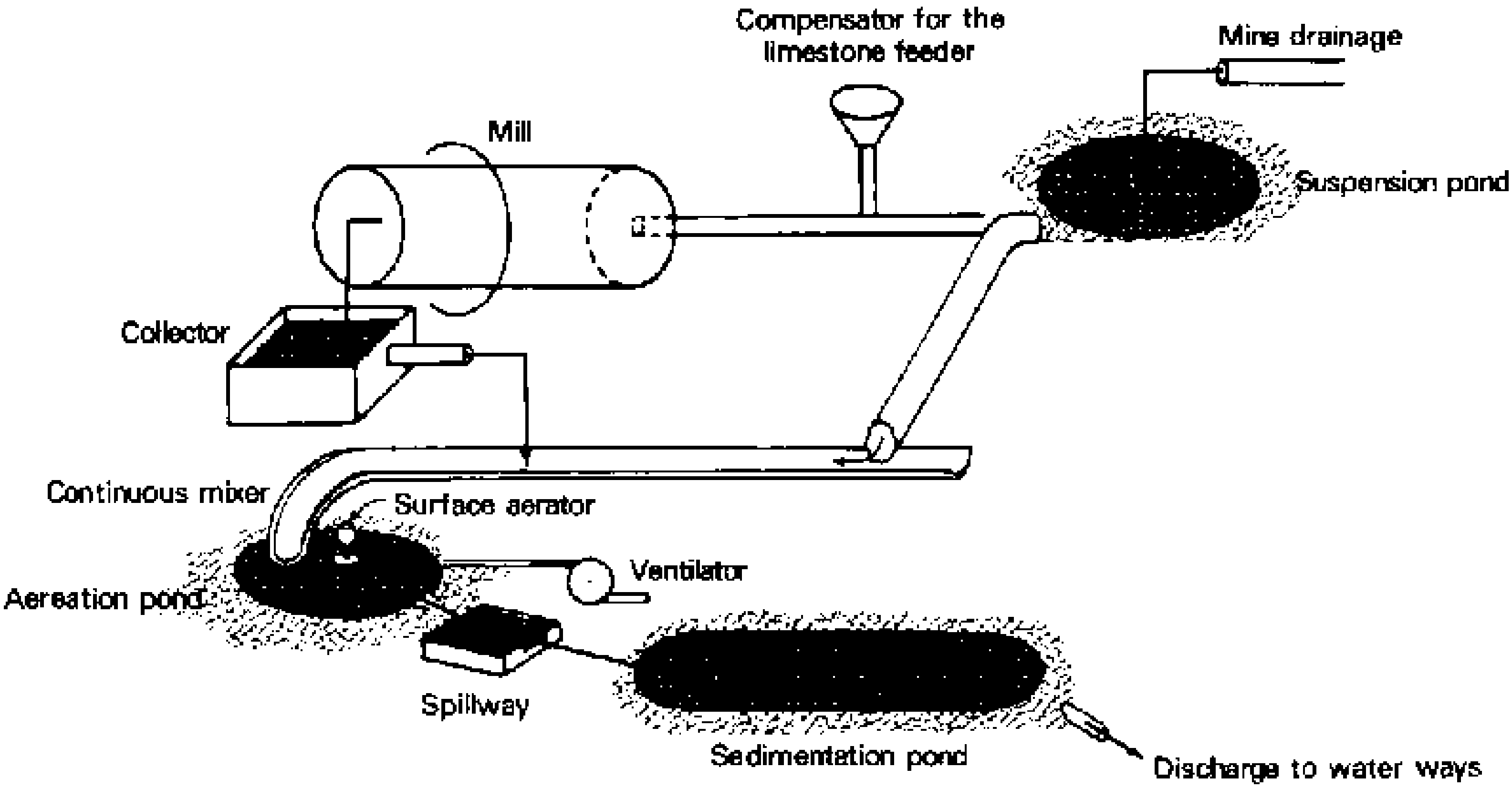


Source: *Use of Latex as soil sealant to control acid mine drainage. (1972) U.S. Environmental Protection Agency Research Series 10010 EFK*



Source: *"Combination Limestone-Lime Treatment of Acid Mine Drainage"* by Wilmoth, Roger C. et al, (1972), Melon Inst. Pittsburg, Penn, USA.


Compensator for the limestone feeder
Mine drainage
Mill
Suspension pond
Collector
Continuous mixer
Surface aerator
Ventilator
Aeration pond
Spillway
Sedimentation pond
Discharge to water ways

Chapter 15 - Renewable and non-conventional energy sources

The energy crisis which began in 1973 caused petroleum supplies to decrease and prices to rise exorbitantly. This crisis forced developing countries to reduce or postpone important development programs, so they could purchase petroleum to keep their economies operating. It created the urgent necessity to find and develop alternative energy sources, such as other fossil fuels (coal, gas), nuclear energy, and renewable energy resources.

Coal is found primarily in industrialized countries, with Latin American and African reserves making up less than 1 percent of the world total. Thus, it is unlikely that this part of the Third World will be able to use large quantities of coal. The nuclear alternative is undesirable; the associated accident risks, waste disposal difficulties, nuclear terrorism, and nuclear weapon proliferation are dangerous in themselves, and make this form of energy excessively expensive (Brown *et al,* no date). Acquiring nuclear energy from the industrialized world could, moreover, result in greater technological and economic dependence on developed countries. A more feasible alternative to petroleum, coal, and nuclear reactors in developing countries is the *direct* and *indirect* use of solar energy, which is renewable, abundant, decentralized and non-polluting.

Each day, the sun sends to earth many thousands of times more energy than we attain from other sources (the equivalent of 200 times the energy consumed by the United States of America in one year). This energy can be captured *directly* as radiation or - even more significantly - *indirectly* in waterfalls, wind, and green plants. Countries in the humid tropics in particular contain enormous forest biomass resources, which, properly managed, could significantly contribute to the solution of their energy problems, as well as provide wood for other uses. Countries in the humid tropics also possess abundant water resources and high levels of solar radiation, which show promise in generating electrical and thermal energy.

Taking into account that the technology needed for exploiting renewable energy resources is simple and relatively economical, it is important from a strategic point of view that energy planning in Third World countries, particularly in the humid tropics, be oriented to developing the solar alternative. It offers them one of the few opportunities to develop independently of the industrialized countries. To this end, energy planning also must encourage energy conservation and optimize the use of organic by-products and residues generated by economic and domestic activities.

The National Energy Balance Study (MINEMIN, 1979) established the principal premises for the supply of primary conventional energy resources from 1960 to 2000 in Peru (it did not consider the significant introduction of renewable and non-conventional energy sources):

- Peru possesses a great hydroelectric potential, estimated to be 48,000 technically-exploitable MW, only 3 percent of which are being used at present.

- Peru apparently has more than 48 million metric tons of coal reserves, even though no significant production occurred between 1967-1977.

- Known petroleum and natural gas reserves do not support the optimistic predictions that hydrocarbons will maintain their present importance as energy sources in the Peruvian economy (Table 15-1).

- As petroleum presently represents the only raw material for fuel and lubricants, it should be used to satisfy internal consumption, not exported.

- It has been estimated that a gap will appear between supply and demand for petroleum products after 1988-1989, when it will be necessary, to meet internal consumption needs, to import 30-38 million barrels in 1990, 55-60 million barrels in 1995, and 100-105 million barrels in 2000.

- Firewood and plant residues will continue to be the principal combustible energy sources for most of the rural population.

- Considering the projections for electricity supply and demand (an increase from 484 KWH/inhab. in 1975 to 1,000 KWH/inhab. in the year 2000), it will be necessary to increase existing production capacity by 800 MW between 1980-1985,560 MW between 1985-1990, and 2,300 MW between 1990 and 2000.

Table 15-1
NATURAL GAS AND PETROLEUM PRODUCTION IN PERU

Years	Natural Gas Millions in ms/year	Petroleum Millions of Barrels/year
1976	2,028	28
1980	1,294	78-80
1985	1,034	75-76
1990	693	40-41
2000	386	3

When these premises are applied to the Central Selva, the following observations can be made:

- 88.5 percent of potential hydroenergy is found in the Amazon watershed, particularly in the Central Selva.

- The large hydroelectric plants that Peru will need to construct to satisfy projected demand will principally be located on the Atlantic slope. This will enable the Central Selva to export electricity to coastal metropolitan areas, but will not be accessible to large numbers of colonists in the region.

- The Central Selva has natural gas deposits (14,073,000,000 m^3 in Aquaytia) but no proven coal reserves.

- Transporting coal to the area is likely to be expensive.

- While new major petroleum reserves have been detected in the last two years, they are not sufficiently significant to alter the conclusions of the National Energy Balance. Consequently, development planners in the Central Selva will confront serious problems in supplying hydrocarbons.

The major energy resources in the Central Selva are water and biomass which are renewable and do not generally require sophisticated technology. Furthermore, because it is near the equator, the Central Selva receives large amounts of solar radiation. The heat and radiation favor an intense evapotranspiration/precipitation cycle that generates the clouds which give the rain forest its name. This combination of rain, heat, and radiation, assures an unusual photosynthetic activity that potentially can generate large amounts of biomass. These conditions suggest that non-conventional energy sources such as waterfalls, the energy stored in green plants, organic residues, solar radiation, and wind can be viable alternatives to oil, gas or coal to satisfy rural demand for energy in the Central Selva, and, all are resources that can be exploited with presently available technologies, such as small hydroelectric plants.

Small hydroelectric plants

Although this technology is not new, its wide application to small waterfalls and other potential sites is new. It is best suited to high falls with low volume, such as occur in high valleys in the mountains and in the High Selva. Thus ELECTROPERU (1979) conservatively estimates that at least 1,000,000 KW could be generated in hydroelectric plants producing 100 to 1,000 KW. The investment needed to provide this electricity to 1,186 isolated locations in Peru is high - approximately US$1,500 per KW. The ELECTROPERU 1979-1985 Program of Investment for Small Hydroelectric Plants has considered the construction of 14 plants in the high and low forest regions, which would consume 25 percent of the total investment for small hydroelectric plants during this period (Table 15-2). These plants are classified by power and size of waterfall in Table 15-3.

Table 15-2
INVESTMENT PROGRAM IN SMALL HYDROELECTRIC 1979-1985 (Peruvian Selva)

Locality	Location	Power KW	Total Investments (US$ thousands)
Pedro Ruiz	Amazonas	230	-
Chincheros	Amazonas	60	-
Satipo	Junin	750	-
Mazamari	Junin	400	500
Pichanaki	Junin	500	400
Pozuzo	Pasco	110	300
Paucartambo	Cuzco	874	240
Quincemil	Cuzco	500	400
Lamas	San Martin	360	200
San Jose de Sisa	San Martin	257	200
Tabolosos	San Martin	400	300
Tres Unidos	San Martin	200	00
Luya	San Martin	-	250
Jumbiya	San Martin	-	200
		TOTAL	$3,190

Table 15-3
CLASSIFICATION OF SMALL HYDROELECTRIC PLANTS ACCORDING TO POWER AND FALLS

Plant Type	Power Range (KW)	Small Falls (KW)	Medium Falls (KW)	Large Falls (KW)
Microplants	5-50	1.5-15	15-50	50-150
Miniplants	50-500	2-20	20-100	100-250
Small Plants	500-5,000	3-30	30-120	120-400

Another advantage of using water resources in the higher areas of the Central Selva, is that hydraulic works can be made simple and large constructions, such as dams, are not usually required. When dams are necessary, they will affect less area than in lower zones because of the steepness of the terrain.

Another interesting possibility is the utilization of asynchronous generators (conventional motors operating as generators) for supplementing small hydroelectric plants when demand rises. These generators require lower initial costs and have technical operation advantages. In small hydroelectric plants in low areas, Kaplan turbines and Michel-Banki turbines with long wheels can be used to produce 100-2,000 KW of power.

Other hydroenergy possibilities include waterwheels, which, when electrical energy is not available, can feasibly and conveniently generate mechanical energy for such Central Selva industries as grain mills, carpentry shops, and sugar mills. Dams, which exploit the kinetic energy of water by raising small quantities of water to heights through the use of regulated pressure valves, can provide water for domestic uses and for agriculture in areas that are moderately higher than adjacent water courses. Such areas are often selected by isolated colonists as home sites in more humid regions.

Biomass energy

Many technological possibilities exist for exploiting the energy stored in green plants and organic wastes.

Direct Combustion

The combustion of firewood, forest residues, and other cellulose residues produced by urban and rural industry is the oldest process employed by man to provide energy for both domestic and industrial purposes (Table 15-4). Firewood and agriculture and livestock residues (husks and manure) contributed 33.8 percent of the primary energy consumed in Peru in 1976. This energy was not used commercially, but was almost entirely employed in domestic and cottage industries, where it would be more useful and efficient if first transformed to charcoal, a dry combustible material of higher calorific value (Table 15-5). As either wood or charcoal, it would be burned in the home in heat-efficient stoves which can be made in cottage industries or factory-made classic stoves of iron. Wood ovens can be used in small industries such as ceramics, brick-making, construction materials for bread making, smelting and others.

Table 15-4
NATIONAL ENERGY BALANCE AND PROJECTIONS TO THE YEAR 2000

Energy Source	1976	1990		2000	
	%	Autonomous Hypothesis[a]	Hypothesis II[b]	Autonomous Hypothesis[a]	Hypothesis II[b]
Hydroenergy	5.90	6.8	8.0	7.3	8.7
Natural Gas	5.50	4.6	4.5	4.6	4.5
Petroleum	54.40	63.0	53.1	67.1	55.0
Coal	0.46	1.9	6.8	2.0	7.7
Plant					
residues	4.20	2.8	2.4	2.4	2.0
Firewood	27.30	19.4	23.8	15.5	21.1
Manure	2.30	1.5	1.4	1.1	1.0

a. Autonomous Hypothesis: Maintenance of present tendencies.

b. Hypothesis II: 50% of energy transported to urban sites and demand of the transport sector over the total commercial energy demand limited to 25%.

Source: MINEMIM (1979).

Table 15-5
CALORIFIC POWER OF SELECTED COMBUSTIBLE SUBSTANCES

Combustible Substance	Calorific Power (Kcal/kg)
Paraffin	10,400
Diesel Petroleum	9,800
Charcoal	7,100
Dried Wood	4,700
Lignite	4,000
Wood (25-30% Moisture)	3,500

Source: CETEC, 1980.

Scientifically managed forest plantations can annually produce approximately 70 steres per hectare. At a thermal conversion efficiency of 70 percent, it can be deduced that one plantation hectare is the equivalent of $45x10^6$ Kcal/hectare/year, or 28 barrels of petroleum per year. If the 141,764 hectares suitable for forest exploitation in the Perene river valley were to produce firewood the energy produced annually would be equivalent to 4,000,000 barrels of petroleum (ONERN, 1967).

Presently, however, the wood industry in the Central Selva is oriented to harvesting natural stands of trees and using them in construction and in furniture and paper production. Most sawmill wastes (wood chips, sawdust, and unusable pieces of wood) are burned or dumped into rivers. Data from ONERN and from the Subdirectorate of Statistics (Ministry of Agriculture), show that a total of 857,413 m^3 of wood were cut in the Central Selva between 1974 and 1980, generating 257,224 m^3 of cellulose wastes (factor=0.30). In other words, the equivalent of 102,890 barrels of petroleum was lost.

Thermo-conversion Processes

The thermal division of the components of wood and cellulose biomass in different oxidation, temperature, pressure, and catalysis conditions gives rise to a series of thermal conversion processes. Wood is most commonly converted to charcoal, while producing a poor wood gas (gazogene gas), but it is also possible to make combustible solids, liquids, and gases with different characteristics and applications, using various production technologies, including the pyrolosis and wood gasification for production of methanol and ethanol.

Pyrolysis, or dry distillation of wood, is a process in which wood and woody substances are heated in the absence of air. The process becomes exothermic and successively liberates gases, water vapor, and organic liquids. Residues, such as charcoal and heavy tar oil, remain. All of the products of the process except the water are combustible.

The most simple pyrolysis produces only charcoal in batch furnaces constructed in cottage industries; neither liquids nor gases are recovered. Charcoal-makers along the north coast in Peru (Piura, Lambayeque) use another primitive technology, making charcoal from mesquite trees that are stacked and covered with mud in ovens used only for this purpose. However, in Brazil and in northern Argentina cylindrical ovens covered with a roof of bricks (*media naranja* ovens) can be used to obtain charcoal in the forest or to produce it in foundries for industrial and domestic uses.

Making charcoal in these batch furnaces consists of filling them with dried wood, then completely closing the doors except for an orifice in the upper part to allow ignition and a series of other orifices at ground level to permit air to enter. After ignition, air intake is controlled by closing the lateral openings so that combustion proceeds slowly, without enough air to burn the formed charcoal. One successful operation should produce some 40 kg of charcoal from 100 kg of dried wood. A *media naranja* oven produces 150 tons of charcoal a year, lasts five years, and costs US$800.

Other raw materials that can be pyrolyzed are the husks of coconuts and nuts, which, because of their high density and quantities of lignin, can produce high quality charcoal for foundries and other applications. Wood residues from sawmills and paper mills are still other potential raw materials.

Biomass gasification is a thermal process that transforms vegetal material (wood, charcoal, cellulose residues) into combustible gas containing carbon monoxide and hydrogen. The wood is burned in controlled conditions in oxygen and water vapor in a gasogene oven.

In practice, gasification is a continuation or natural complement of wood pyrolysis, but in gasification wood dries, becomes charcoal, and then gasifies in the same equipment, thus improving efficiency and reducing cost. For this reason, present-day research is investigating wood gasification as a replacement for coal.

The gas produced contains varied proportions of carbon monoxide, carbon dioxide, hydrogen, and methane, as well as several minor substances that vary according to the chemical composition of the wood or charcoal used and the gasification technology employed. The gas has basically two uses: as a substitute for petroleum in industry and in generating power; and as a component in the production of methanol and ammonia. Wood gasification in the Peruvian Central Selva is a promising alternative for small-scale thermal applications such as for vehicles, boilers and ovens.

Methanol and Ethanol are popular sources of alternative energy that may be synthesized from plant matter. Methanol (methyl alcohol or wood alcohol) is a chemical product now manufactured world-wide by processing natural gas. It is used principally as a raw material for the production of formaldehyde (40-50% of production), industrial solvents, dimethyl-sulfoxide (DMSO), and others. After the 1973 petroleum crisis, methanol began to be considered one of the more promising combustible alternatives to liquid fossil fuels, because it is easily synthesized from wood gas. Today, numerous investigations into methanol use are being carried out in developed countries.

Ethanol, also called ethyl alcohol or alcohol, is either synthesized from ethylene, or it is fermented from amylaceous and glucidic substances. The use of alcohol today has spread from the distillation of spirits to the chemical, pharmaceutical and cosmetic industries. Pure alcohol is produced throughout the world by fermenting molasses (made from sugar cane and sugar beets) with *Sachoromices cerevisae, a* yeast that segregates specific enzymes that break down hexose and other simple sugars. The resulting substance is then distilled, producing pure ethanol and a form of wine as a residue.

Ethanol is most commonly made from sugar cane, sucrose and glucose, but can also be made from manioc, wood, and other substances. Sugar cane needs only a physical treatment; manioc, on the other hand, requires a thermal and enzymatic treatment, while wood requires a thermoacid treatment and hydrolized neutralization.

Manioc alcohol has been investigated in several pilot programs in Brazil and industrial projects are now being developed. Its alcohol yield is compared with that of sugar cane in Table 15-6.

Table15-6
ETHANOL PRODUCTION FROM SUGAR CANE AND MANIOC

Raw Material	Agricultural Productivity ton/ha/year	Alcohol Yield 1/ton	Alcohol Production 1/ha/year
Sugar cane	57	70	3,990
Manioc	12.5	180	2,250

Source: Klinge (1980).

The Central Selva has several features, especially optimal climatic conditions, that favor producing alcohol from sugar cane and manioc. The region produces more manioc than it can use for food because of the difficulties of transporting it to processing centers. From a global point of view, therefore, producing combustible ethanol from saccharides and amylaceous products can be a viable alternative in solving the Central Selva's energy problems in the near future, even though it is currently unprofitable. This process can also generate by-products that can prove useful as food and as raw material in industry and agriculture. Such products include:

husks, which can be a useful raw material in the pulp, paper, and particleboard industry; a combustible solid for boilers; a cellulose substance that can produce alcohol through hydrolysis; and a nutritious food for animals;

non-hydrolizable residues, (from manioc or from amylaceous substances), which can be a nutritionally-balanced food and a raw material for producing biogas;

carbon dioxide, which can be used to produce solid carbon dioxide (dry ice) and unicellular protein (microalgae, filamentous fungi, etc.);

fuel oil, which can be used to make industrial solvents, aromatic esters, and various chemical products; and

wine. which can be used to recover and produce yeast, fertilize soil, make firm airstrips, and, as a liquid substrate, produce biogas.

The Anaerobic Fermentation Process

Research into anaerobic fermentation has achieved some spectacular results, and the process now appears to have several uses that can contribute to rural development: it can provide energy, boost agricultural productivity, and aid in environmental sanitation. The anaerobic fermentation process converts the complex organic material in agricultural, livestock, and human wastes into combustible gas with high methane content and leaves a highly nutritious and harmless by-product. The process is carried out in easily constructed and operated biogas digesters, which use all types of wastes as raw material, including agricultural wastes (straw, leaves); animal wastes (manure, rumenal fluids, viscera); urban organic wastes (garbage, sewage); and industrial organic wastes (from food, fish, fruit, and vegetable processing plants).

The process depends on various factors, such as pH (between 7.0 and 7.2), temperature (the mesophyllic range being 10°C-40°C and the thermophyllic range being 40°C-60°C), digester hermeticity (absence of O_2), and the carbon/nitrogen ratio of the raw material. Also important are operating parameters such as flow, percentage of solids, and processing time. In hot climates like the Central Selva, external heat sources are not required. Assuming an average biogas calorific power of 4,767 Kcal per m^3, Table 15-7 presents the biogas and energy production of different resources.

The presence of such resources as plant stems, leaves, wood residues, and wastes from coffee, manioc, banana, and aquatic plant production, combined with the optimal environmental conditions, can make biogas production a significant industry in the Peruvian forest region. Biogas can be an economical source of domestic and semi-industrial energy, useful for cooking food, lighting, warming chicks, refrigeration, and operating motors and pumps (Table 15-8).

Table 15-7
THE BIOGAS AND ENERGY PRODUCTION OF DIFFERENT RESOURCES

Raw Material	Yield of Wastes[a] of 1 Unit/kg/unit/year	Biogas Yield m^3/kg fresh	Biogas Yield m^3/unit/yr	Energy Kcal/unit/yr
Cattle manure	6,000	0.0372	223	1,164,000
Horse manure	5,000	0.0573	286	1,365,700
Swine manure	3,000	0.052	156	744,000
Sheep manure	800	0.152	121	580,000
Poultry manure	25	0.091	2.28	10,868
Human wastes	250	0.042	12	57,204
Corn residues	9,988	0.190	1,898	9,046,200
Rice residues	3,379	0.190	642	3,043,000

a. Animal or hectare unit.
Source: Verastegui and Matero (1979).

At present, ITINTEC, in an agreement with the Special Project for Madre de Dios, is constructing four demonstration digesters in Iberia, la Cachuela, Puerto Maldonado, and Fundo Ganadero Amazona. ITINTEC has also been investigating the agriculture and aquacultural uses of biofertilizer. Greatly increased yields of potatoes, lettuce, corn, onions, and other crops have been obtained by using fresh manure. The yields are as high as those obtained with chemical fertilizers. In no case were pathogenic parasites detected in the biofertilizer. Another interesting application of biofertilizer (the effluent of digesters) is its use as animal food. Excellent results have been obtained in Mexico feeding cattle with silage containing biofertilizer.

Plant Oils

For the last several years, efforts have been made to develop diesel fuel substitutes made from plant oils obtained from oleaginous seeds (sunflowers, cotton, peanuts, and others).

The Brazilian PROOLEO Program is considering increasing the production of colza, sunflower and almond oils to 1,000,000 liters for the short-term, and, at the same time, stimulating the planting and cultivation of oil palm (*Elaeis guineensis*) in order to significantly increase plant oil production by 1986-87.

Table 15-8
QUANTITIES OF BIOGAS REQUIRED FOR DIFFERENT USES

Use	Specification	Quantity m^3/h
Stove	2" Burner	0.33
	4" Burner	0.47
Gas Lamps	100 watt	0.13
	bulb	0.07
Gasoline Motor	Biogas/hp	0.45-0,51
Refrigerator	$Ft.^3$ capacity	0.034
Incubator	$Ft.^3$ capacity	0.013-0.017
Gasoline	By liter	1.33-1.87m^3
Boiled Water	One liter	0.11 m^3
Propane Gas	One 24 Ib. tank	22 m^3

In Peru the EMDEPALMA corporation is attempting to introduce, cultivate, and harvest oil palm to provide food in Tocache, San Martin Department. Over 5,000 hectares have been planted and a processing plant constructed that can extract the oil from 20 tons per hectare of fresh fruit. EMDEPALMA has found 210,000 hectares appropriate for this crop in the Manite river region.

Other Biomass Energy Applications

Latex from the caucho tree (*Hevea brasilensis*) is an oleo-resin that is a mixture of hydrocarbons of high molecular weight. At present, it cannot be used directly in internal combustion engines because of its high viscosity. Genetic engineering research, however, is attempting to modify the chemical and physical characteristics of the latex so that it can ultimately be substituted for gasoline.

Solar energy

The Peruvian Central Selva and the Amazonian humid tropics in general receive high amounts of solar radiation. There are so many trees hiding the sun, however, that it was once thought too difficult to directly exploit solar energy. Today, however, it is understood that such endeavors could enhance integrated development in Central Selva.

Solar energy can be used in low potency thermal generation. For example:

Heating of water is necessary for industrial and cottage industry requirements, such as making cheese and preserves. Flat collector technology is widely known, with many brands existing in the national marketplace. One of these is made in Peru, licensed by ITINTEC which has been conducting research in this field since 1975.

Solar dehydration of agricultural products is the most promising solar energy option for the Central Selva, considering the enormous difficulties that confront small farmers when preparing such products as rice, bananas, and manioc for the market. A program to distribute appropriate solar dehydration techniques to farmers can use equipment that optimizes the use of transparent plastic in place of glass and that also dries products (rice) by creating forced air convection that is heated by solar radiation of the product stored in vertical silos. Industrial concerns in Brazil can provide and install such operations. *Solar heating,* on the other hand, is not practical in households, but can be used for some production and livestock purposes.

Potent thermal generation also is possible using solar energy. Techniques exist to focus solar radiation on a single point, which can transform the latent heat of liquid vaporization into closed primary circuits. The absorbed heat is transferred to secondary circuits in series with mechanical works (turbines), eventually generating electric energy (helioelectric plants). At present, these techniques are in the experimental phase and are not yet competitive because of the very high cost of their sophisticated mirror systems that move synchronously by computer to derive maximum benefit from solar energy.

Photovoltaic generation is a technology that directly converts solar energy to electric energy through the use of cells with monosilica and polycrystalline surfaces that act as semi-conductors. It can probably supply the limited energy demands of remote and rural areas in the near future. The technological advances appearing day after day in developed countries have reduced the cost of energy produced by photovoltaic panels by five times since 1976; therefore, production has increased, the products are of better quality, and their manufacture is now automated and uses less expensive materials. Photovoltaic generation has its place in the integrated development of the Central Selva, particularly in providing energy for telecommunications and television and for water pumps and electrical service to homes in remote areas.

Wind energy

There is little potential for wind energy in Peru. Although no map exists that illustrates wind patterns in the Peruvian forest, recent reconnaissance of the High Selva in San Martin, Pucallpa, and Satipo did not detect winds with energy-producing potential. Nevertheless, before discarding this option, and taking into account its unpredictability, wind velocity should be evaluated where wind is being considered a potential energy-producer.

Wind's application for mechanical (mills) or electrical (aerogenerators) purposes would depend on the presence of continual wind; the demand (water to be pumped or KW required); the design and dimensions of the equipment and; whether equipment is produced nationally or locally.

Table 15-9 summarizes non-conventional energy alternatives.

Conflicts and interactions between alternative energy use and other sectors

Conflicts and Interactions with the Livestock Sector

The livestock sector can only benefit from biogas techniques which, among other things, use animal wastes. Because Central Selva soils are poor in phosphorus, phosphate needs to be imported and applied for good grass growth. One way to provide phosphates is to use the livestock manure that now is dumped into water courses and lost.

Table 15-9
SUMMARY OF NON-CONVENTIONAL ENERGY ALTERNATIVES

Technology	Process	Raw Material	Product	By-Product	State of the Art	Applications	Applicability in the Central Selva
1. Hydroenergy	P.G.H.	Water Courses and Waterfalls	Electricity	-	Commercial	Rural Electrification	The majority of its present and future populations
	Waterwheels	Water Courses and Waterfalls	Mechanical Energy	-	Commercial	Cottage and small industry	Sawmills, carpentry shops, grain mills, sugar mills, etc.

	Hydraulic Rams	Water Courses	Mechanical Energy		Commercial	Pumping of water for domestic and other purposes	Homes and isolated lodging establishments on slopes near rivers
2. Biomass	Direct Combustion	Wood and wood residues	Heat, steam mechanical	Smoke, ash	Commercial	Domestic, rural and industrial	Cooking food, dehydrating agricultural products, ceramic and brick-making ovens, industrial production of paper, operating sawmills, etc.
	Thermo-conversion	Wood, cellulos residues	Charcoal, metallurgical coke	(Phenols) Tar. Methanol acetic acid	Commercial	Domestic, rural metallurgical, industrial	Id., also in steel-making and generating electricity
			Wood gas	Ash. CO_2	Commercial and experimental	Rural and Industrial	Ovens, boilers, and industrial engines, generating electricity
			Methanol	Ash, CO_2	Experimental	Industry and Transport	Chemical industry, vehicles
	Alcohol Fermentation	Sugar cane, manioc, wood, etc.	Ethanol lignin	CO_2, pulp, wine, fusel oil neutralized acid acid	Commercial and experimental (wood ethanol)	Transport, metallurgy, and industry	Gasoline-powered vehicles, foundries, chemical industry
Biomass	Anaerobic Fermentation	Organic, animal and plant waste	Biogas (methane)	Fertilizer, Environmental Sanitation	Commercial and small scale	Energy for domestic, rural and industrial (experimental) use	Cooking food, heating, lighting refrigeration, internal combustion engines, turbine/operation
Solar	Low-level Thermal	Solar Radiation	Heat applied to air and water	Reduction of accessible land	Commercial and experimental	- Dehydrating agricultural products - Heat for chicks	Drying rice, etc.
	High-level thermal production	Solar Radiation	Concentrated heat that generates steam and electricity	Reduction of accessible land	Experimental	Pumps, industrial ovens, electricity	None for the short and medium term
	Photovoltaic	Solar Radiation	Continous electrical current	.ID	Experimental, nearly commercial	- Domestic - Pumping - Telecommunications in remote localities	Wide applicability in colonies, if affordable equipment is available
Wind	Wind-driven	Wind	Mechanical energy	-	Commercial	Water pumping Grain mills, etc.	Little, because of scarcity of wind

	Aero-generators	Wind	Continuous electricity		Commercial (low power) and experimental (high power)	Continuous electricity for domestic use	Little, because of scarcity of wind

Biogas can replace kerosene and propane gas in refrigeration and in providing heat for chicken and swine breeding operations (the largest farm in the Central Selva is presently using this technology). It can provide heat and electricity to the human settlements associated with livestock operations. Biofertilizer can also be partially recycled in the animals' diets through the use of digesters.

Animal manure used in aquaculture should be pre-treated aerobically, as this improves its quality as food and reduces contamination risks. This technique is widely utilized in China in carp and tilapia pisciculture.

Conflicts and Interactions with the Use of Forest Resources

Forest operations actually complement biomass energy production. Both the wood remaining in the countryside and the residues of forest production can be used much more efficiently than they are today.

The Central Selva region accounts for 19 percent (132,000 m^3) of national wood production. In a recent survey it contained 116 sawmills, 22 parquet factories, three wood veneer factories, 40 factories that produced cartons, and one that made paper. Wood residues that could produce biomass energy are found at these industries, but today 50 percent of the wood sent through these sawmills is lost and represents a substantial loss of energy and money. Residues are burned, dumped into rivers, or, as at the Pucallpa factory, burned in special ovens which do not exploit the heat produced. The energy producers and the forestry sector need to find ways to work together to achieve the important goal of efficient energy use.

Conflicts with and Complements to Agriculture

Agricultural residues are excellent for use in anaerobic fermentation, which complements biogas production as it returns the necessary nutrients to the land. In addition, the use of manioc surpluses and the production of hydrocarbon-containing ethanol can help stabilize farmers' prices. Although oleaginous seeds can be used both as food and diesel substitute fuel, food production takes precedence.

Conflicts with and Complements to Conservation

Large scale biogas production requires the introduction of exotic tree species (or monocultures of high-yield species), which can profoundly modify local ecosystems. These plantations can affect, in unpredictable ways, some economically-important pursuits, as well as such native subsistence activities as hunting and fishing. If acid hydrolysis of wood is used to produce ethanol, the acid remaining at the end of the process has to be neutralized, even though it is tempting to use low-yield sugar fields to dispose of these acids without first neutralizing them. This, however, can so seriously injure aquatic and plant life at the dumping sites that all life can disappear from the rivers, as actually happened when acid metallurgical wastes were dumped into the Mantaro river.

Pyrolysis operations in which the acids are not recovered can also significantly pollute the atmosphere with escaping tar, methanol, acetic acid, and other vapors. Pyrolysis by-product and effluent disposal needs to be regulated and vapor-condensing units should be used.

Small-scale conflicts are easy to find where biogas operations are not properly managed. If the user does not allow time for anaerobic degradation (because of climatic and operating conditions), the effluent applied as fertilizer can contain pathogenic parasites, especially if the effluent contains human excrement.

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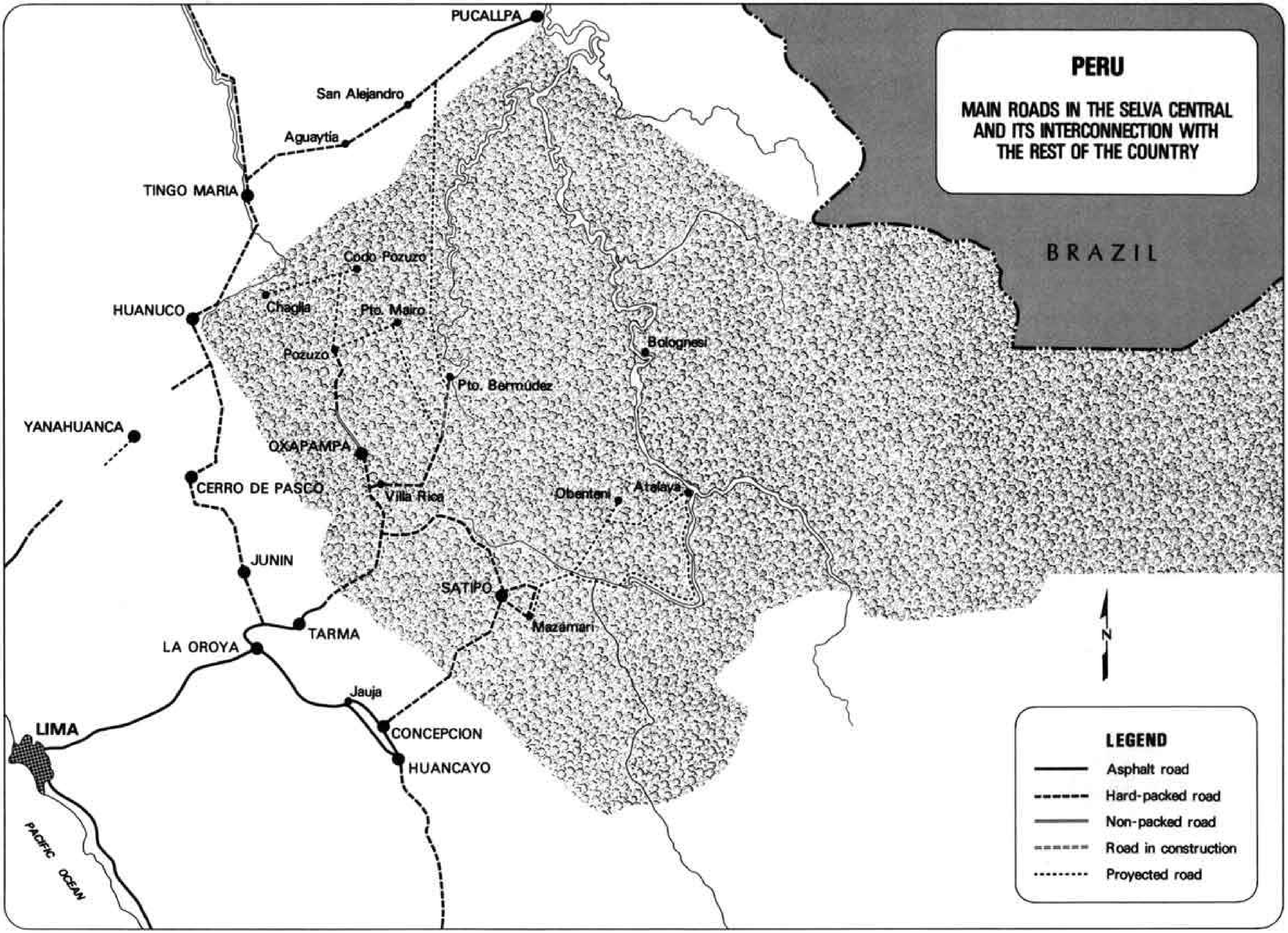

PERU
MAIN ROADS IN THE SELVA CENTRAL AND ITS INTERCONNECTION WITH THE REST OF THE COUNTRY
BRAZIL
PUCALLPA
San Alejandro
Aguaytia
TINGO MARIA
Codo Pozuzo
Chaglia
Pto. Mairo
HUANUCO
Pozuzo
Pto. Bermudez
Bolognesi
YANAHUANCA
OXAPAMPA
CERRO DE PASCO
Villa Rica
Obentani
Atalaya
JUNIN
SATIPO
Mazamari
TARMA
LA OROYA
Jauja
LIMA
CONCEPCION
HUANCAYO
PACIFIC OCEAN
N
LEGEND
Asphalt road
Hard-packed road
Non-packed road
Road in construction
Proyected road

Chapter 16 - Guidelines, recommendations and observations

Introduction

The development planning process designs strategies and activities to use, enhance or conserve both natural and economic goods and services. In big modern cities, economic goods and services almost completely replace the natural ones. On the other hand, in frontier areas like the Central Selva, natural goods and services play a relatively greater role. Shifts towards economic goods and services are the result of increased human activity designed to improve human quality of life. For example, development activities in "new areas" of the humid tropics are aimed at establishing farms and forest industries; building homes for greater numbers of people; growing food for expanding urban populations; promoting national defense and territorial sovereignty; and utilizing idle resources. Meeting these goals requires more economic goods and services.

In a simplified model of the process by which a nation seeks to fulfill these objectives, it first identifies "empty" territory within its humid tropics that has underutilized resources. It wishes to develop these resources to contribute to the socioeconomic well-being of the people who live in the area as well as those who will migrate there, and to benefit the nation as a whole. The government of that country then formulates national policies that guide migration, expenditure of funds and the use of technology. These policies may be adjusted by the support or opposition of international development assistance agencies (World Bank 1986).

Unfortunately, development efforts frequently fail due to such obstacles as inadequate support by centralized agencies and local institutions, poorly defined land tenure systems, lack of coordination among development sectors, and scarce information on the structure and function of social and natural systems. As the previous chapters often suggest, these same conditions are involved in creating the conflicts that have come to be known as "negative environmental impacts."

A more comprehensive model of the process identifies additional conditions and events that must be considered in the design and execution of development projects and programs. Chief among these are that, though sparsely settled, the humid tropics are seldom "empty"; that justifiable development activities allow uncontrolled access by farming and grazing practices not entirely appropriate over extensive areas; that the "richness" of tropical forests is one of the characteristics making tropical forest management so difficult; that *any* development activity will change ecosystem structure and function; and, that the appropriation of goods and services for the good of a society will create conflict within that same society. This chapter will make extensive comments on this model in the form of observations, guidelines, and recommendations that will help development planners in the humid tropics to overcome these and other problems.

Ecosystem structure and function

Chapter 2 of this report described the process by which competition for the goods and services of an ecosystem can lead to conflict. This first set of guidelines attempts to show how to resolve many of these conflicts in the planning process, before they threaten the project's success.

1. *Develop a regional conceptual model.* Despite the scarcity of data about the humid tropics, an awareness of ecosystem structure and function during planning is possible. Seeing the region as an integrated whole is vitally important, and this requires a team who understands systems in general, who thinks in terms of relationships, and who can synthesize information from different disciplines (Moiling, 1978). Conceptual modeling of a region is a useful method in that it forces integrated thinking, and the process itself is as important as the final product. Using the method presented in Appendix A, a Preliminary National System Model of Peru (Figure 16-1) and a Regional System Model of the Central Selva (Figure 16-2) were developed so that anyone fully participating in the process can understand in some detail the major components and interactions.

2. *Inventory goods and services.* Classical natural resource inventory methods will continue to be used in development planning. In addition to these, there are additional methods that are more specific in the evaluation of what human beings may take and use from ecosystems. Table 16-1 is an extensive list of the goods and services that can be provided by the natural structure and function of ecosystems. Each planning effort must develop its own list, however, based on interviews with the people who live in, use, or have an interest in the ecosystem(s) under study. Planners should also recognize that exploitation of any good or service, however small or seemingly insignificant, proves that something there is of value to someone, to be used, enhanced, or protected. Tables 16-2 and 16-3 indicate the goods and services of humid tropical ecosystems which may need protection in order to be used.

3. *Inventory natural hazards.* The same characteristics of ecosystem structure and function which give rise to water, food, minerals and energy also create earthquakes, high winds, intense rain, flooding, erosion, and poisonous plants and animals (Table 16-4). Since hazardous natural phenomena restrict the development of human activity, the planning team must identify and describe them, and predict how they might threaten the project at hand.

FIGURE 16-1 - PRELIMINARY NATIONAL SYSTEMS MODEL OF PERU

FIGURE 16-2 - PRELIMINARY CENTRAL SELVA REGIONAL SYSTEMS MODEL

Table 16-1
NATURAL GOODS (RESOURCES) AND SERVICES

I. Goods/Products (Resources)
1. Surface and ground water for drinking
2. Surface and ground water for industry
3. Surface and ground water for irrigation
4. Biomass for lumber
5. Biomass for firewood
6. Biomass for construction materials (posts, vigas, etc.)
7. Ornamental plants (indoor, landscaping, dry)
8. Vegetable fibers
9. Medicinal plants
10. Food for human consumption (fruits, chicle, honey, sap, shoots, etc.)
11. Plant chemical substance (dyes, stains, waxes, latex, gums, tannings, syrups, drugs, etc.)
12. Fish for human food (crustacians, finfish, mollusks)
13. Fertilizer (guano, other dung, fish meal)
14. Aquatic plants for human food (algas)
15. Aquatic precious/semiprecious materials (pearl, coral, conchas, mother of pearl)
16. Materials for artisan work (rock, wood for carving, fibers for basketmaking, etc.)
17. Metallic minerals (bauxite, ores, nuggets, etc.)
18. Non metallic minerals
19. Construction materials (sands, clay, cinders, cement, gravel, rocks, marble)
20. Food materials (salt)
21. Mineral nutrients (phosphorus)
22. Material for mineral dyes, glazes
23. Hides, leather, skins
24. Other animal materials (bones, feathers, tusks, teeth, claws, butterflies)
25. Other vegetation materials (seeds, pods)

26. Live fish (ornamental, aquaria)	
27. Live animals for pets, zoos	
28. Live animals for research (medical, other)	
29. Fossil fuels (oil, gas, coal)	
30. Other fuels (peat, other organic matter dung - biomass)	
31. Livestock forage	
32. Food for livestock (fish meal)	
33. Pulpwood	
II. Ecosystem Maintenance Services	
1. Nutrient cycling	
2. Nutrient storage	
3. Nutrient distribution	
4. Photosynthesis-Respiration (biomass-succession)	
5. Population control (predator/prey)	
6. Flooding	
7. Sediment transport	
8. Habitat for local finfish	
	- feeding
	- breeding
	- nursery
	- resting (refuge)
9. Habitat for migrating finfish	
	- feeding (including transient food source)
	- breeding
	- nursery
	- resting (refuge)
	- migration route
10. Habitat for Crustacea	
	- feeding
	- breeding
	- nursery
	- resting (refuge)
	- migration route
11. Habitat for mollusks	
	- feeding (including transient food source)

		- breeding
	12. Buffering	
III. Non-tangible Goods and Services		
	1. Windbrake	
	2. Shade	
	3. Recreation use of water (swimming, boating, waterskiing, sailing)	
	4. Zones for scenic tourism	
	5. Zones for recreation tourism	
	6. Zones for scientific tourism	
	7. Scientific values	
	8. Spiritual values	
	9. Historical values	
	10. Cultural values	
	11. Sport hunting and fishing	
	12. Early warning system	
	13. Moisture modification (humidity)	
	14. Temperature modification	
	15. U.V. filtration	
	16. Endangered species (fauna)	
	17. Endangered species (flora)	
	18. Gene resource (fauna)	
	19. Gene resource (flora)	
IV. Economic Services		
	1. Hydroelectric power source	
	2. Other energy sources (wind, sun, tides)	
	3. Dilution of contaminants	
	4. Decomposition of contaminants	
	5. Oxidation of contaminants	
	6. Transportation of contaminants	
	7. Airshed (dilution of air contaminants)	
	8. Erosion control	
	9. Sediment control	
	10. Flood control	
	11. Groundwater recharge	
	12. Space for urban, industrial, agriculture, occupation, roadways, canals, airports, waste storage	

13. Physical support for plants
14. Pollination

Table 16-2
NATURAL GOODS PRODUCED BY PROTECTED AREAS IN THE AMERICAN HUMID TROPICS[a and b]

Goods	National Parks (I-II)	National Reserves (VIII)	National Sanctuaries (III-IV)	Historic Sanctuaries (V)	Protective Forest (VI)	Wildlife Areas (VIII)	Reserved Zones (VI)	Native Reserves (VII)
Water	VI	VI	S	NS	VI	S	VI	NS
Genetic bank (Flora)	VI	I	I	NS	I	S	VI	NS
Genetic bank (Fauna)	VI	I	I	NS	I	I	VI	NS
Goods from fauna		VI			I	VI		VI
Goods from fishing		I			S	NS		VI
Non-lumber vegetative goods					VI			
Lumber vegetative goods					S			S

a. *The Roman numbers* (*I-VIII*) *indicate management categories adapted by IUCN* (*1978*).
b. *VI: Very Important: I: Important: S: Significant: NS: Not Significant.*

Conflict identification

Conflicts arise during the development process either from open competition for goods and services or as a result of human activities which change the quality and quantity mix of available goods and services. There are several ways that such potential conflicts can be identified during planning.

1. *Use an environmental management advisor*. The environmental management advisor undertakes studies and evaluations that help coordinate the planning process, and which help identify significant interrelations within the region being planned.

2. *Coordinate to reduce potential conflicts.* If formulation of sectoral projects is well coordinated with other sectors, many potential conflicts will never occur. Coordination will, of course, require that all planners and other team members work together to allow an exchange of ideas and to insure that consultants are aware that the work of sectors other than their own may be relevant to the success of the

project.

3. *Review the conceptual model.* Since conflicts arise between two or more sectors only if development activities are somehow related, review of the conceptual model described above is helpful. If done with the help of all relevant sectors, lines of complicated interactions will emerge. The exercise enables representatives of the many disciplines and sectors to understand where their work fits in the overall scheme; it enables team members to identify information gaps and promising areas of study; it enables team members to foresee the ramifications of each activity and, because of this, to identify potential conflicts early in the planning process.

4. *Analyze natural and economic goods and services.* A third method is to list the goods and services in the subsystems of the region being studied (Table 16-1) so that each of the goods and services can then be assigned to individual sectors.[1] Since any component of a system is linked to others in that system, use, enhancement, or conservation of the component will influence the availability and/or quality of other goods and services. Once sectors that are interested in the same good or service from the same or linked subsystems are identified, potential conflicts are also known.

> [1]. For more information on this method see Case Study number IV of "Integrated Regional Development Planning: Guidelines and Case Studies from An OAS Experience". 1984. General Secretariat of the Organization of American States. Washington, D.C.

A general example can be seen from Table 16-5 where ecosystem "a" has land for locating industry, agriculture, and livestock production, as well as for wildlife habitat. It would be difficult, if not impossible, to undertake activities which would meet all four of these objectives on the same piece of land at the same time. Consequently any project using "land" would be in conflict with the other projects. Likewise, subsystem "b" has groundwater that can be used for irrigation and domestic consumption. In this case, both uses are possible depending on the quantity of groundwater actually available and the demand of each sector. Subsystem "b" has also land for industry. However, since both land and groundwater are in the same subsystem, the groundwater may be contaminated by industrial wastes, and made unfit for domestic use. On the other hand, use of groundwater for domestic purposes will require either that the industry be sited somewhere else or, that it incorporate additional technology to avoid groundwater contamination. Here conflicts have been identified and a decision in favor of either side will negatively affect the other party.

Table 16-3
NATURAL SERVICES PRODUCED BY PROTECTED AREAS IN THE AMERICAN HUMID TROPICS[a]

Services[b]	National Parks (I, II)	National Reserves (VII) (VIII)	National Sanctuaries (II, IV)	Historic Sanctuaries (V)	Protection Forests (VI)	Wildlife Refuge (VIII)	Reserved Areas (VI)	Common Reserves (VII)
Recycling of Atmospheric Contaminants	VI	VI	S	NS	VI	I	I	NS

Maintenance of the Local Precipitation Regime	VI	VI	NS	NS	VI	S	I	NS
Buffering of Local Climate	VI	VI	NS	NS	VI	S	I	NS
Regulations of the Water Regime	VI	VI	NS	NS	VI	S	I	NS
Maintenance of Supply of Quality Water	VI	VI	NS	NS	VI	S	I	S
Soil Conservation	VI	I	NS	NS	VI	S	I	S
Protection from Landslides, Floods and Other Hazards	VI	I	NS	NS	VI	S	I	S
Maintenance of Genetic Diversity	VI	I	VI	NS	I	S	I	NS
Maintenance of Natural Diversity	VI	I	VI	NS	I	S	I	NS
Reservoir for Species which Offer Biological Control of Plagues	VI	I	I	NS	I	I	I	S
Reserve for Species of Interest to Science	VI	I	VI	NS	I	I	I	NS
Reserve for Species of Interest for Domestication	VI	VI	S	NS	I	I	I	NS

Genetic Bank for Future Improvement of Domesticated Species	VI	VI	S	NS	I	I	I	NS
Scenic Beauty	VI	S	I	S	I	S	I	NS
Area for Hunting	-	VI	-	-	VI	VI	-	VI
Area for Fishing	-	VI	-	-	I	VI	-	VI
Area for other Recreation	VI	I	S	I	VI	I	S	S
Area for Tourism	VI	S	I	I	S	I	S	NS
Conservation of Natural and Historic Scenery	I	NS	-	VI	NS	-	-	-
Conservation of Cultural Patrimony	I	S	VI	S	S	S	S	-

a. *The Roman numerals* (*I-VIII*) *indicate equivalent management categories adopted for IUCN* (*1978*).

b. *VI: Very Important, I: Important, S: Significant, NS: Not Significant, -: Not Applicable.*

Table 16-4
NATURAL HAZARDOUS PHENOMENA

1. Diseases and plagues (virus, bacteria, flukes, parasites, fungi, etc.)
2. Natural flooding
3. Avalanches (land, snow, ice), land slips, mudflows, etc.
4. Wind (tornados, hurricanes, cyclones, dust storms)
5. Natural erosion/sedimentation
6. Temperature extremes (duration, intensity)
7. Extremes of humidity (duration, intensity)
8. Drought
9. Snow
10. Ice
11. Hail
12. Fog, mist
13. Frost
14. Solar radiation

15. Lightning
16. Fire
17. Toxic chemicals, gas concentration
18. Nuclear radiation
19. Earthquakes
20. Noxious vegetation (poisonous plants, "invader" species)
21. Poisonous animals (snakes, insects)
22. Predators
23. Volcanos
24. Tidal waves

Table 16-5
EXAMPLES OF NATURAL GOODS AND SERVICES PROVIDED BY TWO HYPOTHETIC ECOSYSTEMS AND THEIR USE IN CONFLICT IDENTIFICATION

	Ecosystem	
	a	**b**
Land for Agriculture	X	
Land for Industry	X	X
Land for Grazing	X	
Wildlife Habitat	X	
Underground Water for Irrigation		X
Underground Water for Domestic Use		X

5. *Use an activity matrix.* An activity matrix requires a fairly complete understanding of the different sectoral activities as well as in-depth discussions between representatives of the sectors or interests involved (there may be more than two). In the example given in Table 16-6, the activities underway or being proposed are:

a. *Rice culture,* including land transformation and preparation; seeding, cultivating and pest control; irrigation and drainage including the construction of canals, dikes and ditches; harvest and marketing.

b. *Vegetable culture*, including land transformation, planting, cultivating, pest control, irrigation and drainage; harvest and marketing.

c. *Livestock production,* including transformation of new land and replacement of other uses by livestock production for beef and dairy cattle, swine and poultry.

d. *Forestry,* includes the cutting and removal of trees as well as the building of access roads and trails for these purposes. In this case, it does not include any silvicultural treatment or management.

The matrix is shown on Table 16-6 where the cells are numbered to indicate the conflicts discussed below. The conflicts that can be identified on the basis of this matrix are between:

(1) *Rice culture and rice culture.* The expansion of irrigated rice area will create additional

competition for available irrigation water; rice growing will bring with it the problems of any monoculture; and long-term rice culture on the same land can compact soils - especially if heavy machinery is used.

(2) *Rice culture and vegetable culture.* The aerial spraying of pesticides in rice production may contaminate vegetable crops or reduce vegetable production if the wrong herbicides are used.

(3) *Rice culture and livestock production.* Competition for the same land.

(4) *Rice culture and forestry*. Competition for the same land. Land clearing by fire may burn nearby forests.

(5) *Vegetable culture and rice culture.* If vegetables are not to be killed or contaminated by the pesticides used in rice culture, changes in the timing of spraying, method of spraying, kind of pesticide, etc. would have to be instituted.

(6) *Horticulture and forestry*. See number 4.

(7) *Livestock production and rice culture.* Competition for the same land. If grazing does occur on rice fields, compaction of soils may occur and canal borders and dikes may be broken down.

(8) *Livestock production and forestry*. See number 4.

(9) *Forestry and rice culture.* Competition for the same land. Forests serve as refuge areas for noxious fauna.

(10) *Forestry and horticulture.* See number 9.

(11) *Forestry and livestock production.* See number 9.

(12) *Forestry and forestry*. Forest exploitation without management destroys the possibilities of sustained yield forestry. The creation of access allows migrants to enter and utilize the forest ecosystem in ways that are not compatible with sustained yield forestry.

Table 16-6
INTERSECTORAL MATRIX IDENTIFYING POTENTIAL CONFLICTS BETWEEN SECTORAL ACTIVITIES

	Rice Cultivation	**Vegetable Cultivation**	**Livestock Production**	**Forestry**
Rice Cultivation	1	2	3	4
Vegetable Cultivation	5			6
Livestock Production	7			8
Forestry	9	10	11	12

A number of actual and potential conflicts in the Central Selva can be identified based on this concept (some of these have been examined throughout this report). For example, Table 16-7 indicates conflicts generated between the creation of protected areas and the activities of other sectors. Figure 16-3 identifies conflicts between the fisheries sector and the others, while Figure 16-4 presents those that occur between the other sectors and wildlife.

Table 16-7
PRINCIPAL CONFLICTS BETWEEN THE PROTECTION OF AREAS[a] AND OTHER DEVELOPMENT ACTIVITIES IN THE AMERICAN HUMID TROPICS

Conflicts[b]	National Parks (I, II)	National Reserves (VII)	National Sanctuaries (II, IV)	Historic Sanctuaries (V)	Protection Forests (VI)	Wildlife Refuge (VIII)	Reserved Areas (VI)	Common Reserves (VII)
Restriction of Agricultural Expansion	VI	VI	SN	NS	NS	S	VI	NS
Restriction of Forest Exploitation	VI	VI	NS	NS	NS	S	VI	NS
Hunting Restrictions	VI	-	I	NS	-	-	VI	-
Fishing Restrictions	S	-	NS	-	-	-	I	-
Restrictions on Energy Use and Transmission	VI	I	VI	VI	I	S	VI	S
Restrictions on Mining	VI	I	VI	VI	I	S	VI	S
Restrictions on Petroleum Development	VI	I	VI	VI	NS	S	VI	S
Reservoir for Agriculture, Forest and Range Pests	VI	VI	S	NS	VI	S	VI	NS
Reservoir for Diseases of Livestock and Humans	VI	VI	S	NS	VI	I	VI	S

Refuge for Species that are Dangerous for Humans and Livestock	VI	VI	NS	NS	VI	VI	VI	NS
Restriction of Urban Expansion	VI	VI	VI	VI	S	S	VI	S
Restrictions on Road Development	I	S	VI	VI	-	I	I	I
Restrictions on Certain Kinds of Tourist Development	VI	I	VI	VI	-	I	VI	-
Restrictions on Use of Certain Technologies Outside of the Protected Area	I	S	VI	I	S	I	I	S

a. *The Roman numerals* (*I-VIII*) *indicate the management categories adopted by IUCN* (*1978*).
b. *VI: Very Important; I: Important: S: Significant: NS: Non Significant; -: Not Applicable.*

Figure 16-3 - PRINCIPAL CONFLICTS BETWEEN ACTIVITIES OF THE FISHERIES SECTOR AND THE ACTIVITIES OF OTHER SECTORS

Figure 16-4 - PRINCIPAL CONFLICTS BETWEEN WILDLIFE AND ACTIVITIES TO USE OTHER RESOURCES

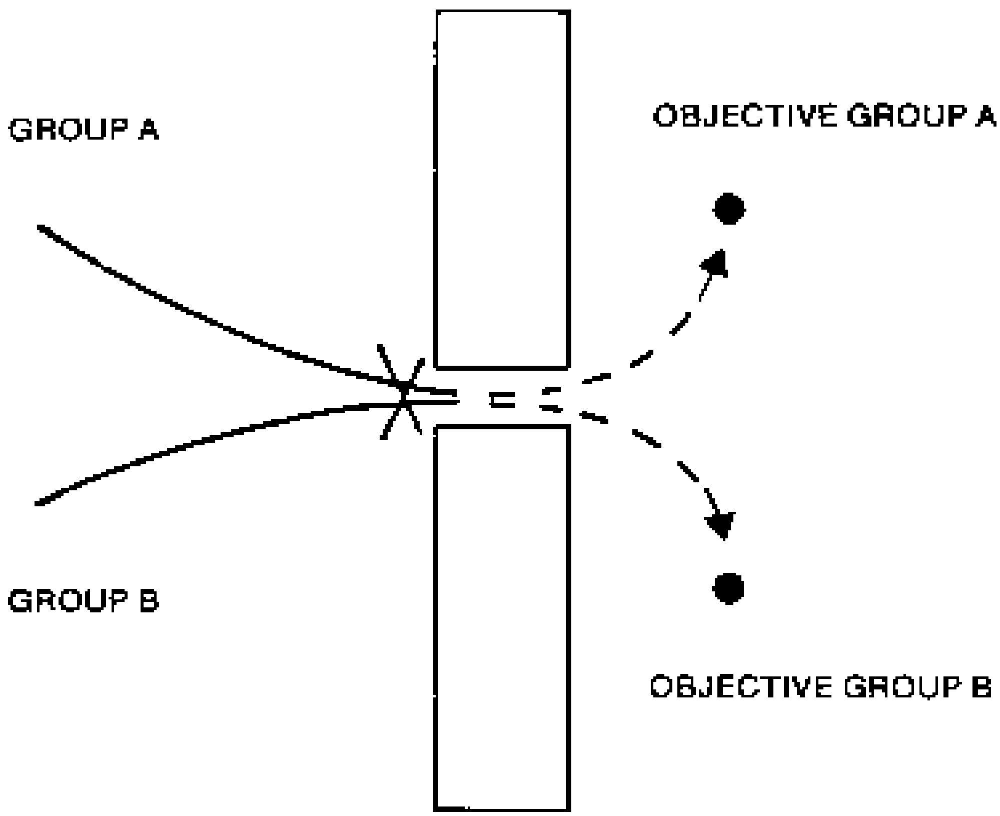
6. *Distinguish between real and apparent conflicts.* Some "conflicts" arise because objectives and methods are not clear to one or both of the parties. Their resolution is easiest if information is shared and if issues are clarified. Other conflicts easily resolved are those where the parties encounter a common problem as they attempt to reach different compatible objectives, as illustrated in Figure 16-5. A third kind of conflict is "conflict of interest" where the objectives and the means to meet them are opposed. Here the techniques of third party arbitration are the most valuable.

And, to show that not all relationships are conflictive, Figure 16-6 identifies relationships between aquatic life and aquaculture on one hand and other development activities on the other, which are supportive, rather than conflictive.

Colonization: Pressures and problems

The mere existence of sparsely occupied territories in humid tropical areas of a country is not sufficient to create pressures for their further development: Suriname's small population is concentrated almost totally along the coast for example, and is not in need of more space. Rather pressures to "develop and modernize" arise in countries with high unemployment, large economically marginal populations, unbalanced land tenure, and failing agriculture programs, combined with a need to secure national borders. Guidelines which respond to these pressures are required if progress is to be made.

Figure 16-5 - EXAMPLE OF A "COMMON PROBLEM" CONFLICT



Several things can be done to insure successful colonization.

1. *Review and adjust policies at the national level to assure that colonists represent cohesive groups who want to migrate.* Pressures that make life difficult in new colonies are great enough without having to deal with confrontations resulting from dissimilar beliefs, different economic status within the groups, and the need to search for, and approve of, new leadership.

2. *Recruit and select migrants from areas having climatic, edaphic, and topographic conditions similar to those of their final destination.* New efforts at development in the humid tropics often run into problems with colonization. The ingredients for a successful colonization project include a group of people who form a tightly knit social unit, who are experienced in living and working in ecosystems similar to those of the new colony, and who have a strong desire to relocate. Data also suggest that the most successful colonies consist of people who have no options: they can neither return to where they came from nor move on to another area (Nelson, 1973; Bridger, 1980).

3. *Institutionalize policies that give the sectoral agencies most closely allied to the colonization effort the resources they need to carry through the new plans.* Continue this technical and political support until the colony can manage on its own.

There are two major advantages to this model. Overall coordination is assured as long as an institution exists that remains in control; and which can provide financial and technical resources without continually competing for scarce funding and personnel through the normal budget process. Disadvantages are, clearly, that any changes in overall national priorities can nullify advances if support is withdrawn before the colonies are consolidated.

4. *Undertake regional equalization.* Regionalization looks toward allocation of development resources and efforts throughout the nation which will reduce pressures to migrate as well as to properly guide development in areas targeted for colonization.

5. *Establish regional development authorities* (such as the TVA in the United States and the CVC in Colombia) to defend local interests in national budgeting decisions, to assure that their share of social services and development projects are forthcoming and to undertake development activities on their own. However, the creation of regional authorities is not easy; pressures for more centralization are great and competition between development sectors and between the various political units operating in a region are always a threat.

Directed occupation and authorized uses of the humid tropics

"Directed occupation" is defined as the consolidation of human settlements through planning and project execution by public agencies or private organizations. "Spontaneous" colonization is included if it results from the creation of access routes where colonization was anticipated but not funded. "Authorized uses" refers to the open or implied permission of a government to allow appropriation of the goods and services available from an area.

Figure 16-6 - PRINCIPAL RELATIONSHIPS OF SUPPORT AND BENEFIT BETWEEN THE ACTIVITIES OF OTHER SECTORS AND THE ACTIVITIES OF AQUACULTURE AND FISHING

If the decisions as to where and how colonization is to take place are poorly made, development activities based on those decisions have little chance of success. To make the number of colonists, the activities of development and the exploitation of systems goods and service compatible with what the system offers requires formulation of policy, financing, and available appropriate technology. Policy guidelines for a large variety of development activities in the humid tropics include land use capability studies and the application of appropriate agriculture, forestry, and livestock management practices.

Land use capability

Much of spatial development planning is based on an analysis of "land use capability" - the suitability of an area for any use that will not damage the resource being used. Land use capability studies place land in a number of classes dependent on a survey of the soils and related features of the area with subsequent interpretation of this information according to its future use and management.

1. *Include cost and availability of technology in decisions on land use capability.* Table 16-8 presents the results of three different land use capability studies by three different groups in the same area of the Central Selva. Despite the fact that land use capability studies have long been used, they are strongly influenced by the opinion of the technician, and serious errors can be made if all the assumptions that went into the classification are not known. In the case of Table 16-8, the differences are apparently the result of different ideas on what land use is best under three dissimilar scenarios of available technology. Here study "B" appears to be production oriented, requiring heavy use of fertilizer and other inputs. Study "C" looks toward conservation, in the belief that although the technology anticipated in study "A" exists, its use in this area of the Peruvian Selva will be limited by funding and logistical constraints. Land use capability is dependent on both the inherent characteristics of the landscape *and a* certain level of technology. The figures in Table 16-8 can only be understood if the technology being considered is described. And, information on land use capability can only be used for development purposes if the anticipated technology is supplied. For example settlement schemes based on either study "A" or on study "B" will require much more credit, extension services, and other inputs than will a scheme based on study "C." On the other hand, "forest protection" also requires that a certain level of technology (guards, patrol vehicles, sensitization of incoming population with reference to the values of forest protection) be present if the project is to be successfully implemented. It is interesting to note that adherence to any of the three strategies in Table 16-8 will cause the destruction of the humid tropical ecosystems in question if the technology on which the alternatives are based is not forthcoming.

Table 16-8
THREE MAJOR LAND USE CAPABILITY CLASSIFICATIONS OF THE SAME PROJECT IN THE PALCAZU VALLEY OF THE CENTRAL SELVA

Land Use Capability	% of Total Land Use		
	Study A	Study B	Study C
Clean tilled crops	16,8	9.4	7.5
Permanent crops	5.3	32.4	14.4
Pasture	27.8	53.1	13.3
Forest utilization	36.7	4.1	46.2
Forest protection	13.4	1.0	18.6
Total	100.0	100.0	100.0

Source: ONERN, 1982; Villachica, 1981; Tosi, 1981.

2. *Base land use decisions on realistic evaluations of the potential benefits and risks of proposed development, as well as on actual land use, land tenancy, and migration patterns.* Development controversies in the humid tropics are focused on the availability of long-term sustained production; the appropriate level and kind of technology for managing tropical agroecosystems; and the suitability of the humid tropics for specific economic activities such as extensive livestock or oil palm production. Planners need to exercise extreme caution in using available data since much of it can be misinterpreted or interpreted in conflicting ways.

For example, the U.S. Soil Conservation Service land capability classification was developed for temperate regions but it has often been applied to tropical regions without sufficient consideration of the region's potential for soil erosion and nutrient leaching. As a result, developers in the humid tropics have designed agricultural production systems based on overly optimistic potential land use and agricultural credit and project funding encourages inefficient land use, increased clearing of forest lands and minimal use of natural goods and services. Appropriate land classification systems that are designed for use in the humid tropics include the soil fertility capability classification (Boul *et al*, 1975) and the Life Zone System (Holdridge, 1967), which Peru has now adopted as the official land classification system.

Agriculture

The problems and promise of movement of the agriculture frontier into the humid tropics are well known (Chapter 4 and 7). Large areas of the humid tropics now have access to rudimentary transportation, infrastructure and markets. However, many of these lands have been so over exploited that they have been abandoned, making both infrastructure and market access useless.

1. *Develop sustained yield management for humid tropic ecosystems.* Such lands are becoming accessible and new markets are becoming available. Planners should design projects that include the following:

a. Plantings representative of home gardens where 10-40 different varieties of fruits are grown. Size of planting area can be adjusted to fit physical and economic characteristics of the available space;

b. selected seeds and propagation nurseries;

c. cultural practices already in use, i.e., weeding; little or no use of fertilizer, pesticides or fungicides; pruning; and intercropping;

d. continuous income based on the use of species that do not require plant harvest; and

e. continuous harvest based on marketing and processing that are integrated with planting schedules and varietal selection.

2. *Evaluate and include native fruits* as a *component of socio-economic development in the humid tropics.* The native fruits of the Amazon represent a natural, rational, balanced, and renewable use of natural resources where the nutrition potential, especially vitamins, is proportionately higher than the other fruits (Table 16-9).

3. *Encourage systems of sustained agriculture production.* See Tables 16-10, and 16-11 for examples. Advantages of annual cropping and permanent or mixed cropping (agroforestry) are compared in Table 16-12. Different crops and neglected economic plants such as native tropical fruits and palms can be used (Table 16-13). Raising soil fertility levels, especially on acid infertile soils, can sometimes be cost effective. Management practices should strive to keep the ground covered by using mixed or sequential cropping when annual crop production is necessary. Often tree crops and/or pastures can be incorporated into the system after 1-2 years of continuous cropping of annuals, producing a tree canopy that replaces a crop canopy, provides soil protection and reduces loss of nutrients on a long-term basis.

4. *Use forest clearing techniques for agriculture that avoid soil compaction and that maintain water percolation and topsoil conservation,* such as manual felling and burning rather than clearing by heavy

machinery. The following guidelines should be followed when forests are to be cleared:

a. Maintain interspersed stands of natural forest on cleared lands to form an agriculture-forest mosaic.

b. Use intensively managed annual crops on fertile alluvial soils that are in little danger of flooding or, if floodable, adjust the cropping cycle to the flood cycle. Although fertilizers will be required in such areas, the level of use will be minimal.

5. *Examine the feasibility of rural development based on the management capabilities of colonists and native communities; institutional constraints of production and marketing; and, the maximum debt load a farmer can withstand.* The success of producing annual crops depends on fluctuating markets and unpredictable growing conditions. Consequently, colonists, as well as native communities with capital, establish permanent crops soon after forest clearing. Permanent crops require relatively little maintenance, provide a long-term steady income, and increase land values. On the other hand, annual crops are less expensive to establish and can provide quick returns. However, if yields are low or the crops destroyed, especially in the initial stages of colonization, there is little reserve capital available for land clearing, seed, and labor expenses for the next cycle. If the entire farm income is continuously dependent on annual crops, it is quite easy to fall into a cycle of financial debt that limits further investment in permanent production systems.

Table 16-9
NATIVE FRUITS EXCEPTIONALLY HIGH IN NUTRITION[a]

Fruit	Nutritional Aspect	Proportion higher than average fruit
Aguaje (*Mauritia flexuosa*)	Vitamin A	16 x
	Vitamin B	2 x
	Calories	5 x
	Calcium	3 x
Pejibaye (*Guilielma gasipaes*)	Vitamin B2	3.5 x
	Protein	2 x
	Carbohydrates	3 x
	Calories	3 x
Cocona (*Solarium sessilflorum*)	Niacin, Iron	4 x
Passion fruit (*Passiflora edulis*)	Niacin	4 x
Lucuma (*Lucuma obovata*)	Niacin	3 x
Camu-camu (*Myrciaria paraensis*)	Vitamin C	121 x

a. See also NAS (1975) and NRC (1982) appendices 7, 8 and 9 for extensive lists of species native to the humid tropics.

Table 16-10
ACTUAL AND POTENTIAL AGRICULTURAL PRODUCTION SYSTEMS IN THE AMAZON BASIN

Agricultural Production	Crops	Production Systems
1. Annual crops	Corn Rice Beans Peanuts Soybeans	Subsistence agriculture crop production alternated with secondary forest cover (shifting field agriculture)
2. Semi-permanent crops	Banana Plantains Papaya Cassava	
3. Backyard orchards	Fruit bearing trees having nutritious value; avocado, bread fruit, pejiyava palm	Sedentary agriculture[a]
4. Perennial crops Coffee	Cacao Citrus	
5. Cattle Production	Forage Grass Legume Supplemental forage	Commercial agriculture[b]
6. Plantations	Production systems	
1. Forest Trees 2. Rubber 3. African palm 4. Brazil nut 5. Cashew nut	1. Homogeneous plantations 2. Line enrichment planting 3. Taungya[b] 4. Agroforestry 5. Silvo-pasture	Implemente by industry or governmental agencies. Implemented by the agricultural sector in multi-strata production systems[a]

a. Suitable for multi-strata production systems.

b. Taungya is distinguished from agroforestry systems by the fact that the tree component is only associated with annual or biannual crops during the establishment phase. After one or two years the farmer leaves the planting site permanently and the responsible institution takes charge of it. In agroforestry systems, to the contrary, the farmers are continuously managing the association and, needless to say, are the beneficiaries of the timber production.

Source: Peck, 1977.

6. *Encourage conversion from shifting to permanent agriculture and design agricultural credit for medium-term* (4-10 years) rather than for short term (1 year) before repayment begins; adjust the grace period and credit to specific realistic conditions of crop or animal production.

Table 16-11
LIST OF CROPS SUITABLE FOR THE HUMID TROPICS

Tropical Crops	Best Growing Conditions	Environmental Limitations

Annual Crops[a] Rice corn, beans, peanuts	Adequate nutrients, and water to take advantage of short-growth period	Pest and weed competition reduces yields, dry season needed for harvest and drying
Sugar cane	High water use and fertile soils	Without marked dry season harvest is difficult and sugar content low
Root Crops Cassava, taro malanga	High requirements for potassium	Continuous harvest not limited by wet climate
Tree Crops Mango	Distinct dry-wet season favors flowering and fruit set	Extremely humid conditions or evenly distributed rainfall causes aborted flowers with little or no fruit set
Citrus	Proper soil conditions to maintain well drained root zone	Excessively wet or cool temperatures slow growth
Coffee	Cool temperature, fertile soils	Change in soil moisture levels induces flowering
Cacao	Fertile soils, sufficient water	Excessive precipitation results in lower fruit set
Tea	Acid soils, cool temperatures	
Avocado		Susceptible to poor drainage conditions
Papaya		Virus and mosaic limits length of production
Coconuts		No tolerant of heavy textured soils
African Oil Palm	Fertile, well drained soil, high moisture requirement	High yields required minimum hours of sunlight
Others Pineapple	Acid soils for high fruit acidity	
Bananas/Plantains	Require fertile soils and even distribution of water	Susceptible to poor drainage

a. Personal communication with Carlos Robles, soils specialist, ONERN, September 1982.

Table 16-12
A COMPARISON OF ANNUAL CROPPING AND SUSTAINED YIELD SYSTEMS IN THE HUMID TROPICS

Characteristics	Intensive Annual Cropping System	Sustained Yield Agriculture
1. Net Production	High - requires heavy fossil fuel inputs that are expensive.	Moderate - but sustainable at low costs.
2. Dietary Contribution	Low - complete diet dependent upon outside sources of food at considerable cost.	High - complete energy, vitamin, and protein from a variety of cultigens and animal sources.
3. Species Diversity	Low - generally devoted to a single plant species or animal breed.	High - both in total and number of individuals of each species.

4. Space Utilization	Poor - bare soil unoccupied by photo-synthetic material due to simple crop. direct and diffuse light.	Excellent - three dimensional space largely filled by plants adapted
5. Inherent Stability	Low - dependent upon the fossil fuel inputs for fertilizer, pesticide and mechanical control of outbreaks of host-specific pests and diseases. forest ecosystems.	High - competitive exclusion of weeds by diverse food plants, avoidance of pest epidemics through diversity of host plants. Analogous to natural
6. Nutrient Cycles	Open - large proportion of all nutrients applied to crops is lost to leaching and crop export.	Closed - minerals trapped by early successional annuals and perennial crop plants. Nutrient cycling mechanisms located above ground living biomass.
7. Economic Stability	"Boom or Bust" - with optimal conditions and large expenditures of fossil fuel inputs, high yields and profits are possible. Yields are vulnerable to market fluctuations other environmental stress beyond the farmer's control. Labor requirements highly seasonal. Tendency for mechanization to replace human labor.	High - variety of food produced for region or national consumption assures a market for some crops. Flexibility to switch plant energy flow from and direct marketing to increased animal production is practical. Low capital investment makes subsistence on a quality diet feasible. Harvest can be programmed throughout the year, as can labor requirement.
8. Social Viability	Volatile - economics of scale tend to concentrate management decisions, production and profit in the control of a socioeconomic	Adaptable - emphasis on the direct involvement of small to medium size farmers in viable systems of sustained

Permanent crops such as plantains can be harvested within a year after planting, whereas cacao, coffee, or fruit trees may take as long as 3-5 years to reach a first harvest and even longer to reach economic breakeven levels. A successful agroforestry system combines cropping of annuals and perennials that provides a short-term source of income (annuals), imitates the natural forest succession, minimizes labor and energy inputs for pest control, and establishes long-term production (perennials) at relative low initial cost.

7. *Evaluate current national agricultural research, extension, and training priorities to see if they are in line with actual farm problems in the humid tropics.*

In Peru many of the priorities are dedicated to rice, livestock, and potatoes on the coast and sierra only. As a result, researchers, extension agents, and teachers are ill-prepared to plan projects in the humid tropics because they understand neither the problems of tropical agriculture nor problems among the sectors.

8. *Encourage communication and information exchange with national and international agricultural*

institutions (*CIAT, CATIE, REDINAA*) *and donor agencies* in order to avoid duplication of effort or repetition of past mistakes.

9. *Exercise caution when extrapolating results of research from one particular site of the humid tropics to the entire humid tropics and implement crop and animal production systems on real farms.* Soil characteristics of the Tulumayo Experiment Station near Tingo María are excellent, but not representative of large areas of potential farmland being considered for development.

10. *Be sure that research priorities in tropical agriculture are compatible with development needs and criteria for the humid tropics.* Just as planners need guidance from scientists, researchers need guidance from developers. Cost/benefit evaluations of livestock production as compared with permanent crops, forestry, or annual crops are needed; the cost of clearing new lands as compared to establishing permanent agriculture on degraded or abandoned lands needs to be determined.

Forestry

Experience in the management of native forests in the American humid tropics on a sustained basis is scarce. As a result, most forest management plans for these areas are theoretical or experimental and require a certain degree of flexibility so as not to overly commit energy and resources to management schemes that may not work.

Table 16-13
TREE CROPS SUITABLE FOR PERMANENT AGRICULTURE

Common Name	Scientific Name
Native Fruits	
Bread fruit	*Artocarpus sp.*
Lucuma	*Lucuma obovata*
Guayabano	*Annona muracata*
Ubos	*Spondias lutea*
Taperiba	*Spondias dulcis*
Huito	*Genipa americana*
Umari	*Poraqueiba paraensis*
Uvilla	*Paurouma ceropiaefolia*
Cocona	*Solanum sessilflorum*
Passion fruit, Granadilla	*Passiflora edulis*
Araza fruit	*Eugenia stipitala*
Gumba	*Inga edulis*
Guayaba	*Psidium guajava*
Camu-camu	*Myrciaria paraensis*
Palms	

Huasai	*Euterpe edulis*
Chonta, pijuayo, pejibaye	*Guilielma gasipaes*
Aguaje	*Mauritia flexuosa*
Ungurahui	*Jessenia batatua*

In general there are two basic alternatives in managing humid tropical forests: management of pure forests and management of forests associated with some other activity.

1. *Apply pure forest management in lands designated as productive forest.* Here the sole objective is to harvest timber and other forest products and is not associated with agriculture or livestock production. This type of management incorporates methods which clear-cut a forest of all trees and reforests the area with native or exotic species. Although technically easy to manage and despite high and homogeneous production per hectare, there are some disadvantages: the initial harvesting and planting costs are very high; the risk from pests and diseases is great and wood not able to be used immediately is lost.

2. *Use natural forest management methods* where natural forest conditions are required. Such methods are used to obtain maximum production without significantly modifying the forest's floristic composition over the long term. Managing natural regeneration focuses on selecting the most desirable wood-producing species and on treating them to encourage regeneration. Improving natural regeneration may involve planting commercially valuable species of proven growth capacity on small parcels. The approach is directed toward exploiting the forest's natural capacity for self regeneration, and the original ecosystem is not significantly modified. Further, costs are relatively low, and, if regeneration is successful, the forest can be exploited on a sustained yield basis. The disadvantages are that the final production per hectare is relatively low and that it requires a high degree of technical information and preliminary research, both of which are scarce.

3. *Use associated forest management on land which has forest production potential, but which is being used for agriculture and livestock production.* The goal is to reestablish forest land use where necessary by supplementing agriculture and livestock with forest production.

The potential value of this management method can easily be seen. More than 800,000 hectares have been cleared in the Central Selva to establish small agricultural and livestock operations. Only 25 percent of this land, however, is presently being used; 600,000 hectares are abandoned. This land can be profitably incorporated into associated forest management efforts, along with the 200,000 hectares already being exploited for agriculture and livestock. This system can also be applied to lands before they are abandoned.

Throughout the forested regions of the humid tropics only a small percentage of land is suitable for agriculture, and this land is being subjected to significant demographic pressure. As people's principal activities always include agriculture and livestock production, some forested land will have to be given over to these ends. The associated forest management alternative is suitable because it avoids massive forest destruction and, at the same time, allows both semi-intensive forest production and agriculture and livestock operations - if they focus on permanent crops.

Associated forest production can integrate forest exploitation and agriculture and livestock in both space and time. Spatial integration is achieved by growing forest and agricultural products at the same time; time integration occurs when agricultural and forest products are grown at different times on a rotational basis.

4. *Use spatial integration of agriculture and forestry activities when possible.* This alternative begins with a climax forest being subjected to semi-intensive harvesting. A remnant of the cut-over forest is left alone, and natural regeneration and adult seed trees of valuable species are nurtured. Later, the land will be used for a forest plantation or for permanent or temporary cultivation of such crops as cacao, coffee, bananas, acheote, and native fruits such as pineapples and pacae (*Inga* sp.) and planting native fruit trees - many of which are used by the indigenous peoples of the Central Selva (Table 16-13).

When trees are exploited for fruit, latex, resins, and other products besides wood, this system can be permanent. If, however, trees are to be harvested for wood, rotational planting must be precise so that forest management and timber harvest do not damage agricultural crops and non-wood forest products. In some cases, depending on the land, light, and other factors, a third productive stratum of temporary cultivation can be included. Appropriate crops for this level include beans, cocona, and corn.

5. *Use time integration of agriculture and forestry activities when possible.* This is a management system in which the harvest of one type of crop (agricultural or forest) is followed by the planting of the other. This alternative can be used in shifting agriculture and on lands designated for forest use. The steps required in applying this systems are: the initial exploitation of the natural forest; harvesting the timber for industrial and commercial purposes; the selection and establishment of temporary agricultural crops, after the land has been cleared without the use of heavy machinery; after five years, the planting of fast or slow growth trees, according to the plantation's objectives; and management of the resulting forest first of all, to produce wood, followed by either a new agricultural crop or survival of the forest.

This system can also be applied to second-growth forests or *purma*, which occur when climax forest is cleared or cultivated land is abandoned. Second-growth forests consist of more or less pure stands of heliophyte species (those that require abundant light) such as *Cecropia, Ochroma lagopus, Jacaranda, Copaiba,* and other species that have known industrial uses.

The Taungya system, which originated in Africa, is a rotational method that integrates both time and space. This method consists of planting trees among agricultural crops. When the last crop harvest is obtained, a two to three year old forest remains, which can be easily maintained. This method has been successfully tried on experimental plots in the Alexander Von Humboldt National Forest in Pucallpa. Normally, it is associated with corn, manioc, and, eventually, grass when these crops have exhausted the soil of nutrients. Table 16-14 summarizes recommended land uses on certain kinds of land. Table 16-15 presents the recommended native species and silvicultural systems reviewed above.

Livestock management

Three general types of livestock management occur in the American humid tropics: artisan, extensive, and intensive. The first of these (practiced at the level of the small family farm), may include both small and large animals for production of both meat and milk, while the second two use primarily large animals. The following guidelines and observations treat livestock management at these three levels in the humid tropics.

1. *Include livestock production at the level of small family farm in any scheme that proposes settlement in the humid tropics.* In the family farm, livestock ownership confers social status and represents a method

of saving income above that required for immediate needs. There is a common saying among small farmers that cows provide both daily milk and a long-term savings account to provide for other farm needs.

2. *Consider that livestock development provides many goods and services in addition to food for human consumption.* The income (constant and future) generated from the sale of livestock products permits people to acquire clothes, food, home utensils, medicines, etc. Cattle and water buffalo provide draft animals for plowing and transporting cargo. Ruminant animals (cattle, buffalo, sheep, and goats) and horses, mules, and donkeys effectively convert fibrous plant biomass to high protein food. Mixed agriculture-livestock, forest-livestock, and agriculture-forest-livestock systems mean that plant biomass can be converted to milk, meat, labor and transportation. Ruminant animals, especially cattle, provide hides, horns, and manes used in handicrafts, and glandular substances from which drugs can be synthesized. Finally, industries are stimulated, such as those producing pulp from dehydrated citrus fruits, pineapple bran, meat, flour, bone meal, and oleaginous cakes that produce food for both ruminant and non-ruminant animals.

3. *Suggest policies and projects that stimulate improved systems of animal production.* Livestock operations are widespread in the Selva but show different levels of production. Dourojeanni (1979) estimates that carrying capacity in the Central Selva is 0.3-0.5 animal units per hectare; Staver (1981) calculated a range between 0.7-1.7; Blasco *et al,* (1977) estimated values of 1.8-2.0 for Peruvian Amazonia; and Toledo and Serrao (1982) judged it to be between 1.2 and 2.6 for the Pucallpa region. These discrepancies occur because the data were collected during different stages of pasture growth. New pastures influenced by the benefits of burning produce more biomass and consequently, support more animals, while degraded pastures support only 0.5-0.7 animals/hectare (CATIE 1978).

Extensive grazing of Yaragua grass (*Hyparrhemia rufa*) pastures decreases soil fertility and leads to economic failure (Riesco *et al,* 1982). While a traditional system of livestock management produces only 149 kg of live weight/ha/year and a load of 1.8 animals/ha, supplementing this with a legume, such as *Stylesonthis guiarersis,* and 100 kg/ha/year of simple superphosphate can increase production 3.14 times (469 kg of weight/ha/year), in part because it allows one to increase carrying capacity (2.6 animals/ha).

Table 16-14
RECOMMENDED LAND USES

Land Use Capacity	Types of Lands According to Their Condition	Types of Lands According to How They Are Used	General Guidelines for Silviculture Development
AGRICULTURE	Agriculture and livestock	1. Lands used for agriculture 2. Lands used for livestock	- Extensive Agrosilviculture - Used for Conservation and supplying products for household use - Multiple use species

FORESTS	Exhausted lands (abandoned)	3. Marginal cultivated (low economic returns) 4. Non-productive cleared land (including lands covered with weeds)	*Agrosilviculture* - Semi-intensive - Used for production (multiple use and conservation) - Forest species suitable for agroforestry
		5. Eroded lands (already eroded or susceptible to erosion)	*Reforestation* - Intensive - Used for conservation (land rehabilitation) and production (semi-industrial) - Rapidly-growing tree species
FORESTRY	Lands in recuperation	6. Areas in the initial stages of recuperation (young "purma")	Land *rehabilitation* - Semi-intensive - Used for production (industrial)
	Second-growth forests	7. Areas in the advanced stages of recuperation (adult "purma") forest cover.	- Rapidly-growing tree species under secondary Exploitation of Natural Regeneration
	Natural forests	8. Little-altered and easily-accessible forests (selective harvesting)	*Land Rehabilitation* - Semi-intensive - Used for production (commercial)
	Altered productive forests	9. Unaltered and relatively-accessible forests	- Moderately rapidly-growing species under semi-dense cover
			Management of Natural Regeneration - *Extensive* - *Used for production* (*commercial*) - *Desirable, slow or moderately-growing forest species*
	Protected Areas	Forests with limited production capacity	*Forest Reserve* - Indirect benefits

Table 16-15
REVIEWED SILVICULTURAL SYSTEMS AND DESIRABLE NATIVE SPECIES SELECTION

Value	Species	Silviculture	System	Observations

A	B	C	D		1	2	3	4	
	x			Guano masha		x	x	x	Low plant density to reduce damage.
	x			Alcanfor		x	x	x	
	x			Andiroba		o	x	x	
o		x		Azucar huayo		o	x	x	Low plant density to reduce damage.
	x		x	Bolaina	x(R,A)				
x				Caoba	o(A)	x	x	x	
	x	x		Catahua	o	x		o	On alluvial sites.
X				Cedro	o(A)	x	x	x	Low plant density to reduce damage.
x				Copaiba		x	x	x	
		x	o	Copal		o		x	
	x			Cumalas		x	x	x	
	x		o	Goma pashaco	x(A)	x		o	
	x			Huamansamana	x(R,A)				
o		x		Huayruro	o(A)	o	x	x	
	x		o	Huimbas	x(A)	x			
	x			Huira caspi	x	x			
	x		x	Huito	x(A)	o			
x				Ishbingo		x	x	x	
		x		Itauba			o	x	
x				Lagarto caspi		o	x	x	On alluvial sites.
		x	x	Leche caspi	x(A)	o			
	o	o		Lupunas	x(A)	x		o	On alluvial sites.
		x		Mashonaste (tulpay)		x	x	x	
	x			Maquisapa (Naccha)	x	x			
	x			Marupa	x(A)	x	o	x	
	x			Moenas		o	x	x	
x				Palo de sangre		o	x	x	
	x		o	Paschacos	x(A)	x			
	x			Requias			x	x	
	x		x	Sachauva	x(A)	x			
	x		x	Shimbillos	x(A)	x			
			x	Shiringa (jebe)	x(A)	x		x	
o		x		Tahuari		o	x	x	
	x			Tangaranas	x(A)	x		o	

	x			Topa	x(R)	o			
x			o	Tornillo	x(A)	x	x	x	
	x		x	Ubos x(A)		x			o
		x		Yacushapana		x	x	x	
	x			Zancudo caspi	x(R)	o			

A = Valuable wood, in high demand, presently used commercially.

B = Multiple use wood, of potentially high demand (many products), presently used commercially in limited amounts.

C = Wood of restricted usefulness, presently used commercially in limited amounts, with less perceived potential (single products).

D = Products other than wood (fruit, forage, living fences, soil improvement, extracts, etc.).

x = Recommended.

o = Possible with limitations.

1= Plantations on open land. Two possibilities: A = agroforestry combinations; R = based on regeneration potential.

2 = Plantations in second-growth forest (low "purma," closed or open).

3 = Supplementary plantations (in selectively-harvested forest).

4 = Management of natural regeneration in closed forests (desirable species).

4. *Use the new livestock management technology being developed for the humid tropics.* Examples are the use of selected grasses and legumes of the humid tropics which are superior in nutritive content to predominant grasses (*Melinis minutiflora*, *Hyparrhenia rufa* and *Axonopus compresus*). The range of livestock technology is wide and selection of a given level depends on technical abilities of the farmer, credit and extension services, and availability and costs of production inputs.

5. *Determine which life zones and soils are suitable for livestock production.* Livestock are generally permissible in life zones where precipitation does not exceed 4,000 mm/year and where slope does not exceed 30 percent, but in some forest-livestock systems, animals can be grazed on steeper slopes. Similarly, livestock operations must be associated with forest production on slopes less than 30 percent with sandy or shallow soils (Table 16-16).

Table 16-16
SUGGESTED FACTORS TO USE IN IDENTIFYING LANDS SUITABLE FOR LIVESTOCK

Slope	Soil Classes	Depth	Drainage[a]	Minimum pH	Susceptibility to flooding[b]
0-8	Entisols, Inceptisols, Ultisols	Shallow	Except D and E	4.0	Up to 2
0-15	Inceptisols, Alfisols, Ultisols	Medium	Except D	4.0	-

15-30	Inceptisols, Alfisols	Deep	Except D	4.0	-

a. D is very slow drainage and E is flooded terrain (Tosi, 1981).

b. 2 signifies moderate flooding (Tosi, 1982).

6. *Train farmers and technicians in livestock development.* Traditional techniques of training and extension include the use of bulletins, field days, and radio programs; and prototypes of small production units, using improved technology adapted to and integrated with existing systems. One advantage of these is that they transmit and demonstrate technology in practice and the degree of information complexity is appropriate to the listeners. But problems to watch out for include: lack of official support where participating institutions do not carry out responsibilities assigned to them; failed management caused by deficient coordination of involved people and institutions (delay in authorizing spending, late application of fertilizers, etc.); field trainers and producers who may not understand technical principles; producers who may be wary of contracting debts (credit, loans) and of trusting outsiders ("Government" technicians); producers or merchants with scarce resources who may be intimidated by the large landholders and money lenders; trainers who favor certain producer groups according to race, religion, or political affiliation; and banks which prefer to make large loans, thus neglecting the small producers.

7. *Direct technology transfer and training programs toward improving, reorganizing and relocating livestock operations to areas already settled.* Many authors assert that most lands in the Central Selva suitable to agricultural and livestock development are already used in some form and the livestock enterprise may be especially damaging to them if carried out with rudimentary or nonexistent technology.

8. *Encourage animal production systems in the most appropriate areas.* Livestock development in the humid tropics must look toward intensified production seen as optimizing the use of goods and services available to livestock systems. New parameters need to be adopted to evaluate the money and labor invested per unit of land, system stability, and the degree of economic risk involved in incorporating new methods. Evaluations must include local criteria and customs.

9. Base *livestock development planning on assessments of existing and potential livestock systems and on the search for stable associations of activities.* Increased livestock production can be achieved either through expansion onto new lands or through intensification of production systems. The first alternative is easier, but leads to a predictable result of ultimate failure. Intensified livestock production requires not only new technologies but also intersectoral support, new services, and industries.

10. *Design integrated systems of exploitation.* For example, livestock and fish culture do not significantly conflict and can co-exist with spatial organization of farms and regions. Even aquaculture, which involves the use of land depressions for ponds, does not have a notable negative impact on the amount of land dedicated to livestock such as poultry and swine.

Consideration can be given to associations of annual cropping systems and livestock such as the use of sweet potatoes (*Ipomoea batata*) *as* forage. Harvested at the end of the cultivation cycle, it produces daily livestock weight gains of 600-700 grams (Backer, *et at*, 1980) with 47 percent profits under some conditions. In confined areas livestock feces can be collected and used as fertilizer. Combining livestock with forest production is another possibility and appears to be stable in tropical environments since it partially approaches the natural ecosystem (Bishop, 1980). Both activities are of long duration, and both produce products highly appreciated by man. For a number of reasons, combining these activities reduces the production of each one alone, but raises the combined production of the two (Table 16-17).

Figure 16-7 is a scheme for locating, regulating, and associating agriculture, forest, and livestock production systems. Areas with more than 30 percent slope are not included, as they are basically best suited for forest protection and wildlife.

Prior inhabitants and uses

To the casual observer looking out from the capital city, much of the humid tropics appears to be "empty," "new," or "virgin." In fact, the opposite is almost always true. Though population densities may be light, such areas have a long history of dynamic settlement and use. Decisions as to who would occupy them and for what purposes were contested long before the arrival of the Europeans. Virtually every attempt at "opening a new frontier" in any country and at any time has been faced with conflicts between newcomer and prior inhabitant. The American humid tropics are no different.

Prior occupants consist of four main categories: native tribal communities; colonists who have previously settled in the area and who may or may not be able to establish title or legal usuary rights; persons or groups that have been granted concessions by the government to use specific resources; and individuals or groups that are using the area for illegal ends. Major problems concerning new development efforts in such areas relate to the legal status of the prior inhabitants and users and the formulation of a strategy for coming to terms with any illegal activities.

1. *Prepare clear and acceptable national and institutional policies and legislation which are sympathetic to the socio-cultural patterns of the prior inhabitants.* The type of agriculture practiced by these peoples requires long rotation periods and the forest constitutes for them a source of many goods and services; moreover, in much of the humid tropics, indigenous populations are rapidly increasing as a result of easier access to sanitary and health services and drastic reductions in infectious diseases.

2. *Grant title to the native communities over a large percentage, if not all their traditional lands.* This is justified if these peoples are to be fully and fruitfully drawn into the process of modernization. Negotiated payments for lands that are "condemned" and provision of technologies that will allow them to live on less land will be needed if granting full title is not possible. The Palcazu Valley of the Central Selva already has an estimated population of 15,000 colonists and native peoples (Amuesha and Campa) who are worried about land shortages resulting from the increasing size of its native population. It is unrealistic to design development projects for more than an additional 5,000-8,000 settlers.

Even though livestock production would be economically feasible, for them, this scarcity of land suggests that cattle raising may not be an alternative for the Amuesha. A comparison of total area of agricultural lands with areas under cultivation shows that in all but two of the nine native communities, areas grazed for pasture far exceed the land area classified as suitable for that activity and in two native communities, the total area under cultivation surpasses the land use capacity.

3. *Undertake population censuses and inventories of current and potential land use.* Where occupants are eligible according to the law, they should be granted legal land title *before* land speculators or spontaneous migrants move to the area.

4. *Provide for justifiable transfer and resettlement of prior inhabitants before other development activities begin, and give them the option to participate in the new settlement scheme.*

5. *Make efforts to train the prior occupants as guards, wardens, laborers, concessionaries, etc. if they are occupying lands to be reserved for conservation purposes.*

6. *Search for alternatives to eviction.* The model of "lifetime" leases may be used - if applicable. That is, previous occupants may be allowed to live on the land or use its resources within certain limits until they voluntarily leave or die. In this case, title or usary rights may not be sold or transfered to descendants or others. Compatible uses in areas requiring protection can be considered. Low density human settlement may be possible in some areas where specific conservation activities are anticipated.

7. *Make efforts to understand and sympathetically work within socio-cultural beliefs of tribal peoples and early colonists.* Social anthropologists can provide early input to development analyses and plans. Several international agencies can effectively lobby for the rights of indigenous peoples, while many international development assistance agencies' policies restrict their participation in efforts that unjustly usurp lands traditionally held and used by tribal peoples. (See, for example, the World Bank publication *Economic Development and Tribal Peoples: Human Ecologic Considerations.* 1981.). Native communities can participate in national development without having their ethnic identity destroyed.

Table 16-17
RELATIONSHIP BETWEEN TREE DENSITY AND GROWTH OF GRASS[a]

Years	Availability of Grass	Reasons for Limitations	Tree Density/ha.
1	20	Grazing is not permitted for almost one year.	750
2	40	Pasture deterioration in the first year.	750
3-6	60-80	Branches and leaves from the first pruning and thinning, some shade.	500
7-12	50-60	Branch and leaf residues, more shade	200
13-16	40-50	Shade from the tree canopy.	150-200
17-20	20-30	Continual canopy closing.	150-200
21-25	20	Closed canopy.	150-200

a. Knowles *et al.* (1973).

FIGURE 16-7: SCHEME FOR THE LOCATION, AND MANAGEMENT OF COORDINATED SYSTEMS OF AGRICULTURE, FORESTRY AND LIVESTOCK PRODUCTION. AREAS OF MORE THAN 30% SLOPE HAVE NOT BEEN INCLUDED SINCE THESE ARE BASICALLY FOR FOREST PROTECTION AND WILDLIFE. (Sanchez *et al.*, 1982).

8. *Do not minimize the problem of prior inhabitants who are there illegally or who are otherwise making illegal use of the area* such as in coca production and traffic in endangered species and national historic and archeologic artifacts. Even though coca is grown both legally and illegally in much of the American humid tropics, few, if any, planning agencies include this crop as part of the technical analysis for future development. Coca contributes to the local and national economies, but the socioeconomic importance and adverse consequences are often ignored. Since there is no other crop that provides a farmer with such a high, steady income, the economics and substitution strategies for this crop should be recognized as an integral part of any rural development project. And since cocaine traffic is primarily, but not always, a problem of the more industrialized countries that has come to affect land use problems in the developing

countries, it will also need to be dealt with on the international level.

9. *Pay close attention to international legal instruments and institutions that may help to deal with these problems.* For example, the majority of tropical nations have, to some degree or other, acceded to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Concerted effort on the part of individual governments that would bring the full resources of such instruments to bear on these and other problems would go a long way towards their resolution.

Spontaneous migration

Spontaneous migration, in the context of this document is the unauthorized and unplanned movement to sparsely populated areas by landless peasants for the purposes of subsistence agriculture or by land speculators who hope to turn a profit. It is not equivalent to, but may include, aspects of shifting agriculture, slash and burn farming, forest fallowing or any other of the traditional land use methods in sparsely populated regions of the humid tropics. As originally practiced, shifting agriculture, slash and burn farming and forest fallowing, are "planned" and sustainable over the long term. Spontaneous migration on the other hand has its roots in social and economic inequalities which force populations of marginal means to invade lands of marginal utility made accessible by other development activities, and, in the end, make it impossible to use the land for pasture, flood and erosion control or the other goods and services associated with a well-managed landscape.

We are not talking about spontaneous colonization which often is a positive force in the long-term appropriation of goods and services. Rather, we are talking of a process that is not stable - the need to move on is built in; the original migrant abandons the lot or sells usary rights to an even poorer migrant who will use it for an even shorter period of time and eventually it is turned into pasture by someone on the other end of the economic scale who will use it until the remaining soil nutrients are gone or until the cost of clearing the secondary growth becomes too high.

The apparent uniformity of the process disguises internal differences that require distinct treatments. Migration takes place for a number of reasons. There are those who are forced to migrate for social or economic reasons and those who voluntarily migrate looking for a better life while holding on to what they had previously. Some migrants are workers on local farms or ranches who "supplement" their income by using small plots belonging to their employer and then invade nearby areas hoping to gain their own plots. Others are workers on road, forest harvest, or petroleum exploration crews, etc., who stake a claim alongside the access route for speculative purposes; and still others appear to be "spontaneous settlers" but actually migrate as part of a plan to gain control over an area or as a part of a plan to escape management clauses in concession contracts. The main premise of the guidelines in this unit is that any migration that is neither planned, expected, nor wanted, should be slowed and ultimately stopped.

Spontaneous Migration and Access

One possibility for slowing such migration is to control access. Access is created by previous colonization efforts or concessions; by directed colonization and authorized intervention; and by spontaneous migration and unauthorized intervention itself. Guidelines to control access under each of these are:

1. *Where it is advisable to control access, concession granting or controlling agencies*

should do so. For example, although forestry, mining, and petroleum exploration are valuable sources of income to a region or country, many of the activities of these sectors provide unplanned access for other groups or sectors.

2. *Provide funds from these sectors for infrastructure and manpower to assure that unauthorized entrance to their concession areas is not provided.*

3. *Make sure development objectives are compatible between sectors.* The objectives of creating access for forest, mineral and petroleum exploitation are different from those for agriculture or livestock production, and they should not be mixed without prior assurance that resources basic to agriculture and livestock production are also present in the area being accessed.

The Office of the Pichis-Palcazu Special Project has attempted to control access and the effort has met with some success. That success has depended on a motivated project staff which understands the need to control unauthorized access, which is trained and which has the means to enforce the policy. Their enforcement authority is backed up at the local, regional and national levels.

Spontaneous Migration in Relation to Prior Inhabitants

It is assumed that the activities as well as the presence of current occupants and at least some of the activities of the migrating populations are legal. Conflicts often arise because of contradictions within, or lack of, relevant legislation.

1. *Review and amend the legislation to make it internally compatable.* Three examples of conflict may be given. First, incompatibility in legislation and institutional mandates allow forest concessionaires legally to escape the terms of their concession contract when concession lands are "invaded" - normally after exploitation but before land rehabilitation. Invaded lands are treated as agriculture lands though they may continue to be best suited for their original forest use. Second, delays in processing land titles create situations where two or more claims are made on the same parcel of land. And, third, invasion may legally occur on "unused" traditional lands of native comunities which, in reality, are fully used according to the technology available to the communities.

2. *Remove migrants illegally occupying lands that are legally inhabited or in use by others.* Although in theory this response is clear, in social terms, such a guideline is not so easily applied. Unless arrangements can be made to rent or lease land or to provide labor as an alternative to rent, authorities should move the migrants to evade potentially even more drastic measures on the part of those who have usary or occupational rights. Care should be taken to assure that the migrant eventually *settles* elsewhere instead of continuing the life of a spontaneous migrant.

Spontaneous Migration and Overuse of Natural Goods and Services

Overuse of natural goods and services is inevitable in areas such as the humid tropics where so little is known of ecosystem structure and function. Spontaneous migration exagerates this problem since the migrant's marginal economic condition, lack of management information on the part of the authorities, and the nature of the resource combine in synergistic ways to lead to overuse.

1. *Undertake very broad land use studies rapidly to identify the goods and services provided by natural ecosystems and then assure that access is not given to sparsely populated areas until all important*

resource use conflicts are resolved. Such inventories should be made quickly since the mere fact that they are being made will provide an impetus for migration to occur. Subsequent protection through a system of reserves and legislative/institutional instruments would help make resolution of any future conflicts easier.

2. *Public or private extension and information services that are adequate to provide incentives and means for holding the migrant on the land being occupied should be provided.*

3. *Do not inadvertently suggest that a "new" area is capable of solving the problems of a nation because of its "richness."* Both media and politicians have a major responsibility not to exagerate an areas' potential since this, in itself, can create unauthorized migration and speculation.

Spontaneous Migration and Extra Demand for Economic Goods and Services

Given the need to slow and eventually stop spontaneous migration, the phenomenon still requires additional resources to help consolidate migrating populations and to provide basic support for their welfare.

1. *Provide support which emphasizes health, education and security.* Only minimal effort should be given for construction and maintenance of housing and community centers, or extending credit. Credit may be very important during certain phases of settlement consolidation before crops are established but, there is a fine line between too much and too little help.

2. *Include health, education and security costs in sectoral budgets.* Spontaneous migration is a fact of life for most countries of the humid tropics - especially where needed development activities are creating access.

Spontaneous Migration to Restricted Areas

Establishment of forest reserves, wildlife reserves and National Parks appears to be an open invitation for migrant invasion, which is in direct opposition to the need for conservation and must be treated.

1. *Provide for early control of access* to forest reserves through the use of well trained and equipped forest guards. The cost will be minimal compared to the cost of allowing illegal migrants to enter.

2. *Orient the activities of the migrant so* that they are compatible with the original legal use of the reserve, such as, forest stand improvement, surveillance, or, small scale agriculture in appropriate zones for that purpose.

3. *Assure that wildlife is not exploited for any purpose* other than for food or other legal ends and only then within well-prescribed limits.

4. *Stop migration to National Parks, wildlife or other equivalent reserves.* Such migration is different from invasion of forest reserves since most countries hold these areas to be inviolable for logical and valid reasons. Access roads, if constructed at all, should be strictly controlled until adequate provision has been made to assure the long-term protection and management of these areas.

5. *Remove migrants from areas where natural hazards have been identified.* Many areas of the humid tropics are closed to human activity because of landslides, diseases, flooding, and high potential erosion rates. Others are restricted because they protect development elsewhere from the occurrence of natural hazardous events.

Spontaneous Migration to Areas Where There Is No Conflict

1. *Consolidate migration activities that are not causing conflict through granting title or usary rights in an organized way,* if the spontaneous migration is "illegal" but does not cause conflicts.

2. *Reevaluate policies that make migration illegal;* if, after reevaluation, such migration is still to be prohibited, the migrants must be moved; if no problem is found, granting the occupants title and/or usary rights should be considered.

Monitoring

Development activities manipulate ecosystem structure and function to appropriate them as goods and services. This is a precarious business in any case, but it is much more so in areas where ecosystem structure and function are relatively unknown. Manipulation will beget other changes in both the natural and social components of the ecosystems in question. These changes may occur rapidly or slowly but, regardless, both kinds require monitoring if conflict is to be minimized through its early identification and resolution.

1. *Adapt the early planning evaluations* (*reconnaissance, diagnosis*) *of the major ecosystems of the study area to serve as baseline studies for future monitoring as well.* Although the data gathered may be the same for both purposes, it will be gathered, reduced and interpolated with a future monitoring activity in mind. This later monitoring effort need not be at the same intensity or detail of the baseline/reconnaissance studies. The early studies, however, should be compatible with the future monitoring effort.

2. *Include both the biophysical* (*natural*) *and social components in any monitoring schedule.* This will be equivalent to tracking change in the mix of goods and services and in the characteristics of structure and function. Together, these two sets of data will allow one to focus in on important changes early.

3. *Plan the monitoring schedule as a compromise between budget restrictions and need for information.* A few good, complete records are better than many records that are poorly kept and incomplete. Budgets can be held in check by sampling, by undertaking "rapid" assessments (Chambers, 1980), and by following key indicators.

4. *Use remote sensing as a tool in monitoring.* Remote sensing is particularly applicable to humid tropical areas because of its flexibility, wide range of application, and low cost compared to ground surveys.

5. *Use aerial surveillance and aerial photography to focus in on problem areas or areas of special interest.* I n the humid tropics, deforestation is often an indicator of a large number of problems and aerial reconnaissance and photography are easy ways to monitor important but inaccessible areas.

International development assistance agencies

Many, if not most of the large scale development efforts in the humid tropics are only possible through support of the international development assistance agencies. Each of these, be they multilateral or bilateral, non-governmental or private, have their own agendas and goals which may or may not coincide with those of the sovereign governments they are assisting nor with one another and this is no less so in terms of environmental management. Guidelines for governments are:

1. *Analyze and insure the compatibility of goals of the various assistance agencies operating in the country.*

2. *Negotiate the terms of the assistance with the assistance agency to insure that project formulation and execution will include concern for, and input from, all sectors that will be affected by the activity.*

3. *Insist that planning teams sent by the assistance agency have an intersectoral perspective and make-up even if the team is "sectoral."*

4. *Insist that any projects and programs supported by the assistance agency fit an overall development strategy for the region under consideration.*

On the other hand the assistance agencies should:

1. *Negotiate the terms of the assistance with the requesting country to insure that project formulation and execution will include concern for, and input from, all sectors that will be affected by the activity.*

2. *Insist on sending planning teams that have an intersectoral perspective and make-up even if the team is responding to a sectoral invitation.*

3. *Insist that any projects and programs to be supported fit an overall development strategy for the region under consideration.*

4. *Insure that in-house project formulation and review are intersectoral and that any intersectoral conflicts that have been identified are resolved before project execution.*

Observations on political will

It is a truism in both the development community and in the environmental movement that the failure of development can be laid at the feet of those decision makers who lacked the political will to execute the recommendations and strategies that have been so carefully and conscientiously made.

Political decisions, just as any other decision, however, are seldom, if ever, made on the basis of political will - whatever that may be. Lamenting the lack of political will evades the issue; the issue being, what can the planner and advisor do to design and execute development activities that improve life quality for a target population while maintaining or improving the life quality of other populations affected by those development actions in time and space.

Political decisions are made based on a perception of the issues that prescribes a route of "least resistance" or "minimal conflict" for the decision maker. Among the various alternatives, decisions are made to favor the route of minimal conflict with the decision maker's powerbase and philosophy. It is unrealistic to assume that a decision maker's powerbase or philosophy are the same as those of the many opposing interest groups that surround most any issue. Indeed, more often than not what the decision maker believes to be the route of minimum conflict is not at all correct.

What this means then is that it is incumbent upon the planner to design development efforts that minimize conflict taking neither one side nor the other but making sure that all sides understand and agree to what has been proposed. That is the real route of minimal conflict and, if offered, the decision maker will take it.

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Appendix regional modelling

Models are an abstraction and simplification of reality. A region may be represented by using models of increasing abstraction such as aerial photographs, a map, a diagram, or a series of equations representing the dynamics of the regional system. The method presented here is that of Odum and Odum (1976) which uses a series of diagrams to focus attention on key elements and interactions.

Modelling requires a macroscopic perspective to eliminate superfluous detail. Several relatively simple steps are employed.

Step 1. Identification of system limits. All ecosystems have arbitrary limits. However, the principle of integrative levels indicates that to understand a system such as a river and its flood plain, one should analyze the next higher encompassing system - watershed - in order to understand the internal interactions of the prior system.

Consequently, each person representing a different sector during the planning process should understand how a given boundary affects his analysis of the system as a whole. A boundary cutting across a statistical enumeration district or ecosystem can, of course, complicate the analysis. Political and other considerations may dictate other limits. Once lines are drawn, boundary conditions are established and internal interactions can be distinguished from exchanges with other systems.

Step 2. Definition of scale. The planning mandate determines the focus of the model. Finding a place to locate a highway requires a very different model than one for a general mandate to "optimize regional development." Scale, units of measure, quality and other characteristics of information, and compatible levels of detail in analysis depend upon the common constraints of the area's size, availability of time and funding and planning objectives.

Step 3. Identification of inputs and outputs. Once system limits have been established (Step 1), outside energies, materials and information which affect the system can be listed (Table 1). These may include sunlight, rainfall, tidal action, tectonic movement, fuels, goods, technology, infrastructure, finances, immigrants and policy decisions, all of which interact with other system components. Outputs include products, emigrants, water, pollutants, heat, etc. In a complex region, interdisciplinary discussions are essential for identification of components and external interactions.

Step 4. Identification of components (*Subsystems*) *and interactions.* It is useful to go into considerable detail in identifying components and interactions at the early stages of model elaboration. Later, components may be combined or eliminated if not critical to the analysis. The basic divisions in any regional model have to do with their relationships to man, especially the degree of intervention and energy subsidy applied. Therefore, natural components (both terrestrial and aquatic), managed systems such as in agriculture and silviculture, and man-created components such as cities, industries, and water control structures are considered (Table 2). At a later stage, new components proposed as development alternatives can be added.

Step 5. Preparing the diagram. Table 3 gives the basic symbols needed for system diagramming. Each symbol has a unique characteristic as described. When lines are drawn to represent flows of energy or materials and information with energy values, one has a conceptual model of the regional system. By quantifying the flows and storages, such a model can be expressed as a series of non-linear differential equations and computer simulated to test the effects of various management strategies.

Figures 1-4 shows the sequence in preparing a regional diagram. First, the system boundary is shown and the external forcing function or energy sources that have been identified in Step 3 are arranged clockwise beginning with the most dilute source, the sun, and ending with the most concentrated sources (Figure 1). Total systems respiration is shown by the heat sink and all exports by the arrow to the right. Second, the major components or subsystem within the system boundary identified in Step 4 are added (Figure 2). Third, the interaction of inputs to, and transfers between, components are generalized and shown without going into detail on the precise mechanism involved (Figure 3). Fourth, the same diagram in Figure 3 is redrawn to show the complexity of the internal interaction (Figure 4).

Table 1

SYSTEM ELEMENT	**CHARACTERISTICS**
System inputs	1. Technology, information and policy 2. Equipment, materials and all supplies 3. Services 4. Energy quantity and quality - fossil fuels, electrical, solar, wind, etc. 5. Water - rain and inflow from other systems 6. Sediments, organic matter, chemicals, etc. from upstream systems 7. Money - when an input involves an economic transaction 8. Immigrants
System outputs	1. Agricultural products 2. Water, air and water-bone contaminants, and sediments 3. Industrial products 4. Forest products and services to downstream systems such as water quality and hydroperiod regulation 5. Emigrants 6. Recycled gases, solids and liquids 7. Hydroelectric energy production
Background data	1. Physical and political maps 2. Soils, geomorphology, hydrology 3. Map and description of important ecosystems

Legislative regulation	1. Laws governing regional plans and planning 2. Regulation or zoning of landuse 3. Laws governing construction, mining, channelization, etc. 4. Laws regulating quantity and quality of the discharge of wastes into air, water and land 5. Permission requirements for clearing land, cutting timber, mining 6. Laws regulating commercial and sports fishing and hunting 7. Laws establishing and protecting parks 8. Requirements for permits and licenses
Official and private agencies serving the	1. Ministries or institutes with actual or potential functions in project area management 2. Research and teaching institutions 3. Private organizations and businesses with interest in environmental management

Table 2

Components	1. Subsystems having components and processes that are predominantly man-made Industry - extractive, processing, power transformation, etc. People - demographic characteristics, cultural perceptions and interactions Cities - structure and function, interactions with hinterland, intercity interactions Institutions - structure and function, role in relation to all subsystems, actual capabilities 2. Subsystems that combine natural and man-made components and processes Farms and ranches, silviculture, aquaculture-structure and function, area, location, human and institutional characteristics 3. Subsystems having components and processes that are predominantly natural Terrestrial and aquatic - structure and function, diversity, extent, location, degree of intervention
Interactions	1. Industrial production - interaction of materials, energy, water, labor, etc. Interaction of by-products such as heat, chemicals and particulates with man, agriculture and natural systems 2. Agricultural production - interaction of solar and fossil energy, water, chemicals, soil minerals, equipment and technology. Interaction of by-products such as chemicals and sediments with infrastructure and natural systems. 3. Natural systems - interaction of solar energy with water and inputs from other components such as runoff, sediments and wastes. Services to agriculture and man such as hydroperiod regulation, wind breaks, pest predator habitat, recreation, erosion control, etc.

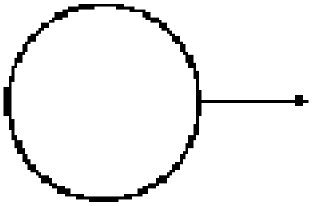
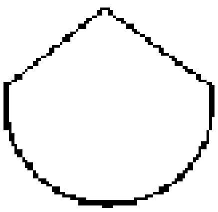
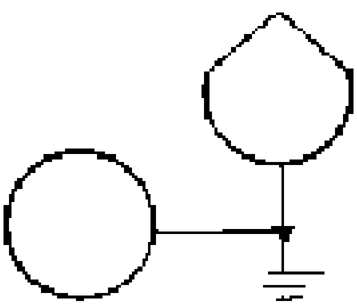
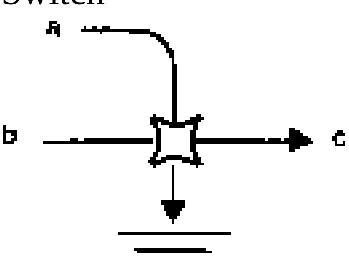
FIGURE 1

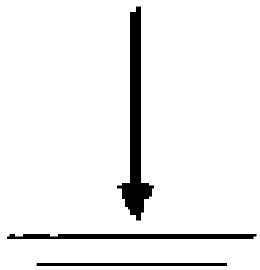
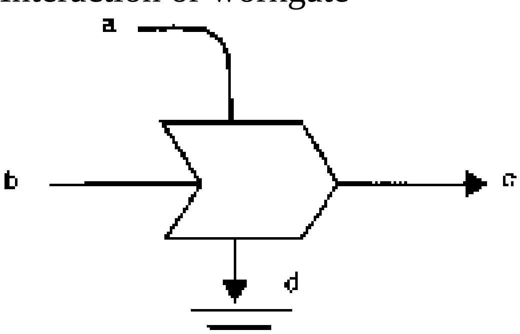
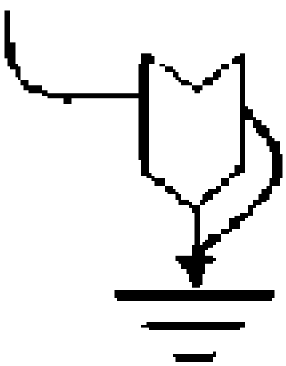
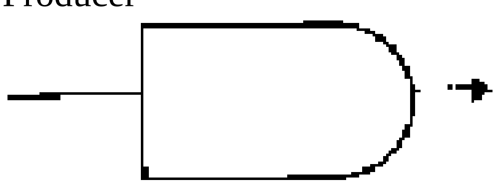
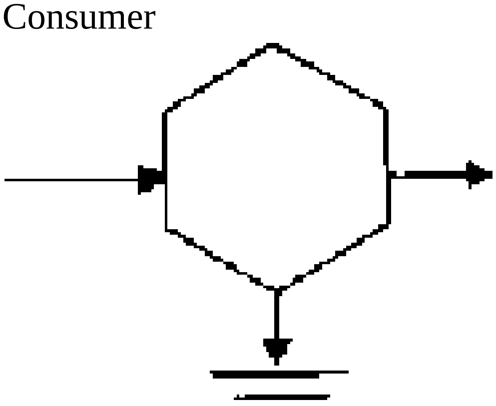
FIGURE 2

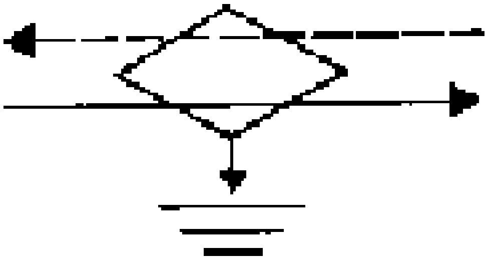
FIGURE 3

FIGURE 4

TABLE 3 - STANDARD SYMBOLS USED IN MODELLING

Energy source or forcing function 	Any source of energy or materials and information with energy content external to the system being studied. The sun and sun derived energies such as wind and rain are considered inexhaustable. Rates of flow are limited and can vary according to intrinsic controls of a predictable nature such as seasons. Earthquakes and hurricanes have frequencies intrinsic to an area. The other major class of energies are those of cultural origin, such as fossil fuels, materials, services, migration and information (technology). Input rates are determined either by policy decisions external to the system or by the ability of the system to attract. Flows are considered to be constant or to vary according to a given program during a given analysis or simulation run.
Energy storage 	The tank-shaped symbol represents any storage of energy, materials or information within a system or system components. Scale may range from the instantaneous biomass of a single plant to that of an entire forest depending on the model. Storages have one or more inputs and outputs and a capacity set by the modeller. Tanks represent structure in many forms, such as a building, the capital assets of a city, ordered information stored in a library or the accumulated experience of a people. A tank without an inflow can represent non-renewable resources.
Energy transformation and storage 	A special case of the previous energy storage symbol. The energy entering (a) via the small triangle is transformed and stored (b) in another form. In keeping with the second law of thermodynamics some of the incoming energy must be degraded (c) in the process of transformation. In Figure 8 incoming oil is transformed by fire partly into heat to warm the house and partly into heat going directly up the chimney.
Switch 	The switch symbol represents an on/off control on an energy flow; switching action (a) determines whether flow (b)-(c) is on or off. Examples include the turning on of fish migration by some cue, the turning on of an irrigation system when soil moisture drops to a determined level and the activation of a crop subsidy.

Heat sink 	The downward pointing arrow represents the degradation of energy into dispersed heat (entropy) associated with work processes in any system as dictated by the second law of thermodynamics. Every development process - the building of structure in a plant, a farm or a region - requires the loss or depreciation of part of the energy available. This is sometimes called an "entropy tax." Energy is constantly entering a system and being stored and transformed. Eventually it leaves the system as either dispersed heat or products bound for some other system. In a steady state inflows equal outflows. For the earth as a whole all energy entering leaves as dispersed heat.
Interaction or workgate 	The workgate symbol represents the interaction of two energy flows in which flow (a) makes possible, increases or reduces (negative impact) flow (b) resulting in a new flow (c) at an entropy cost (d). In a plant, creation of biomass through photosynthesis is represented by a series of workgates in which sunlight interacts with water, CO, and nutrients. Agriculture adds additional work gates for cultivation, pest control, etc.
Stress 	The downward pointing workgate combined with the heat sink symbol represents stress. This is a special case used to make a negative effect more obvious in a model. Disease is a stress on an organism diverting energy from useful work into waste heat. Excess water or drought have the same effect on a crop.
Producer 	This symbol represents a single plant or an entire community which has its basis in photosynthesis. At the regional scale the symbol is used to represent individual ecosystems or combinations; crops, a farm or the agricultural sector.
Consumer 	The hexagonal symbol represents a consumer. A consumer can be a soil microbe, a cow, a human population, a city or an industry. All have in common an outside energy source, depreciation and the output of energy in the form of productions such as minerals, meat, work or tractors.

Economic transactor 	In the part of the system in which man uses money as a means of accounting for flows of goods and services the transactor symbol represents the rate of exchange. Money always flows in the opposite direction to energy.
Non-defined process 	The box is used when it is not important to represent the precise role of a component.

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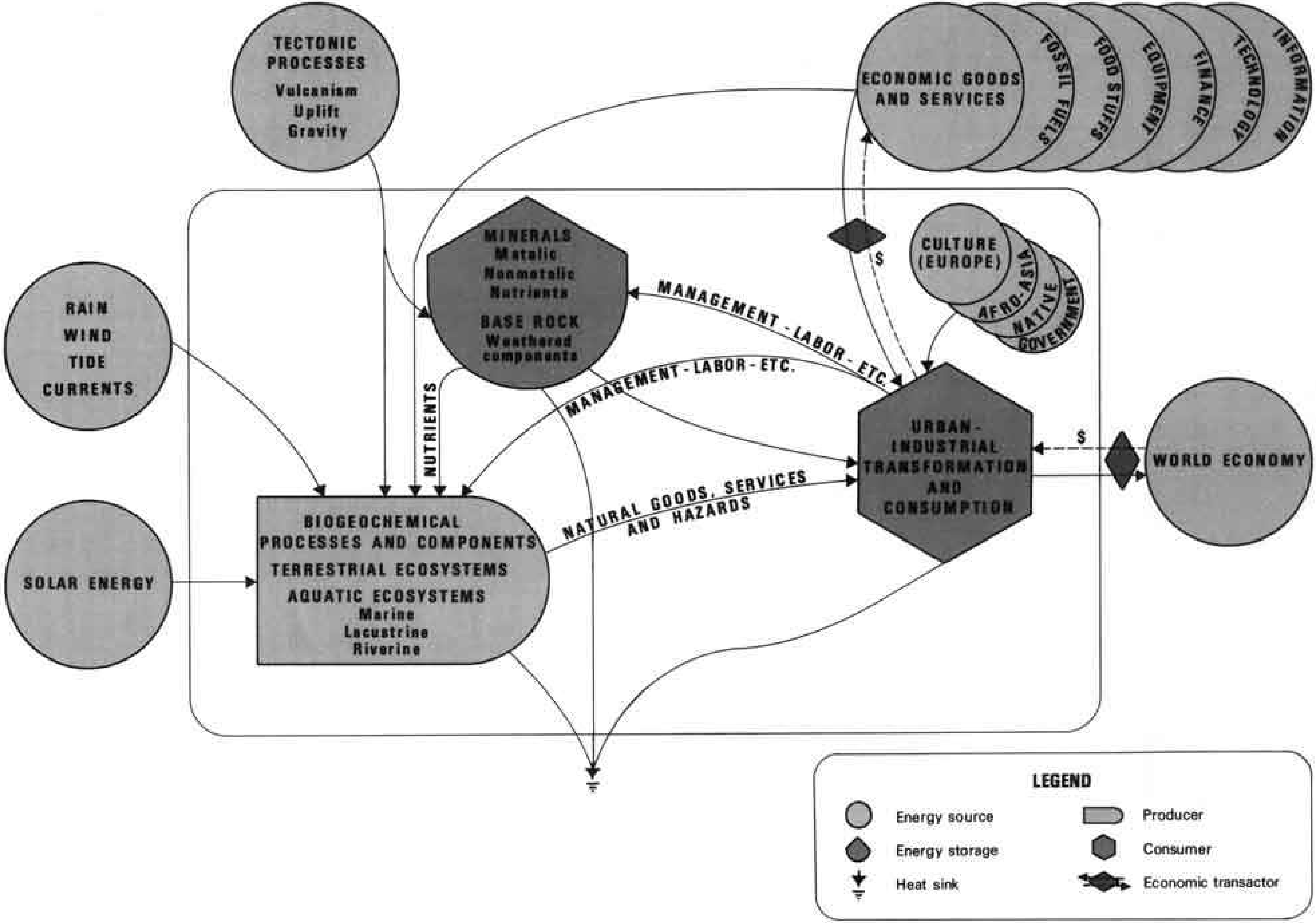
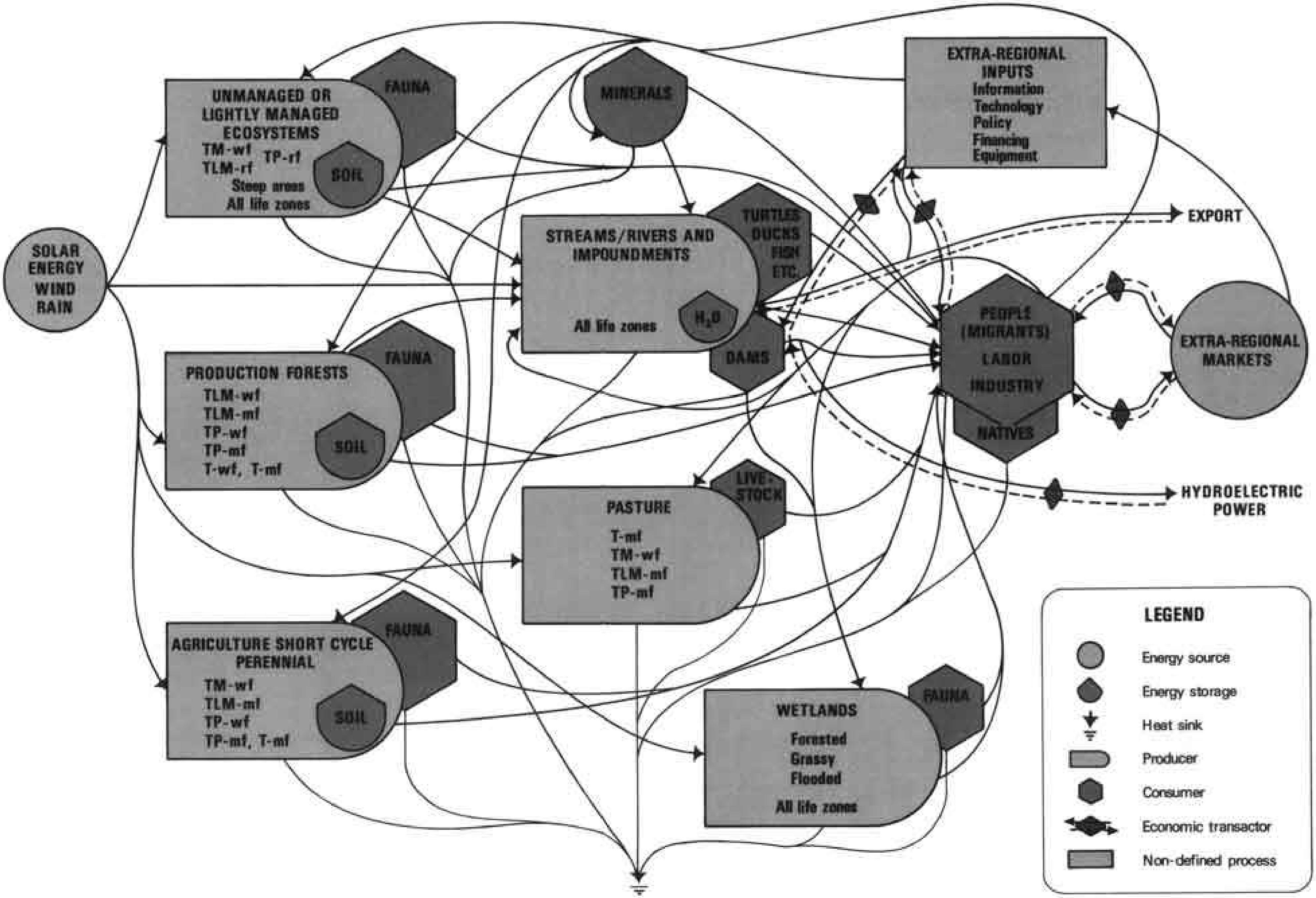
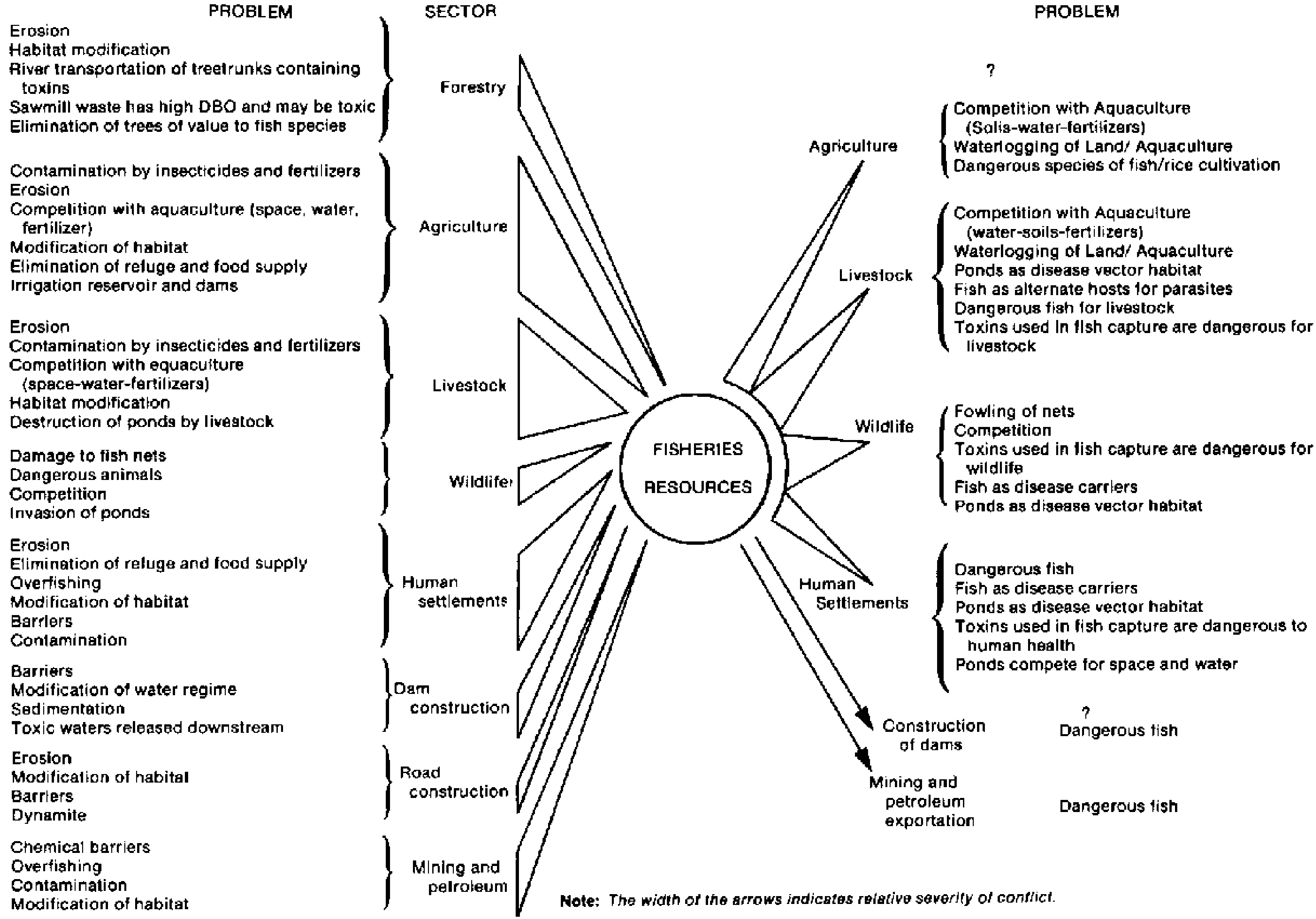
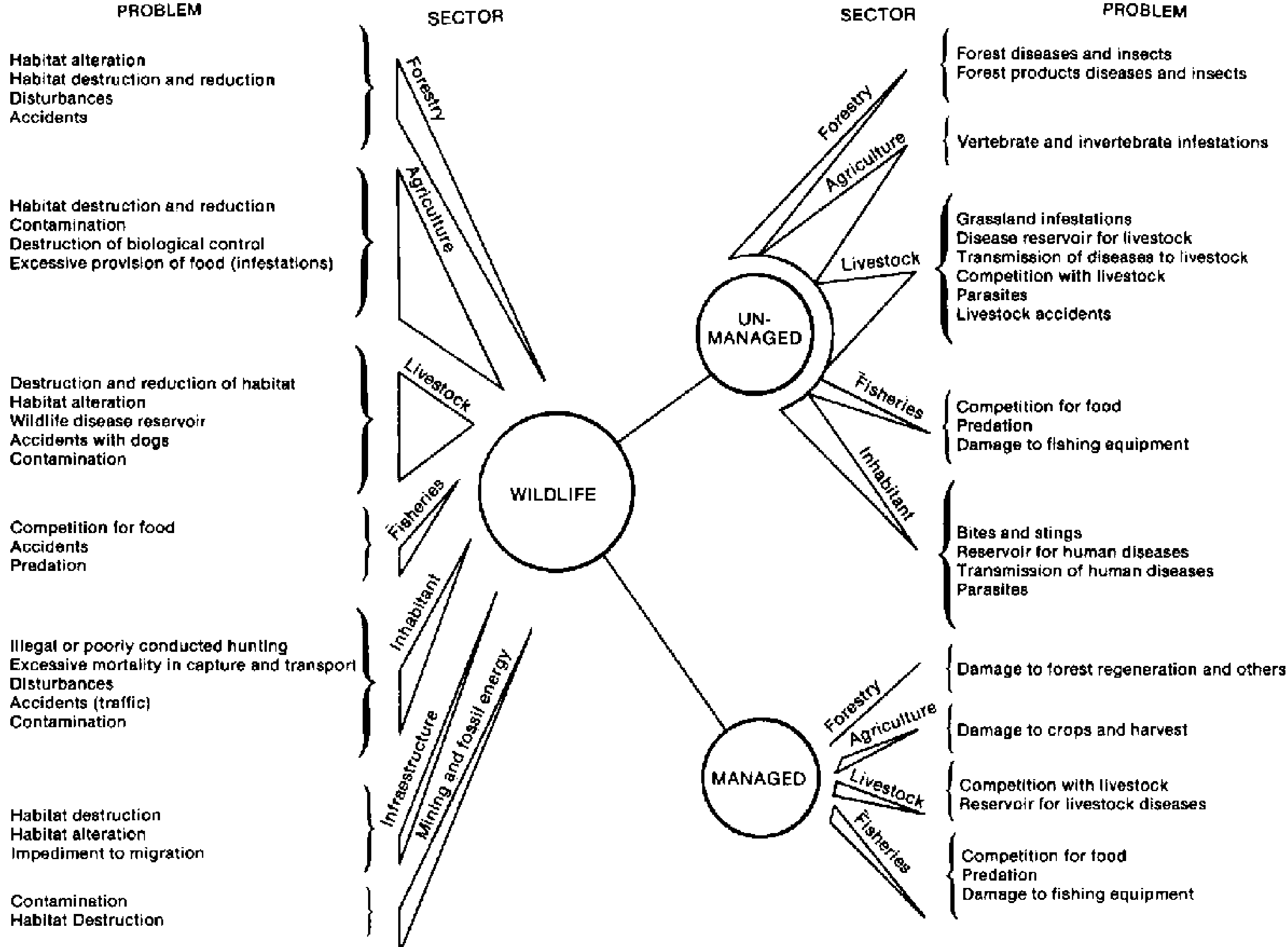
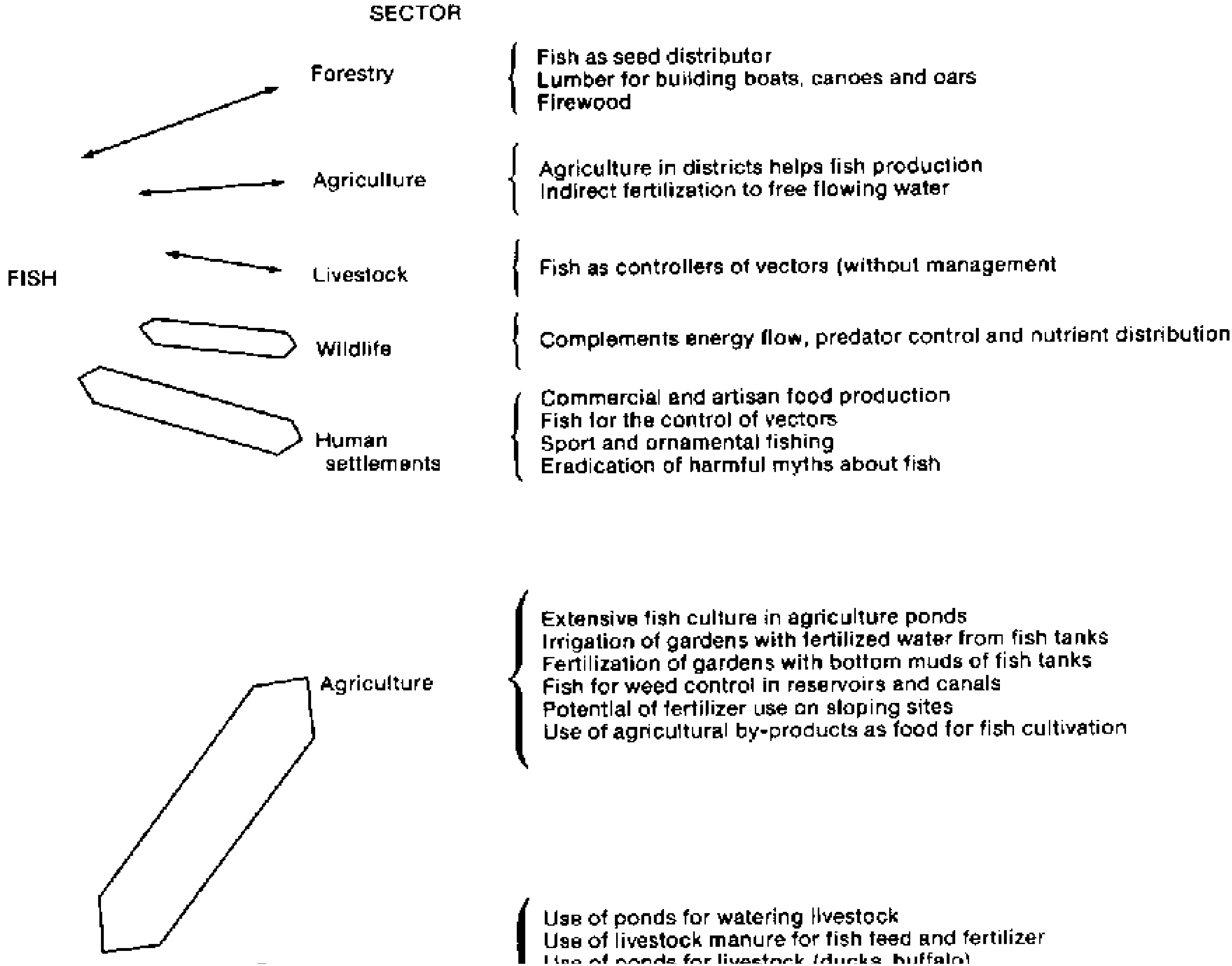

TECTONIC PROCESSES
Vulcanism
Uplift
Gravity
ECONOMIC GOODS AND SERVICES
FOSSIL FUELS
FOOD STUFFS
EQUIPMENT
FINANCE
TECHNOLOGY
INFORMATION
RAIN
WIND
TIDE
CURRENTS
MINERALS
Metalic
Nonmetalic
Nutrients
BASE ROCK
Weathered components
CULTURE (EUROPE)
AFRO-ASIA
NATIVE
GOVERNMENT
$
MANAGEMENT - LABOR - ETC.
MANAGEMENT - LABOR - ETC.
NUTRIENTS
URBAN-INDUSTRIAL TRANSFORMATION AND CONSUMPTION
$
WORLD ECONOMY
NATURAL GOODS, SERVICES AND HAZARDS
BIOGEOCHEMICAL PROCESSES AND COMPONENTS
TERRESTRIAL ECOSYSTEMS
AQUATIC ECOSYSTEMS
Marine
Lacustrine
Riverine
SOLAR ENERGY
LEGEND
Energy source
Producer
Energy storage
Consumer
Heat sink
Economic transactor

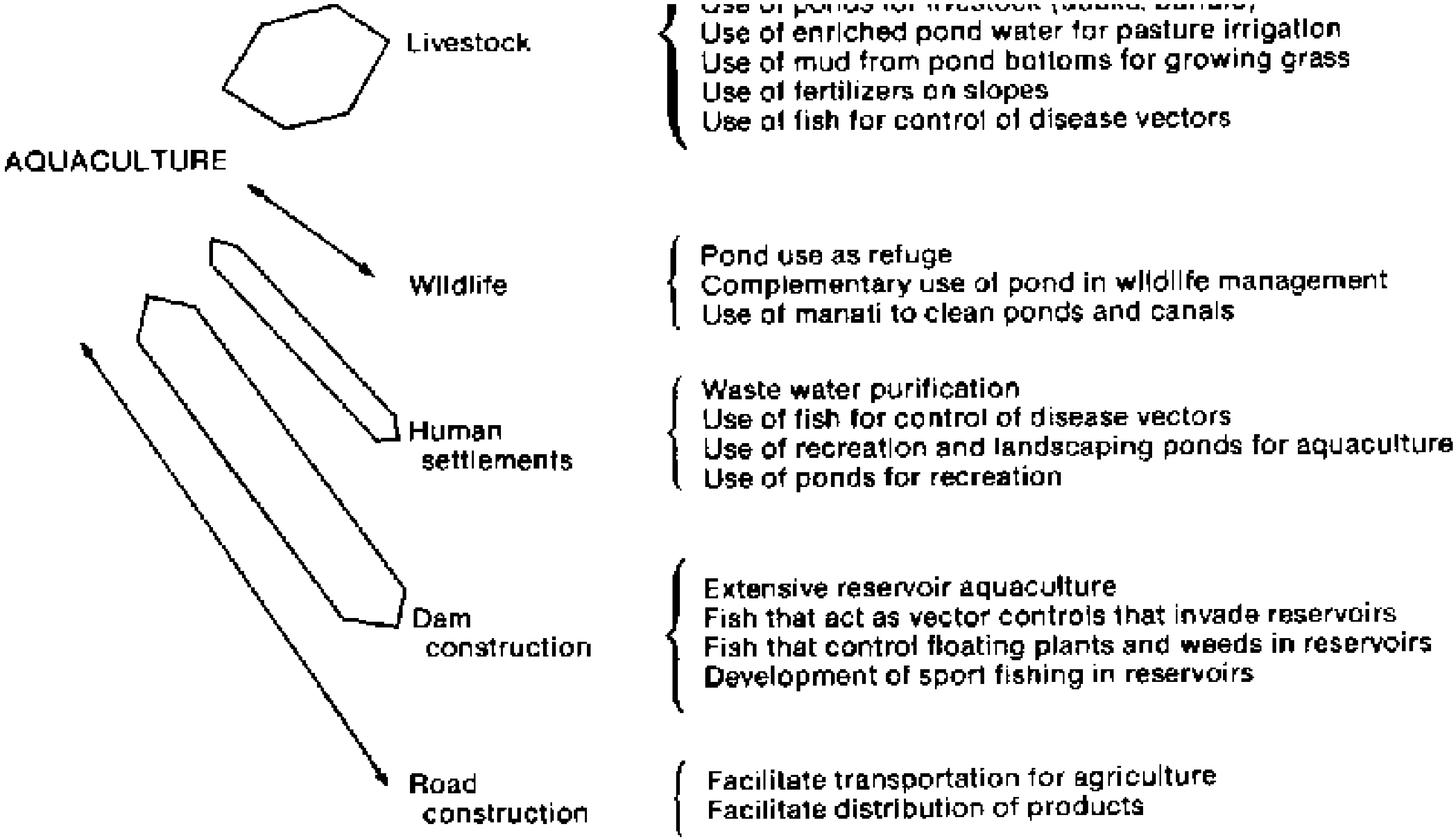

UNMANAGED OR LIGHTLY MANAGED ECOSYSTEMS
TM-wf TP-rf
TLM-rf
Steep areas
All life zones
SOIL
FAUNA
MINERALS
EXTRA-REGIONAL INPUTS
Information
Technology
Policy
Financing
Equipment
SOLAR ENERGY WIND RAIN
STREAMS/RIVERS AND IMPOUNDMENTS
All life zones
H_2O
TURTLES DUCKS FISH ETC.
DAMS
EXPORT
PEOPLE (MIGRANTS)
LABOR
INDUSTRY
NATIVES
EXTRA-REGIONAL MARKETS
PRODUCTION FORESTS
TLM-wf
TLM-mf
TP-wf
TP-mf
T-wf, T-mf
HYDROELECTRIC POWER
PASTURE
T-mf
TM-wf
TLM-mf
TP-mf
LIVE-STOCK
AGRICULTURE SHORT CYCLE PERENNIAL
TM-wf
TLM-mf
TP-wf
TP-mf, T-mf
WETLANDS
Forested
Grassy
Flooded
All life zones
LEGEND
Energy source
Energy storage
Heat sink
Producer
Consumer
Economic transactor
Non-defined process


PROBLEM
SECTOR
PROBLEM
Erosion
Habitat modification
River transportation of treetrunks containing toxins
Sawmill waste has high DBO and may be toxic
Elimination of trees of value to fish species
Forestry
Contamination by insecticides and fertilizers
Erosion
Competition with aquaculture (space, water, fertilizer)
Modification of habitat
Elimination of refuge and food supply
Irrigation reservoir and dams
Agriculture
Erosion
Contamination by insecticides and fertilizers
Competition with equaculture (space-water-fertilizers)
Habitat modification
Destruction of ponds by livestock
Livestock
Damage to fish nets
Dangerous animals
Competition
Invasion of ponds
Wildlife
Erosion
Elimination of refuge and food supply
Overfishing
Modification of habitat
Barriers
Contamination
Human settlements
Barriers
Modification of water regime
Sedimentation
Toxic waters released downstream
Dam construction
Erosion
Modification of habitat
Barriers
Dynamite
Road construction
Chemical barriers
Overfishing
Contamination
Modification of habitat
Mining and petroleum
FISHERIES RESOURCES
?
Agriculture
Competition with Aquaculture (Solis-water-fertilizers)
Waterlogging of Land/ Aquaculture
Dangerous species of fish/rice cultivation
Livestock
Competition with Aquaculture (water-soils-fertilizers)
Waterlogging of Land/ Aquaculture
Ponds as disease vector habitat
Fish as alternate hosts for parasites
Dangerous fish for livestock
Toxins used in fish capture are dangerous for livestock
Wildlife
Fowling of nets
Competition
Toxins used in fish capture are dangerous for wildlife
Fish as disease carriers
Ponds as disease vector habitat
Human Settlements
Dangerous fish
Fish as disease carriers
Ponds as disease vector habitat
Toxins used in fish capture are dangerous to human health
Ponds compete for space and water
Construction of dams
?
Dangerous fish
Mining and petroleum exportation
Dangerous fish
Note: The width of the arrows indicates relative severity of conflict.

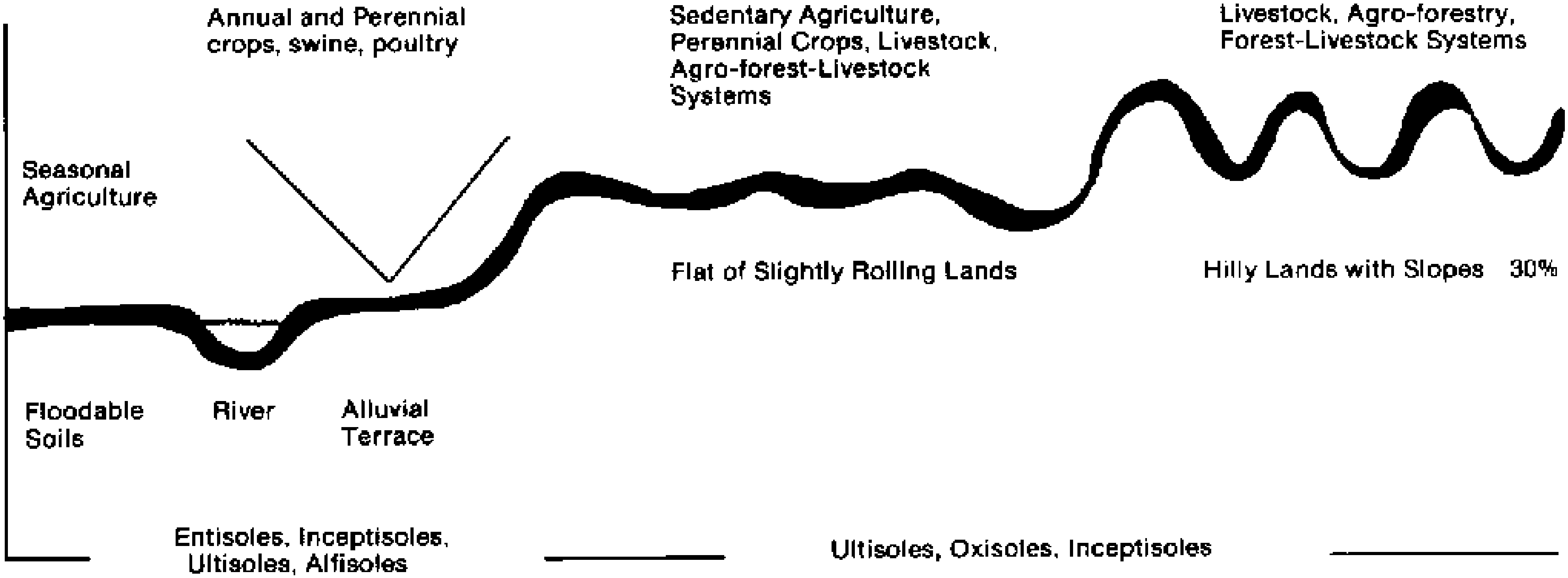


Note: *Width of arrow indicates relative value of relationship.*


SECTOR
FISH
Forestry
Fish as seed distributor
Lumber for building boats, canoes and oars
Firewood
Agriculture
Agriculture in districts helps fish production
Indirect fertilization to free flowing water
Livestock
Fish as controllers of vectors (without management
Wildlife
Complements energy flow, predator control and nutrient distribution
Human settlements
Commercial and artisan food production
Fish for the control of vectors
Sport and ornamental fishing
Eradication of harmful myths about fish
Agriculture
Extensive fish culture in agriculture ponds
Irrigation of gardens with fertilized water from fish tanks
Fertilization of gardens with bottom muds of fish tanks
Fish for weed control in reservoirs and canals
Potential of fertilizer use on sloping sites
Use of agricultural by-products as food for fish cultivation
Use of ponds for watering livestock
Use of livestock manure for fish feed and fertilizer



Note: Width of arrow indicates relative value of relationship.

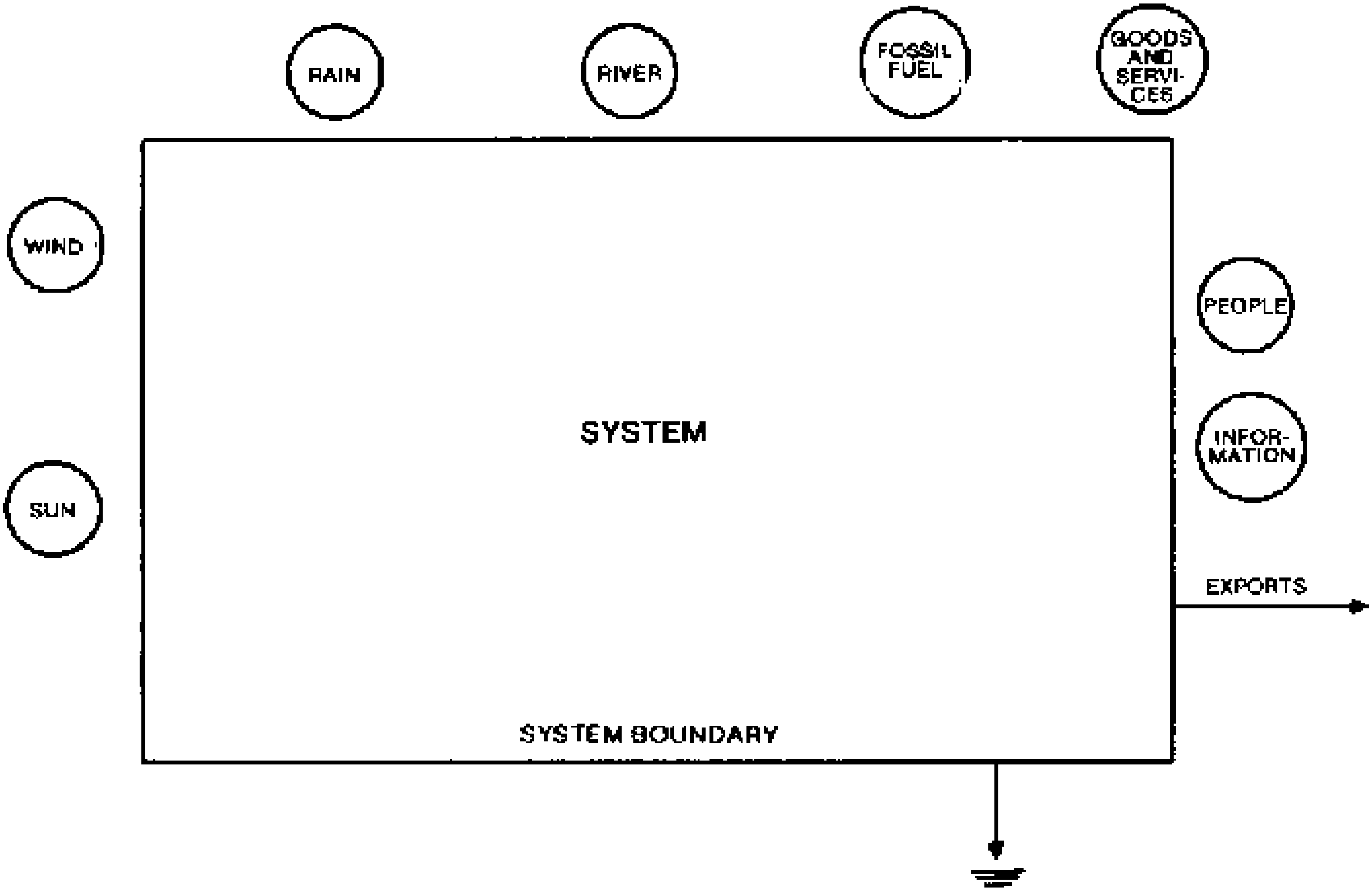


Annual and Perennial crops, swine, poultry
Sedentary Agriculture, Perennial Crops, Livestock, Agro-forest-Livestock Systems
Livestock, Agro-forestry, Forest-Livestock Systems
Seasonal Agriculture
Flat of Slightly Rolling Lands
Hilly Lands with Slopes 30%
Floodable Soils
River
Alluvial Terrace
Entisoles, Inceptisoles, Ultisoles, Alfisoles
Ultisoles, Oxisoles, Inceptisoles

Glossary

Development	A process made up of activities leading to the use, improvement, or conservation of natural and economic goods and services in order to maintain and improve human life quality.
Ecology	The study of the interrelationships of organisms to one another and to their environments. The study of the structure and function of ecosystems.
Ecosystem	A unit of space defined by an interacting, interdependent complex of physical and biotic components and processes that have created characteristic energy flows and material cycling or movement.
Environment (Human)	The aggregate of all conditions and influences affecting the behavior and development of humans as individuals and as societies.
Environmental Management	The mobilization of resources and the use of government to control the use, improvement or conservation of both natural and economic goods and services in such a way that conflicts created by that use, improvement or conservation are minimized.
Environmental Quality	The relative capability of an environment to satisfy the needs and wants of an individual or society.
Environmentally Sound Development	A process wherein ecosystem structure and function are manipulated to appropriate the goods and services offered by the ecosystem in question while minimizing any conflict inherent in the appropriation of these goods and services.
Holocoenosis	Refers to the nature of any environment in which the various factors of that environment act as an interacting, integrated system.
Negative Environmental Impact	The destruction, impoverisment, or enforced non-use of natural and economic goods and services whether the result of human activity or of natural hazardous events.

Sector	Used in several ways: economically as the primary, secondary, and tertiary sectors; spatially; and topically to indicate any division of human activity (or any interest group) that provides for the protection or promulgation of its interests. This last usage is the most frequent in this volume.
Spontaneous Migration	Unauthorized and unplanned movement to sparsely populated areas for relatively short periods by landless peasants for the purpose of subsistance agriculture or by land speculators who hope to turn a profit with the later sale of title or usary rights.
Systems Goods and Services	Specific components and processes of ecosystem structure and function that are of interest to, or have value for, an individual or group of individuals. They may be natural or economic.


RAIN
RIVER
FOSSIL FUEL
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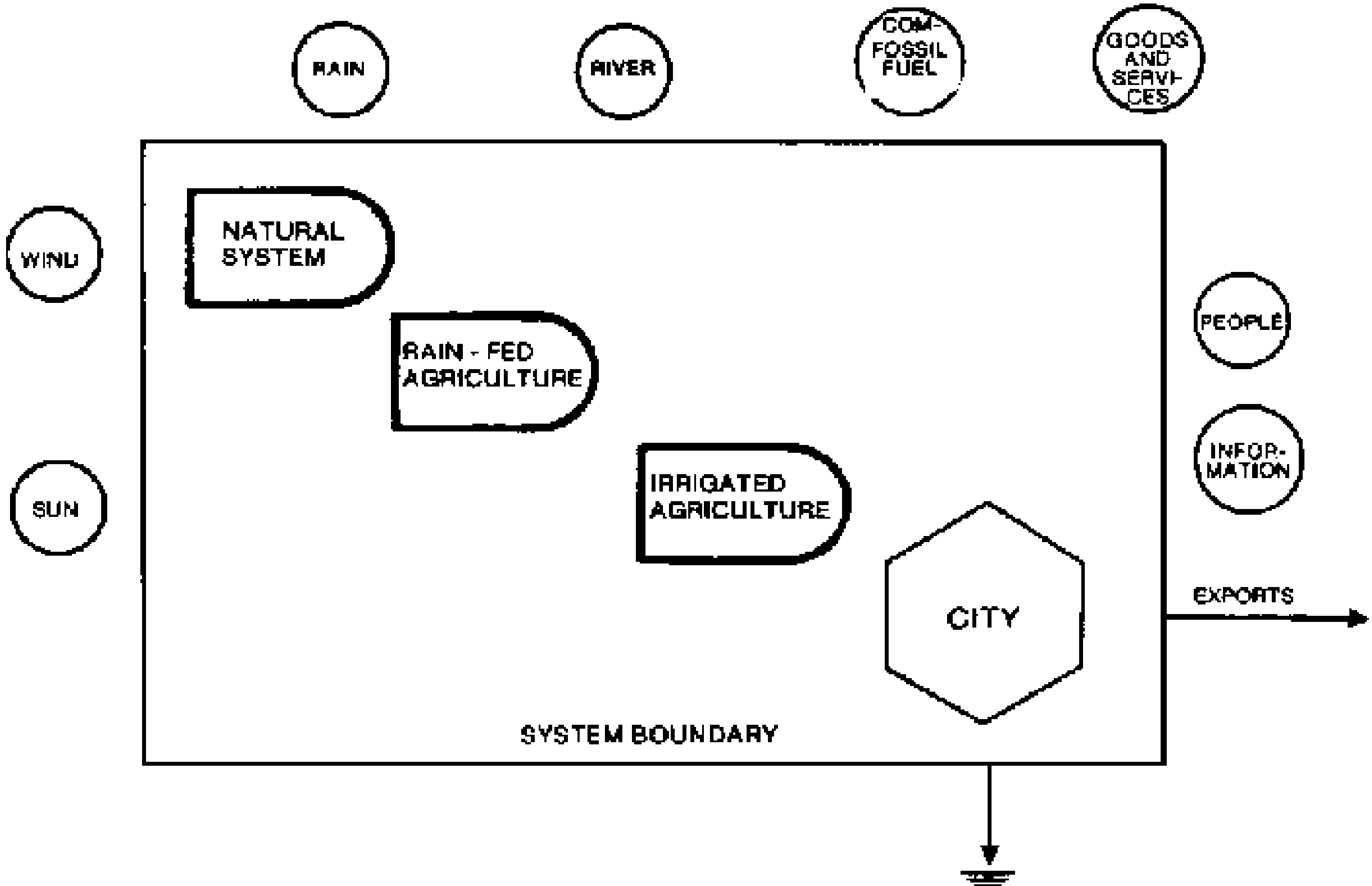
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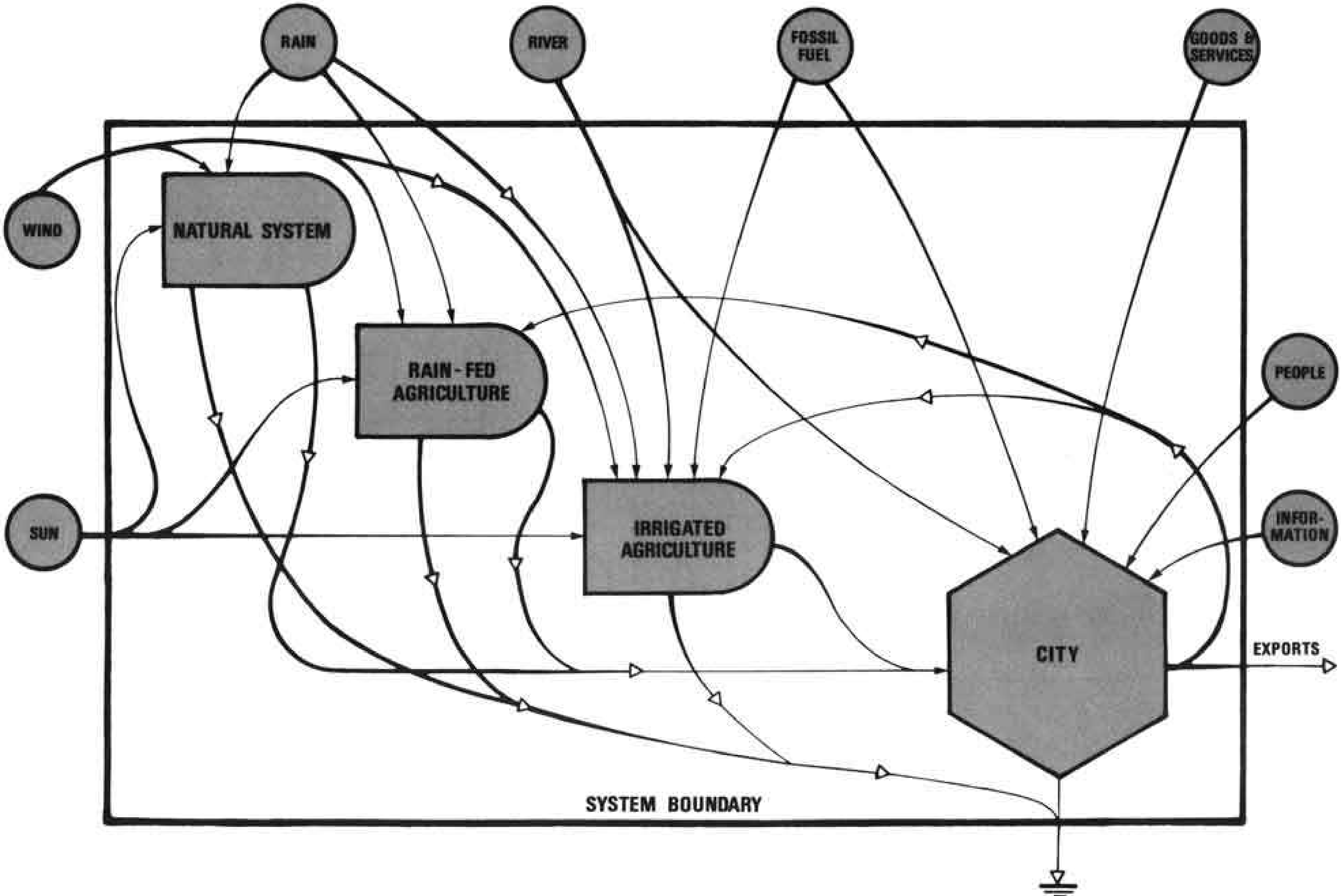
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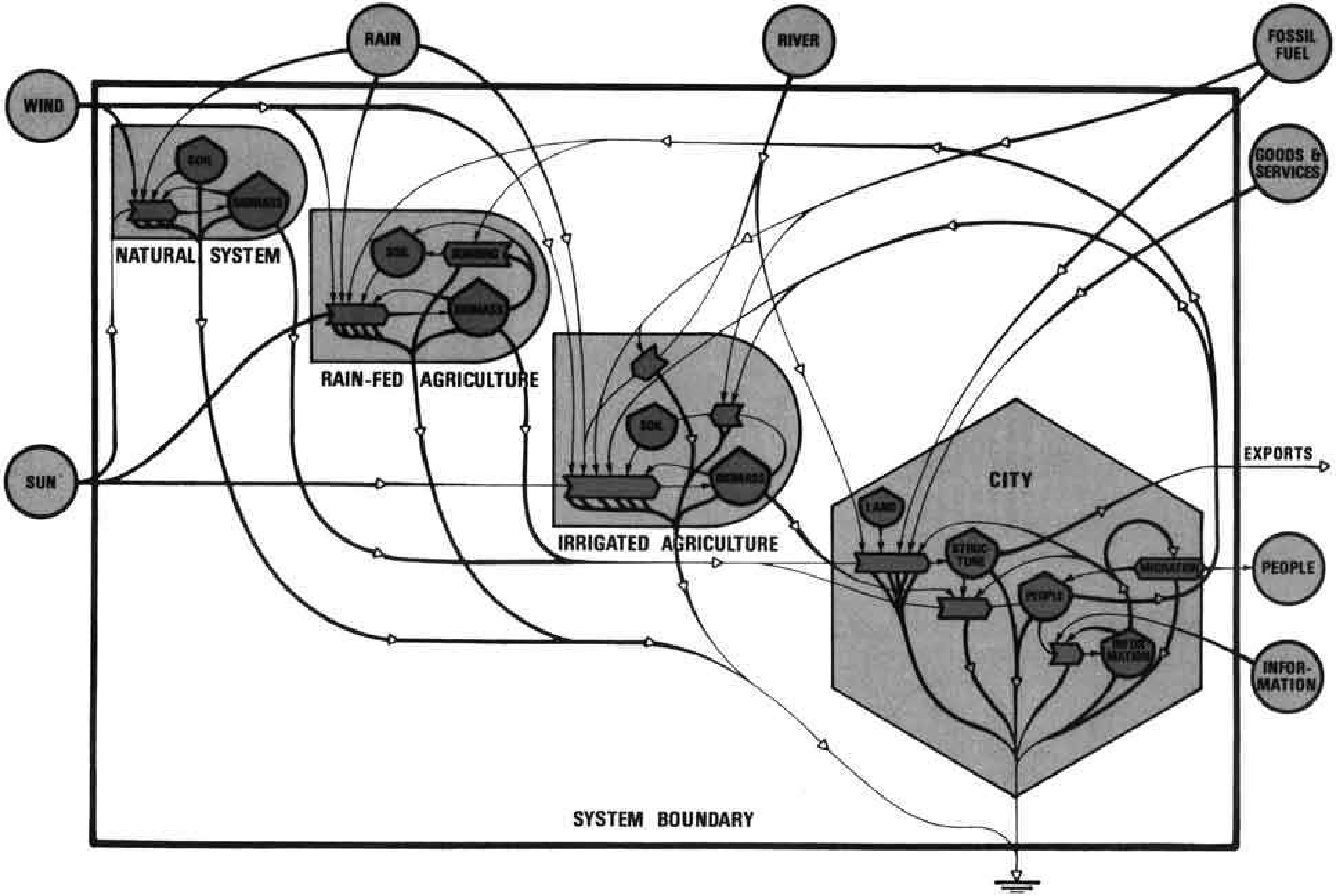
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SYSTEM BOUNDARY

Abbreviations

AID	United States Agency for International Development
CD	Center of Development
CDR	Center of Rural Development
CENFOR	Forestry Center
CEC	Cation Exchange Capacity
CIPA	Center of Agrarian Research and Promotion
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
DBH	Diameter at breast height
DL	Law Decree
DMSO	Dimethyl-Sulfoxide
DS	Supreme Decree
ELECTROPERU	Electric Company of Peru
EPS	Social Property Corporation
FAO	Food and Agriculture Organization
IBRD	International Bank for Reconstruction and Development
IDB	Inter-American Development Bank
INAF	National Institute for Agricultural Frontier Expansion
INCRA	National Institute of Colonization and Agrarian Reform
INDA	National Agro-Industry Development Institute
INFOR	National Forest and Wildlife Institute
INIPA	National Agrarian Research and Promotion Institute
ITINTEC	Technical Research on Industrial Standards
IUCN	International Union for Conservation of Nature and Natural Resources
MTC	Ministry of Transport and Communication
NAS	National Academy of Sciences
OAS	Organization of American States
ONERN	National Office for Natural Resource Evaluation
PEA	Economically Active Population
PEPP	Pichis-Palcazu Special Project

PIC	Integrated Colonization Project
UNEP	United Nations Environment Programme
UNESCO	United Nations Education, Science and Cultural Organization
USCEQ	United States Council for Environmental Quality

THE ORGANIZATION OF AMERICAN STATES

The purposes of the Organization of American States (OAS) are 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.

To achieve these objectives, the OAS acts through the General Assembly; the Meeting of Consultation of Ministers of Foreign Affairs; the three Councils (the Permanent Council, the Inter-American Economic and Social Council, and the Inter-American Council for Education, Science, and Culture); the Inter-American Juridical Committee; the Inter-American Commission on Human Rights; the General Secretariat; the Specialized Conferences; and the Specialized Organizations.

The General Assembly holds regular sessions once a year and special sessions when circumstances warrant. The Meeting of Consultation is convened to consider urgent matters of common interest and to serve as Organ of Consultation in the application of the Inter-American Treaty of Reciprocal Assistance (known as the Rio Treaty), which is the main instrument for joint action in the event of aggression. The Permanent Council takes cognizance of matters referred to it by the General Assembly or the Meeting of Consultation and carries out the decisions of both when their implementation has not been assigned to any other body; monitors the maintenance of friendly relations among the member states and the observance of the standards governing General Secretariat operations; and, in certain instances specified in the Charter of the Organization, acts provisionally as Organ of Consultation under the Rio Treaty. The other two Councils, each of which has a Permanent Executive Committee, organize Inter-American action in their areas and hold regular meetings once a year. The General Secretariat is the central, permanent organ of the OAS. The headquarters of both the Permanent Council and the General Secretariat is in Washington, D.C.

The Organization of American States is the oldest regional society of nations in the world, dating back to the First International Conference of American States, held in Washington, D.C., which on April 14, 1890, established the International Union of American Republics. When the United Nations was established, the OAS joined it as a regional organization. The Charter governing the OAS was signed in Bogota in 1948 and amended by the Protocol of Buenos Aires, which entered into force in February 1970. Today the OAS is made up of thirty-two member states.

MEMBER STATES: **Antigua and Barbuda, Argentina, The Bahamas, (***Commonwealth of***), Barbados, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominica, (***Commonwealth of***), Dominican Republic, Ecuador, El Salvador, Grenada, Guatemala, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, St. Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago, United States, Uruguay, Venezuela.**