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THE ENVIRONMENTAL DIMENSION IN AGRICULTURAL DEVELOPMENT PROJECTS

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CONTENTS

I. INTRODUCTION

In recent years, environmental factors have been conspicuously neglected in development projects prepared in the Latin American and Caribbean region. This failing has often not only led to unintended destruction and degradation of the environment but has also frequently hindered the attainment of objectives and, in extreme cases, has resulted in the failure of such projects.

Since forestry and agricultural development projects are by no means an exception in this respect, it would be well worth the effort to explore the question of incorporating the environmental dimension into such projects; this document hopes to help achieve that goal.

The study is divided into four chapters. The first chapter discusses the fundamental concepts involved in the incorporation of the environmental dimension into agricultural development projects. The second looks at the factors, and their trends, necessary for an environmentally sustainable development. The third chapter is devoted to an analysis of four project simulations based on actual cases; in the course of this analysis the characteristics of these projects are described and some ideas are set forth as to how environmental considerations might be more fully incorporated. The fourth chapter draws conclusions from the examination of the above-mentioned cases.

Based on the recommendations presented in this document, the next step would be to develop more specific methodological guidelines for the incorporation of the environmental dimension into forestry and agricultural development projects.

II. BASIC CONCEPTS REQUIRED FOR THE INCORPORATION OF THE ENVIRONMENTAL DIMENSION INTO DEVELOPMENT PROJECTS

The aim of this section is to briefly define a number of concepts that are basic to any discussion of the incorporation of the environmental dimension into development projects. In order to make it easier to grasp these basic concepts, numerous examples are provided.

A. THE ECOSYSTEM

1. Definition

Various definitions of the concept of an ecosystem are to be found in the literature. In view of its practicality and clarity, the definition formulated by Nava, Armijo and Gastó (1979) has been chosen for the purposes of this study. According to their definition, an ecosystem is a set of biotic (living) and abiotic (inert) components connected or related in such a way that they act as or constitute a unit or a whole. The relationship or connection among these components necessarily involves a transfer of matter, energy and information. The transfer of matter and energy is relatively easy to visualize (for example, the flow of solar energy through plants, herbivores, carnivores and agents of decomposition). The same cannot be said of the transfer of information, however, which is a more complicated concept. Information may be understood here as the way in which the matter and energy in an ecosystem are organized. An example of information transfer among components of an ecosystem is the genetic exchange between individuals of the same species. This mechanism permits the development of two of nature's essential processes, evolution and speciation. Another example which may give a clearer picture of this concept of information is that of a tropical rainforest, which is more diverse and complex --and hence contains more "information"-- than a forest plantation of a single specie of tree. One way of visualizing this greater information content is to consider the fact that if models were to be built which simulated the total productivity of both ecosystems, the model of the forest plantation would be much simpler and would require the input of fewer bytes of information into the computer.

2. The ecosystem as a model

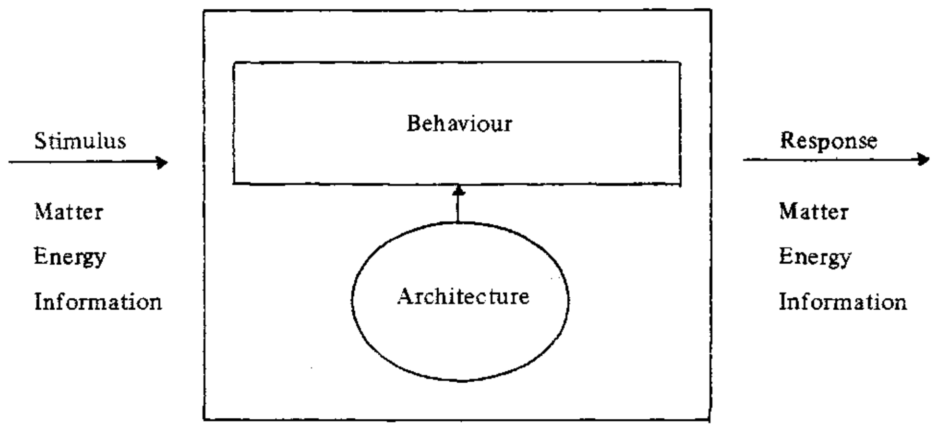
The concept of an ecosystem is of practical use in solving problems when it is conceived of as a model containing the three elements of the above definition: a) it has biotic and abiotic components; b) these components are connected and; c) the system constitutes a unit or a whole.

Ecosystems, understood in this way, can be of different sizes. A pasture, a plot of land, a reservoir, a river basin, a province, a country, a group of countries or even the planet as a whole can be modelled and studied as ecosystems. The minimum size of an ecosystem is determined only by the size necessary to maintain the basic constituent parts of the system (Gastó, 1980).

One concept which is crucial to the understanding of an ecosystem as a model is that no ecosystem is completely independent. All ecosystems are connected to other systems through the exchange of matter, energy and information (Gastó, 1980).

Of the various types of ecosystem models that have been put forth, the "black box" models are particularly suited to the purposes of this study. The "black box" model depicts an ecosystem as a black box into which a number of stimuli or inputs are introduced and which produces a number of responses or outputs (Nava, Armijo and Gastó, 1979). As shown in figure 1, these ecosystem inputs and outputs take the form of matter,

Figure 1



The black box ecosystem model as modified by Nava, Armijo and Gastó (1979).

energy and information. Information is a component of these stimuli and responses insofar as the matter and energy which go into and come out of the system have a measure of organization or information content.

A maize crop can be used as an example to illustrate black box models. In this case the stimuli would be solar radiation, the water provided by rainfall and irrigation, and any other inputs supplied by man (e.g., fertilizers, insecticides, etc.). The main response from this agrosystem would be maize (grain and fodder). However, there may be other less obvious responses as well, such as the nutrients which are lost through leaching, the soil particles which are lost through erosion, etc.

The "black box" contains two basic forces which define the state of the ecosystem at any given time. One is the architecture, or anatomical and morphological aspect of the ecosystem, i.e., the biotic and abiotic components of the system and their spatial organization. The other is the behaviour or operation of the ecosystem, i.e., the physiology of the system or how matter, energy and information are transported and transformed (Nava, Armijo and Gastó, 1979). What links the two together is the fact that the way in which the ecosystem operates is determined by its architecture. Thus, the responses of the ecosystem depend on its architecture and the stimuli it receives.

Black box models will be discussed later on in this study in connection with ecosystem artificialization.

B. ECOLOGICAL SUCCESSION

In traditional ecology, the fully-developed or climax states of an ecosystem were regarded as static phases in which the various components of the ecosystem were in perfect equilibrium. Succession was also seen as a deterministic rather than a probabilistic process whereby ecosystems evolved gradually over time from pioneer states through various intermediate phases to climax states. Within this scheme of things, any natural disturbance (such as a volcanic eruption, earthslide, hurricane, etc.) or anthropic disturbance (such as fires caused by man, grazing, logging, etc.) was seen as an accident that either diverted the ecosystem from its inexorable march towards its climax or else destroyed that climax. Recently, however, a new ecological paradigm has been developed whereby succession is seen as a probabilistic process. This theory thus seeks to incorporate such disturbances into our understanding of ecosystem dynamics. This was what gave rise to the concept of a pattern of disturbances, which refers to the distribution of disturbances over time and space (Picket and White, 1985). The pattern of disturbances is determined by such parameters as area, spatial distribution, frequency and the predictability of each category or type of disturbance (e.g., fires, earthslides, etc.) (Picket and White, 1985). Knowledge of such parameters is crucial to an understanding of the dynamics of the ecosystems in a given area, which should be taken into consideration in resource-use planning. In Latin America various studies have been conducted on ecosystem dynamics as a function of repeated disturbances, e.g., studies concerning the relationship between the dynamics of forests in southern Chile and the occurrence of earthslides caused by earthquakes (Veblen and Ashton, 1979; Veblen et al., 1981; Veblen, 1985) as well as studies of the Andes in the northern Patagonian region of Argentina which examine fire-induced disturbances.

In recent years, ecosystems in the more advanced stages of their evolution have come to be considered as being in a state of dynamic equilibrium, and it is thus more appropriate to describe them as mature or "steady-state" ecosystems rather than as being in "climax" states.

C. STABILITY AND RESILIENCE

Not all disturbances produce changes in the ecosystem's parameters. In other words, ecological systems have a certain ability to withstand external disturbances. The following terms have been proposed as descriptions of this ability: stability, resistance and resilience. Stability or resistance is the ability of an ecosystem to "absorb" certain disturbances and remain unchanged. For example, the stability of an open latifoliate forest when there is a fire is greater than that of a dense coniferous forest. Resilience, on the other hand, is the ability of the ecosystem to fluctuate within certain limits and regain its original state after the occurrence of a disturbance. Such resilience operates within certain limits. If a disturbance's intensity exceeds those limits, the ecosystem is unable to recover its pre-disturbance state and consequently deteriorates to more pioneer successional states. The limits of resilience differ from ecosystem to ecosystem, as does the speed of recovery. For example, if rangelands in a humid climatic zone having a thick layer of topsoil are subjected to intensive grazing and then left untouched for a time, the original composition and biomass can be recovered quickly. On the other hand, if sparse rangelands in a semi-arid zone with little topsoil are grazed to the same extent, a process of erosion may be triggered which could result in an ecosystem with shallower and less fertile soil and rangelands of a poorer composition and lower productivity. In the latter case, the recovery of the ecosystem would probably involve costly soil and rangeland conservation measures and would take a long time.

D. ECOSYSTEM PRODUCTIVITY VERSUS ECOSYSTEM HARVESTING

Ecosystems receive a series of stimuli (solar radiation, water, nutrients, etc.) and are capable of producing a response in the form of an increase in the biomass of their various animal and plant populations. This increase in biomass is referred to as "production" or "productivity" when expressed in annual terms (normally as grammes per square metre or tons per hectare). Production is the result of a complex process of transformation of matter, energy and information which occurs in an ecosystem. The counterpart of this increase in biomass is a decrease in biomass (as a result of death and decomposition) which is called "respiration" of the ecosystem. The total productivity of an ecosystem is called its gross productivity. Its net productivity is its gross productivity minus respiration. Thus, for example, even though gross productivity might be high in a mature ecosystem, it is equalled by respiration, and its net productivity will therefore fluctuate around a level near zero and its total biomass will remain constant. In a pioneer ecosystem respiration is very low, and its net productivity will thus be high, which will lead to an accumulation of biomass. This is precisely one of the reasons why man farms and maintains pioneer ecosystems. Moreover, agricultural systems are designed in such a way that a considerable part of this productivity is of direct benefit to man. On the other hand, in a mature and diverse ecosystem (such as a tropical forest) only a small percentage of total productivity can be used by man.

Harvesting should be understood in this context, as the withdrawal by man at a given point in time of part of the biomass from the ecosystem. In the case of annual crops, it is easy to perceive this relationship, since the harvest normally is equivalent to productivity. Thus, for example, in the case of a maize crop, 10 tons of grain per hectare may be produced and harvested annually. However, in the case of the exploitation of many other resources, such as natural forests, harvests have often far outstripped the natural productivity of the ecosystem. In these instances, what is being harvested is not only the ecosystem's annual productivity, but also the biomass and soil developed over centuries or millennia. This has been defined as ecosystem harvesting (Gligo, 1986), which involves a decrease in the ecosystem's resource base and productivity. If natural forests, the sea and other resources are to be managed in such a way as to obtain continuing harvests over time, the ecosystem must be viewed as an asset from which every so often (once a year or even once every 20 years) the productivity accumulated during that period can be harvested without causing the ecosystem to deteriorate. Thus, for example, if the productivity of a given area of natural forest is 8 cubic metres of marketable timber per hectare per year, the forest can be divided into 10 plots. From each plot 80 m^3/hectare can be harvested every ten years, which will amount to the cumulative productivity of the area during that period. Since there are 10 plots, the harvesting of 80 m^3/hectare per year from a tenth of the total surface area can be carried out on a sustained basis without causing the forest to deteriorate. Using the same example, if the total surface area being managed were 200 hectares, then 1 600 m^3 could be harvested per year from each 20-hectare plot. It should be noted that in this example the forest's total volume of timber, "the asset", would be some 500 m^3/hectare.

E. ARTIFICIALIZATION OF ECOSYSTEMS

1. Definition

A simplified definition of artificialization based on that formulated by Gastó (1979) is the following: artificialization is the transformation of an ecosystem subsequent to any human intervention on it. Every forestry or agricultural activity artificializes the ecosystem to some extent (Gligo, 1986). Ecosystems that have been transformed for purposes of forestry and agricultural production are called agrosystems.

An important concept in the study of the transformation of ecosystems is the extent of artificialization, which would correspond to the intensity of the transformation of a natural ecosystem. There is thus a continuum of ecosystems ranging from those that have not been artificialized by man (for instance a virgin forest or the summit of an explored mountain), slightly artificialized ecosystems (for example, natural rangelands used as pasture, or natural forests where selective management is practised), and moderately artificialized ecosystems (e.g., extensive cropping farmland) to highly artificialized ecosystems such as greenhouses. Other man-made systems such as large cities would also fall into the category of highly artificialized ecosystems which depend completely on inputs of enormous quantities of matter, energy and information by man.

The simple black box model that was discussed earlier provides a clear picture of the process of transforming ecosystems. The basic objective of artificialization is to modify the response of the system (for instance, a system that in its natural state would have a diversified output which is made to produce large quantities of a single product for human consumption or for sale on the market, such as cereals, meat, fibres, etc.). To do this, the way a system operates has to be transformed, and this is accomplished by modifying its architecture. In order to maintain this man-made architecture and form of operation, stimuli such as irrigation water, fertilizers and pesticides have to be constantly added. The more artificialized a system is, the less stable and resilient it will be (in the case of, for example, drought or disease) and hence, the greater the amount of additional stimuli it will require. Highly artificialized agrosystems are heavily dependent upon man, and if the necessary stimuli are not introduced in the appropriate quantities and at the right times, production falters.

The concepts of the black box model have another practical implication for the management of ecosystems. The productivity of an agrosystem can be increased through: a) the introduction of changes into the architecture of the system; b) the addition of stimuli; and c) a combination of changes in architecture and the addition of stimuli. Usually, changes in an ecosystem's architecture require greater initial investments but last longer. A practical example of this is that the productivity of a given area of rangeland could be increased either through periodic fertilization or by planting leguminous trees in an open pattern to reduce the leaching of soil nutrients and increase the nitrogen supply (through nitrogen-fixing bacteria). In the latter case, a change would be made in the architecture of the system which would increase productivity on a more permanent basis.

2. Is there an "optimum" degree of artificialization? For human society to survive and develop, vast ecosystems have to be transformed or artificialized for the production of food, fibres, timber, minerals and so on and for the settlement of the human population. Ever since the birth of agriculture there have been cases of successful artificialization of specific ecosystems, such as terrace farming in the Peruvian and Bolivian Andes or the floating gardens ("chinampas") of Mexico, which were highly transformed or artificialized ecosystems. On the other hand, in almost all countries of Latin America there are also disastrous examples of ill-guided attempts to farm forest land rather than opting for a lesser degree of artificialization (e.g., forest management). Hence, in planning the use of forest and agricultural resources, two fundamental decisions have to be taken: a) what extent of artificialization is appropriate for each ecosystem, and b) what is the most suitable process for achieving a given degree of artificialization (Gligo, 1986). As far as the optimum degree of artificialization is concerned, there are no absolute rules or "recipes", and economic and social factors will have to be taken into account, along with ecological considerations. Nevertheless, a general guideline is that in the case of highly productive land having few limitations (e.g., Group I and II soils) the level of artificialization should usually be high and the addition of inputs would be fully justified. At the other extreme, in the case of land with severe use limitations (Group VII and VIII soils) the ecosystem should usually be maintained at a low degree of artificialization.

At this point it should be noted that research and development of "technological packages" has focused mainly on highly artificialized systems of production. Thus, much is known about intensive cultivation in irrigation zones and about forest plantations, but information on the management of natural forests and rangelands is still very scanty. Therefore, the management of ecosystems with use limitations, which normally account for much greater area than highly productive lands, is a very important question to address, and a considerable amount of innovation will be required in order to do so. It is also essential to draw upon the experience of peasant communities in this connection, many of which have inherited age-old systems of cultivation such as in the above-mentioned cases of the terraces in the Andes and the "chinampas" of Mexico.

F. ENVIRONMENTAL SUPPLY

Environmental supply is defined here as the actual and potential capacity of ecosystems to produce alternative flows of economic goods and services. The environmental supply differs in terms of its diversity depending on the complexity and diversity of the ecosystem in question. For example, a tropical rainforest has a very diversified environmental supply. Such forests can be used as sources of foods (e.g., wild meats, edible oils, fruits, etc.) and chemicals (essential oils, resins, etc.), in addition to timber, fibres, live animal specimens and other products, all of which can be founded on the market. Using suitable management practices, the utilization of this environmental supply can be sustained over the long term. At the other end of the scale, the environmental supply of very undiversified systems, such as crops, yields a very restricted range of goods. For example, an artificial pasture used for intensive grazing basically can supply just four types of products: meat, milk, wool and hides.

There are other goods and services that are also part of the environmental supply but which are usually not traded because not all of them can be valued and, when they can be, indirect methods and approximations have to be used. This is the case of various capacities which are displayed mainly by unartificialized ecosystems, for example: the ability to produce water of a certain quality, to control phenomena such as erosion and flooding, the ability to offer natural beauty and recreational opportunities and to enrich man's cultural heritage, and the capacity to preserve germ plasm which could possibly be used in the future by man.

G. ENVIRONMENTAL SUSTAINABILITY

Any development strategy should be designed to be physically sustainable in the medium and long terms (Gligo, 1987). In ecological terms, the sustainability of an ecosystem is its ability to remain in the same state over time; this is achieved if the parameters of volume and rates of change and circulation remain constant or fluctuate around average values.

Ecological sustainability is achieved spontaneously in nature when ecosystems arrive at a mature or "climax" state. In the case of systems that have been subjected to varying degrees of artificialization, ecological sustainability is achieved when man makes appropriate changes in the architecture of the ecosystem and/or ensures external inputs of matter, energy and information such that the inputs into the system are equivalent to its outputs. There is no sustainability when outputs of matter and energy exceed inputs. An ongoing imbalance of this type leads to the deterioration or destruction of the ecosystem (Gligo, 1987).

The difference between the concept of ecological sustainability and that of environmental sustainability is that the latter stresses the time factor and incorporates technological and financial elements.

The temporal dimension of the stability of an agrosystem is of special importance in view of the fact that the deterioration of such systems is frequently a slow and gradual process. Thus, in the short or medium term, many agrosystems might seem to be sustainable when they really are not. Cases of such deterioration include sheet erosion of cultivated soils and the gradual degradation of the botanical composition of natural pastures (Gligo, 1986).

The consideration of technologies is of importance in determining the technical feasibility of achieving sustainability and refers to the need for both a supply of appropriate technologies and the professional and institutional capacity to apply them. The financial aspect has to do with the ability to mobilize the funds and other means necessary to provide access to the energy and material resources required to offset the outputs of the system. These considerations are what take us beyond the concept of ecological sustainability to that of environmental sustainability.

III. FACTORS REQUIRED TO ACHIEVE ENVIRONMENTALLY SUSTAINABLE DEVELOPMENT 1/

A. BASIC FACTORS

1. Ecological coherence

Ecological coherence is said to exist when natural resources are used in accordance with their capacity. Long-term ecological coherence requires maintaining an appropriate agrosystem architecture and a balance between the extraction of products and inputs of matter, energy and information.

However, the way in which many areas of the region are being exploited is not in keeping with their ecological capacity, and this leads to the degradation of the ecosystems of such areas. Economic motives are probably one of the main reasons behind the inappropriate use of natural resources. Favourable prices, tax exemptions or subsidies linked to given activities or products and the availability of product-specific or tied financing lead, at certain places and times, to the selection of production systems which are highly profitable but not ecologically coherent. Another source of contradictions between the present use and the use aptitudes of ecosystems lies in the problem of peasant marginality. Many poor marginal peasant communities have to practice subsistence farming even though the available natural resources are not suited to this kind of farming. Ignorance of both the limits of crop tolerance and the natural

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1/ This chapter is based on the following document by N. Gligo, Factores y políticas para la sustentabilidad ambiental del desarrollo agrícola, Joint ECLAC/FAO Agriculture Division, Meeting on Rural Agricultural Development Strategies Involving Peasant Participation, 24-27 November 1987.

aptitude of the ecosystem is another major cause of a lack of ecological coherence.

2. Socio-structural stability

The term socio-structural stability refers to the stability of resource ownership derived from a socially just and equitable structure.

The prevailing social systems in Latin America give rise to a structure of resource ownership which is a basic factor in the decisions taken by producers regarding the use of their resources. The structural diversity of the Latin American countries has been subordinated over the last few decades to the development of capitalist frameworks that tend to absorb, break up and dominate other frameworks and systems. There are currently three forms of resource ownership that have a considerable impact in terms of the deterioration of natural resources: modern agricultural enterprises, subsistence peasant economies and areas of expansion of the agricultural frontier.

The main damage caused to the environment by modern agricultural enterprises whether they are geared to the domestic or export market stems from their over-artificialization of the ecosystem (pollution and poisoning as a result of the mishandling and over-use of pesticides, over-reliance on pesticides and fertilizers to maintain the productivity of the system and so on). Another negative impact of this form of ownership is the instability which arises as such enterprises expand and crowd out traditional peasant economies. It is important to take these adverse environmental impacts of modern agricultural enterprises into account in the course of agricultural planning in order to take measures to control such damage.

In peasant subsistence economies, peasants often have no choice but to overtax their resources which have usually already deteriorated and/or are unsuitable for the intended use, thereby exacerbating processes of ecological and social deterioration. The peasants thus become poorer and increasingly marginalized, and the prospects for a sustainable form of environmental management become more and more remote. In planning solutions for these sectors, it is essential to bear in mind the economic implications of their position as subsistence producers. The aim of these peasants is not to maximize economic profits but rather to maximize utility from consumption while generating some surpluses; another factor that has to be considered is that they are highly risk-adverse.

A much greater degree of instability is found in areas where the agricultural frontier is being expanded, primarily as a consequence of the irregularity of the land tenure situation, in combination with the vulnerability of these ecosystems. As the process of expansion basically occurs in the humid tropics, the lack of appropriate environmental policies results in precarious and temporary human settlements due to the deterioration of the physical environment. Planning in this case should provide for appropriate schemes of colonization and land tenure with a view to overcoming the instability characterizing the present settlements. Such plans should also incorporate basic considerations relating to the aptitude of the ecosystems in question and ecologically coherent production systems.

3. Infrastructural complexity

The more artificialized that ecosystems become, the more open the agrosystems thus created and the greater the need for a constant flow of matter, energy and information. These flows are made up of inputs such as fertilizers, pesticides, irrigation water, etc., and of outputs, i.e., farm products. For this reason, a given agrosystem can be kept in operation only if adequate infrastructure is provided to keep such flows in circulation.

Infrastructural complexity may be defined as the presence of multi-faceted, co-ordinated and efficient infrastructure which ensures an adequate flow of inputs and products to and from a given agrosystem.

Irrigation-based agrosystems are one of the cases in which the need for this type of infrastructure is quite clear, since their stability depends directly on irrigation infrastructure and on its overall efficiency.

Complex infrastructures should also offer options in the event of breakdowns; for example, if there is an alternative to the use of an irrigation canal, a problem in the canal will not endanger the sustainability of a given agrosystem since the supply of water will not be interrupted.

4. The State's subsidiary role in the economy

This concept refers to action by the State to promote certain systems of production or conservation practices which are desirable from an environmental standpoint but whose level of economic profitability make them unattractive to the private sector. Price policies designed to minimize short-term fluctuations, credits and subsidies are among the mechanisms that may be used to perform this subsidiary function.

Another facet of this subsidiary role may be State support for the establishment and strengthening of producers' organizations. This permits the State to delegate some of the functions associated with subsidization, credit and price policies, which may facilitate the development of sustainable production systems.

Unfortunately, in Latin America there are few instances in which the State has performed this role. Two examples of the few cases in which it has successfully done so are the erosion control policy implemented in an area of approximately 20 000 hectares in the Bogotá savannah in Colombia, and the reforestation subsidies in Chile which have resulted in the planting of more than 1.3 million hectares, mainly with pine. Nevertheless, it should be mentioned that the expansion of tree plantations in Chile forested by these subsidies has had harmful consequences such as the destruction and substitution of native forests and the displacement of the rural population (Cavieres and Lara, 1983).

5. Uncertainty and risk

The sustainability of any system involves a measure of risk and uncertainty which tends to increase when the ecosystem is transformed by man. Therefore, it is important to stress the need to reduce the uncertainty and risk involved in agrosystems. The degree of uncertainty and risk can be reduced if there is a thorough understanding of the original ecosystem to be transformed, of the agrosystem being established and, obviously, of the transformation process involved. Scientific and technological research has a fundamental role to play in developing such knowledge.

B. ENVIRONMENTAL SUSTAINABILITY BY TYPES OF PRODUCERS

1. Characteristics of the factors involved

One of the most striking characteristics of regional agriculture today is the diversity of production forms and systems, almost all of which have been strongly influenced by the development of capitalist forces of production. Producer classifications reflect the fact that the different types of producers do not exist in their pure forms, and there is considerable overlapping between one category and another, which makes it difficult to establish a typology of agricultural producers. Bearing this limitation in mind, table 1 presents an analysis of the five factors discussed above in relation to two types of producers: those whose profile fits that of the new capitalist entrepreneur, and those whose profile fits that of traditional peasants. The intention is to portray these two types as two different tendencies, the first of which is gathering strength, while the second is on the wane. There are a number of types of producers that fall between the two extremes which have been influenced more by one or the other.

Table 1

CHARACTERISTICS OF CAPITALIST AND PEASANT PRODUCERS IN RELATION TO FACTORS OF ENVIRONMENTAL SUSTAINABILITY

Factors	Producers	
	Capitalists	Peasants
Ecological coherence	Very low	Very high */
Socio-structural stability	Moderate	Moderate
Infrastructural complexity	High	Low
Subsidiary economic mechanisms	Relatively high	Low
Uncertainty and risk	Very high	Very low

*/ In some cases it may be low or very low when the ecosystems are overexploited and have consequently been damaged.

a) Ecological coherence

Price incentives have motivated capitalist producers to introduce many crops into areas having very limited productive capacities. Examples of such situations are to be found in the production of coffee, rice and other cereals in the region. Peasant farming, on the other hand, is more cautious in its approach to production, since the main concern is usually survival rather than maximizing the use of capital. Thus, peasant production is more ecologically coherent, inasmuch as it is based on crops that have stood the test of generations because they are in keeping with the ecosystem's potential.

b) Socio-structural stability

Socio-structural stability tends to be moderate for both types of producers and depends generally on the political processes experienced by each country. Capitalist producers make use of the land market much more than in the past, but without introducing any substantial changes in the forms of land tenure.

Peasant farming is going through a process whereby peasants are leaving the land and small farmholdings are being subdivided into even smaller plots. Although in most countries the legal provisions regarding land ownership have been maintained, the splitting up and sale of small plots has risen sharply, and this is having an impact on the use of resources, the profitability of production and the power of peasant organizations.

c) Infrastructural complexity

There is a heavy concentration of rural infrastructure in areas where modern capitalist systems of production are developing. This is especially evident in irrigated areas, areas where export crops are grown, areas of very intensive stock-raising activities and in the vicinity of large cities where there is intensive horticulture or flower cultivation. Usually, peasant farms have access to complex infrastructure only when they are in the same areas as capitalist enterprises. This is how the situation currently stands in areas where latifundium/minifundium complexes are evolving. In areas where the agricultural frontier is being expanded, however peasants find themselves in a very precarious situation as far as infrastructure is concerned.

d) The subsidiary economic role of the State

Generally speaking, both types of producers have very little access to subsidiary mechanisms designed to further sustainable development. Nevertheless, capitalist farmers usually have the advantage of some degree of political power or the economic influence of their organizations. In some cases, peasants may benefit from price subsidies and support policies on certain inputs and products, but in order for this to happen both capitalist and peasant farmers have to be producing the same products, as occurs in some cases with such crops as cotton, coffee and wheat.

e) Uncertainty and risk

A marked difference exists between the two types of producers in this respect. The more capitalist producers develop their production forces, the more risk they assume and the more capital they mobilize. The high degree of uncertainty associated with such producers is due both to the low level of ecological coherence characterizing their production activities and to economic factors related to input and product markets. Peasant producers, on the other hand, try to minimize uncertainties and risk, and their empirical know-how and diversified production structure enable them to reduce both physical risks and those associated with the market, in which they are only marginally involved.

2. Trends of the factors involved

The style of agricultural development that has prevailed in the region has been based on the penetration and growth of capitalist production forces. In most areas where this type of style has been implemented, there have been significant increases in the productivity of both labour and land. However, this has been coupled with an exacerbation of the environmental problems of resource conservation and the generation of wastes. If the predominant style of agricultural development continues to make inroads and to dictate the transformation of the ecosystem's production processes, then the situation with respect to renewable resources will grow even worse and the already low level of environmental sustainability will be even further reduced. This assessment is summed up in table 2.

Table 2

TRENDS IN THE FACTORS INFLUENCING THE ENVIRONMENTAL SUSTAINABILITY OF CAPITALIST PRODUCTION

Factors	Current status	Trend
Ecological coherence	Very low	Worsening
Socio-structural stability	Moderate	Moderate
Infrastructural complexity	High	High
Subsidiary economic mechanisms	Relatively high	Declining
Uncertainty and risk	Very high	Rising

The trend among peasant producers is also towards a decrease in environmental sustainability. Their ecological coherence is tending to decrease as a consequence of the disarticulation of the system of latifundium/minifundium complementarity, and the result is that greater pressure is placed on the use of resources. In addition, the gradual increase in the use of money in the peasant economy will make the market increasingly important for peasant producers, who will therefore be motivated to introduce economically attractive crops that may not necessarily be the best choice in terms of ecological coherence.

The gradual breakdown of the peasant economy will create socio-structural instability. Peasants' access to subsidiary economic mechanisms and complex infrastructure are expected to remain low, which will certainly not help them to compensate for the deterioration of other factors. Finally, if ecological coherence is lost and the peasant economy becomes more involved in the market, it is logical to assume that uncertainty and both physical and economic risks will increase. These trends are summarized in table 3.

Table 3

TRENDS IN FACTORS INFLUENCING THE ENVIRONMENTAL SUSTAINABILITY OF PEASANT PRODUCTION

Factors	Current status	Trend
Ecological coherence	Very high	Moderate
Socio-structural stability	Moderate	Low
Infrastructural complexity	Low	Low
Subsidiary economic mechanisms	Very low	Very low
Uncertainty and risk	Very low	Moderate

IV. PROJECT CASES, SUMMARY AND COMMENTS

In this chapter four simulated projects based on actual cases will be analysed. The "project identification" section of the following outline is simply a list of the information used in defining each project; the characteristics of the projects are presented under the sections concerning the formulation and implementation phases. Alongside these descriptions, a series of observations are made as to how the environmental dimension could have been more fully incorporated into such projects.

It should be noted that although no comments have been included concerning the project identification phase, one general criticism may be made which applies to all the projects in this connection. This criticism has to do with the fact that in each case a decision has been taken at the outset as to the crop to be produced and the production system to be used, while many other possibly valuable options have been discarded. An alternative procedure would be to carry out as comprehensive an analysis as possible of the resources of the area in question and of their potentials and limitations. Such an analysis would permit an appropriate use to be made of the environmental supply based on a proper mix of crops and production systems.

A. AGRICULTURAL DEVELOPMENT PROJECT FOR THE AREA OF INFLUENCE OF THE LAGARTOS DAM

CHARACTERISTICS OF THE PROJECT	COMMENTS

1. Identification

Origin of the idea:

Lagartos Hydroelectric Project, which included the expansion of the area of irrigated land as an agricultural subproject. The analysis presented here refers solely to the agricultural subproject.

Agencies involved:

National Electricity Commission (NEC) which is the administrator of the hydroelectric project; the agricultural project is being implemented by the Ministry of Agriculture (MAG) and the National Irrigation Institute (NII).

Objectives:

To increase agricultural production through the irrigation of 65 000 hectares of land north of the Tumuñán River and to improve irrigation security from 70% to 90% on 40 000 hectares of land south of the Tumuñán River.

Financing:

International credit from development agencies with local counterpart funding.

Government priorities:

Increasing agricultural exports, import substitution, increasing employment, elimination of extreme poverty, regional reactivation.

Description of the area:

The river basins that drain into the Lagartos dam have a total surface area of 423 000 hectares and although a detailed survey has not been carried out, it is estimated that the use potential of 60% of the land area corresponds to soil protection and drainage (Group VIII) and 35% could be used for limited stock raising or forestry (Group VII).

A total of 4 500 hectares of land is to be flooded; 1 550 hectares of this area is agricultural and corresponds to Group IV soils; 400 hectares are highly productive farmland (Group II); 2 300 hectares are suited to stock raising or forestry (Groups VI and VII); and 250 hectares, most of which corresponds to the bed of the Tumuñán River, are unproductive land (Group VIII).

The area that will benefit from the irrigation project covers 105 000 hectares north and south of the Tumuñán River; 80% of this land falls into use capacity Groups II and III, and 20% into Group IV. It should be noted that most of the farms to be affected also include some land of inferior quality, composed mainly of slopes (Groups V and VI).

The climate is tropical with a seven-month long dry season and annual rainfall of 1 300 mm. The upper portion of the basin has a rainy climate and its annual rainfall is 2 700 mm.

The average flow of the San Carlos River in the vicinity of the dam is 242.7 m^3/sec. Its flow increases considerably in the rainiest month to an average of 865.9 m^3/sec.

The land in the area to be irrigated by the project is mainly used for farming (maize, beans and other traditional crops) and dry land stock raising (cattle). The landholding distribution in the area is as follows: 143 farms of from 100 to 200 hectares, 369 farms of from 50 to 100 hectares, 1 780 farms of from 10 to 50 hectares and 637 farms of from 1 to 10 hectares. All the farms are privately owned and their size is a good indicator of the entrepreneurial capacity and economic resources of their owners.

Approximately 60% of the farms of less than 10 hectares were allocated as family units during the agrarian reform process of the 1970s. The remaining 40% are minifundia.

Project profile:

Investments: US$500 million for the construction of inlets, gates, the main canal, traps, secondary canals and some corrective action in connection with specific project impacts.

Period of implementation: 5 years

Main works: Main dam (87 metres high, volume of materials: 12 million m^3), two small dikes, the north Tumuñán irrigation canal. Reservoir capacity: 1.6 billion m^3.

Physical production targets: (in grain equivalents)
Current : 40 000 ha * 1.05 t/ha = 42 000 tons
By year 6 : 105 000 ha * 2.63 t/ha = 276 150 tons

Technical and credit assistance in increasing crop yields in the area to be irrigated.

Legal counselling on title clearance in respect of *minifundia* of uncertain title.

2. Formulation

Technical study:

Base map at a scale of 1:50 000 with contour lines every 25 metres in the lower part of the basin and every 50 metres in the middle and upper portions. Thematic mapping for the areas to be flooded and irrigated at a scale of 1:20 000 which includes infrastructure (roads, canals, transmission lines, buildings), farm boundaries, and potential and current land use by updating orthophotos (scale: 1:20 000) prepared in 1975. Detailed topographical surveying of the reservoir area at a scale of 1:5 000 with contour lines every five metres.

Maps at a scale of 1:50 000 of the tributary river basins that drain into the reservoir should have been prepared on the following topics: vegetation, land ownership and current as well as potential erosion. Such maps should be used to plan land use in the basins draining into the reservoir on the basis of ecological coherence criteria. Such information would also permit the planning of erosion control measures.

It should be noted that although some national studies classify the middle and upper portions of the Tumuñán river basin as being subject to severe erosion, the project conducted no study on the subject whatsoever.

In the area to be flooded and affected by the project infrastructure, a detailed study and maps should have been prepared of the plant communities and of the flora and fauna.

The study of the use potentials of the area to be irrigated should have included a more detailed analysis of its limitations as regards drainage and the susceptibility of the soil to salinization under irrigation conditions.

Study of flows at five water-level measuring stations on the San Carlos River (12 years of observation). There are also two meteorological stations, one of which is near the future dam (12 years of observation) and the other in the upper basin (7 years of observation).

The flow of suspended sediments in the water and the undertow of the San Carlos River should also have been quantified so that the silting rate of the reservoir could be projected.

Agricultural study of the irrigated area (soil fertility, products and potential productivity, water demand by crops and farm size).

Design of farm models according to location and farm size, cropping patterns, design of farm infrastructure.

Only two systems of production and technology were considered for various farm size and tenure situations. This scheme proved to be too rigid given the great diversity of situations in the area. Consideration should have been given to at least five farm development models in order to provide adequate coverage of the range of local conditions.

Technical and legal studies of the properties in the area to be flooded.

Design of construction works (main dam, secondary dams, spillways, canals and related works).

Financial study:

With respect to the farm models, projection of income and expenditure in line with appropriate technologies according to prevailing technical criteria and market prices.

At NII level, projection of implementation operational and maintenance costs, and of incomes based on current irrigation charges.

The low irrigation charges encouraged inefficient water use and over-irrigation. This intensified the drainage and salinity problems to be discussed below.

The low charges also promoted an over-dependence on State funding for the operation of irrigation works and led to financial difficulties and inefficiency in some instances.

Economic study:

The internal rate of return was estimated at 28% and the net present value at US$203 million; the discount rate used was 12%. Inputs and products were assessed at social (shadow) prices.

Returns were estimated at 20% for producers with over 100 hectares of land, at 16% for those with 50 to 100 hectares, and at 12% for those with less than 50 hectares.

The rate of return calculated for owners of small farms was too low; this was due to the use of a technological model which was too costly and therefore not suitable for this type of farm. The lower rate of return for smaller farms heightened the social differences between owners and thus helped to reduce socio-structural stability in the project's area of influence, since a number of the owners of small holdings could not meet their debts and had to sell their land to owners of larger farms, thereby leading to a concentration of land ownership.

Two of the project's benefits are the creation of jobs during implementation (a maximum of 2 500 workers) and in the subsequent agricultural activities, and the generation of foreign exchange.

Institutional study:

NEC is responsible for designing and supervising the construction of the dam by various local and international firms under contract. An autonomous executing unit of NII will be responsible for supervising the construction of irrigation works by contracting firms. The final designs will be produced by a firm of consulting engineers.

NII will have a specialized division of the executing unit to carry out the necessary studies to determine how much water each type of farm will require. NEC and NII will set up offices in the project area.

A project of this size should have provided for the participation of a wider range of governmental and non-governmental organizations to ensure adequate representation of the interest groups involved. The institutions that should have been involved in the project include: the National Commission on the Environment, the Forestry Service, the National Agricultural Training Agency, the Tumuñán Valley Farmers' Association and the major regional or national conservationist organizations.

Environmental impact assessment:

No environmental impact assessment using the customary methodologies was carried out during the design phase of the project. However, a study was carried out on the infrastructure and farms that were to be flooded or directly affected by complementary project works (roads, quarries, etc.). The studies served as the basis for the legal instruments needed to carry out expropriations and to set the amount of compensation to be paid. The impacts of the project that were considered included: a) flooding of 4 500 hectares of privately-owned land; b) flooding a 13-kilometre segment of the Los Manzanos-Paso La Cumbre highway; c) flooding of land occupied by 217 families not having deeds for the property concerned; d) flooding of the inlet gate and the first segment of the South Tumuñán Canal; e) permanent elimination of irrigation in a section of the lands irrigated by the Southern San Carlos Canal (since this land would be above the new inlet to be built as part of the project); and f) destruction of a 7-kilometres stretch of high tension lines.

Since no environmental impact assessment was made during the design phase of the project, some of the project's main adverse consequences were overlooked, along with the corresponding control measures. These impacts included: a) flooding of three areas and a total of 25 hectares of mature relict forest of a very high ecological and scientific value containing three species of trees in danger of extinction; b) flooding of 980 hectares of semi-dense forest which has been subject to man-induced changes but which is the habitat of three species of birds and five species of mammals classified as endangered species; c) deterioration of the landscape and pollution of the reservoir as a result of the unplanned development of tourism; d) probable impact on the fish of the Tumuñán River, which are an important source of protein in the diets of the peasants of the area; e) probable soil drainage and salinity problems (many examples of such problems are to be found in the country); f) problems of water contamination and toxicity due to an increase in the use of agro-chemicals as a consequence of the project and of the probability of such chemicals being carried by irrigation water; g) an increase in work-related accidents following the introduction of a greater degree of mechanization and of new machinery and equipment; h) damage to the soil structure due to the misuse of machinery; and i) problems of pollution and disease resulting from the generation of a greater volume of agricultural waste.

Corrective measures:

The corrective measures provided for in respect of the impacts identified in the preceding paragraph were: a) payment of compensation to 94 land owners; b) construction of a 17-kilometre segment of the Los Manzanos-Paso La Cumbre highway along the southern bank of the reservoir; c) relocation of the affected families to a temporary settlement on land adjacent to the nearby village of Las Delicias; d) restoration of irrigation using the North Tumuñán Canal; e) payment of compensation to owners of land that would no longer be irrigated; f) construction of 9.5 kilometres of transmission lines.

The corrective measures that should have been taken in respect of the impacts identified above are: a) and b) since the site of the dam and the area to be flooded could probably not have been changed, the destruction of natural ecosystems and of endangered species as a result of the project might have been compensated for by creating reserves in which effective protection would be provided for ecosystems similar to those destroyed by the project and by fostering an increase in the populations of endangered species; c) in order to avoid the haphazard development of tourism and its harmful consequences on the environment, land use around the reservoir should be regulated, as should the recreational activities that might be carried out there, and mechanisms of enforcing such regulations should be established so as to permit a harmonious form of tourism and recreational development; d) the dam's impact on fish should be studied in order to determine what corrective action might be necessary (re-stocking of fish, development of areas suitable for natural reproduction, etc.); e) drainage and salinity problems could be overcome by means of soil studies and the adoption of appropriate farming techniques and irrigation rates; f) the problems of fertilizer and pesticide pollution and toxicity could be controlled through the establishment of adequate fertility and pest management programmes and training in the correct methods of handling and applying agro-chemicals; g) and h) the problems stemming from greater mechanization could be avoided by establishing prevention and training programmes; i) agricultural waste pollution could be controlled through adequate systems for treating the waste and for the possible use of such wastes as manure, biogas, etc.

3. Main problems encountered during implementation

When the reservoir was being filled, leaks were detected in one of the secondary dams; this made it necessary to temporarily evacuate the population of a nearby rural village and to delay the start-up of the project. The leak was brought under control after six months of work on the base of the dam.

The problems caused by leakage could have been avoided if more funds had been earmarked for waterproofing the dam's base.

The filling of the secondary reservoir up to the established watermark was done hurriedly in order to reduce problems that had arisen with some landowners who had lodged legal complaints requesting that their land not be flooded until they were paid more compensation than what the NEC was offering them.	As a result of the rapid filling of the reservoir, some 70% of the biomass of the forests growing in the area was not harvested and ended up underwater. This meant that a considerable volume of timber and firewood was lost and the eutrophication process in the reservoir was accelerated by the decomposition of leaves, branches, tree trunks, etc.
Under an agreement with the National University, a study on the inflow of sediments into the reservoir is being carried out. The preliminary findings, after three years of measurements, indicate that the reservoir is silting up rapidly as a result of erosion in the river basins whose flows drain into the reservoir. It has also been found that as a result of the recreational opportunities offered by the reservoir and the lack of land-use regulations in the zone of the artificial lake, there has been a disorderly and unplanned development of hotels, restaurants, quays and vacations lots, mainly on the more accessible southern bank.	The project overestimated the environmental supply and failed to take into account the erosion in the tributary river basins. This problem could have been avoided if a soil conservation plan based on a detailed erosion study had been implemented in the basins in question. Ways of dealing with this problem were discussed under the section entitled "corrective measures".
A study carried out by researchers of the National University shows that water quality along the southern bank of the reservoir is deteriorating, mainly as a result of untreated sewage water from hotels and condominiums.	Idem.
The replacement of groundwater in the lower basin with surface water, coupled with drainage problems, has caused problems of flooding and salinity. A similar situation occurs in areas without appropriate drainage which are flooded for the purpose of intensive rice cultivation.	Idem.
Other problems such as pesticide pollution and toxicity, work-related accidents and agricultural waste pollution have also increased as a result of the project.	Idem.
The land title clearance process fell behind schedule and the resulting uncertainty made small landowners reluctant to participate in the project.	
Landowners with plots of over 50 hectares have readily adopted irrigation and irrigation-based production technologies. However, owners with less than 10 hectares of land, who account for 22% of the farms, have been very slow to do so.	A technological model in keeping with the situation of small landowners should have been included in the project. Other comments in this connection have already been made.

The original budget for building the irrigation works proved to be inadequate, and an additional credit of US$50 million had to be negotiated with the international agency involved.

Overall evaluation of the project:

Only 60% of the project's production goals were attained, and even after 10 years of operation, the project had still not managed to properly incorporate small landowners, whose standard of living was not improved by the project. The project unintentionally heightened social differences and contributed to the concentration of landholding in its area of influence, as well as triggering a series of adverse environment impacts.

The project's poor performance is closely related to its failure to incorporate the environmental dimension. The absence of appropriate environmental criteria was particularly critical in respect to the following aspects: a) over-estimation of the environmental supply due to a failure to consider the environmental constraints on the project (erosion in the feeder river basins and problems of soil drainage and salinity); b) selection of a technological package which proved to be unsuitable for the majority of landowners, who could not afford to finance a highly artificialized form of agriculture based on an intensive use of inputs acquired on the market; c) generation of a number of adverse environmental impacts for which proper corrective action was not taken and for which the society as a whole consequently has to pay the price; d) the budget did not make provisions for the expenses which would be incurred if the above-mentioned environmental aspects were incorporated. Other budget items that would have to be increased include those for the training and organization of farmers. Nevertheless, despite the greater costs involved, the inclusion of basic environmental criteria would have permitted the achievement of the production and profitability targets which were not met by this project for the reasons discussed above.

B. SETTLEMENT PROJECT IN THE ESMERALDA REGION

CHARACTERISTICS OF THE PROJECT	COMMENTS

1. Identification

Origin of the idea:

National Programme for the Consolidation of Agricultural Frontier Areas.

Agencies involved:

The Institute for Settlement and Agrarian Reform (ISAR) suggested the project and was responsible for its execution; however, other State agencies with specific responsibilities relating to agricultural frontier areas were also to participate in its implementation. These agencies included the Forestry Service, the Regional Department for the Environment, the Agricultural Research Institute and the National Agricultural Training Enterprise. The Public Works Department was responsible for the design and construction of road infrastructure.

Objectives:

To regularize spontaneous settlement processes, to establish new settlements and to increase forestry and agricultural production in the project area.

Financing:

Central government budget.

Government priorities:

Consolidation of sovereignty in remote and marginal areas affected by guerrilla activities, elimination of extreme poverty, creation of opportunities for the surplus population in rural areas.

Description of the area:

The project's target region is located in the zone of Esmeralda and covers an area of 120 000 hectares. Some 40% of the area is made up of slopes with soils that are extremely erosion-prone and are not suitable for agriculture, located at altitudes between 200 and 1 700 metres. About 56% of the area is made up of flatlands and gently rolling hills whose soil is not very fertile, and only 4% corresponds to alluvial terraces of a naturally high fertility.

A total of 80% of the area's vegetation is made up of plant communities of the type found in tropical rainforests, most of which exhibits a low degree of artificialization; 18% is made up of forest stubble and forests which have been exploited to varying extents; and 2% contains crops and pastures on land occupied by settlers.

The climate is tropical and rainy with annual precipitation of 3 000 mm which is distributed relatively evenly throughout the year.

Spontaneous land settlement has occurred along the banks of some rivers, where the settlers practice subsistence farming. These settlers are facing serious social problems (lack of means of communication and of basic health and educational services, low incomes, high rates of malnutrition and infant mortality). Other groups present in or near the project area are landowners, loggers, guerrilla fighters and two indigenous groups who occupy the extreme north of the project area.

A total of 98% of the land in the area is owned by the State.

Project profile:

Investments: Total: US$41 million

Assistance to settlers: US$12 million (approximately US$5 000 per settler, partly in cash and partly in kind).
Roads: US$27 million.

Cost to the ISAR of the implementation of the project: US$2 million (offices, housing, means of transport, administrative expenses and so on).

Period of implementation: Five years.

Beneficiaries: 800 spontaneous settlers and 1 600 new settlers (a total of 2 400 settlers, with 50 hectares per settler in a total area of 120 000 hectares). ("Settlers" refer here to settlers and their families.) The project also includes training and technical assistance programmes for the settlers.

2. Formulation

Technical study:

Base map at a scale of 1:250 000 with contour lines every 250 metres.

Thematic mapping at the same scale which includes: vegetation cover, soil use capacity groups and hydrography.

Proper placement of 50-hectare farms in the areas with the best farmland would have required a base map and thematic mapping at a scale of at least 1:50 000. At this scale, a plot of 50 hectares would cover 2 cm^2. This greater level of detail would be necessary in order to make good use of the environmental supply, since the most fertile land is interspersed with the land that has the greatest use limitations.

Rough topographical survey for the plotting of the main roads.

Plotting of secondary roads and farm boundaries based on thematic maps. Farm boundaries drawn on a map at 1:50 000 obtained by photographically enlarging the base map.

The project provided for the settlement of a continuous area of 120 000 hectares, thereby overlooking the fact that, because of their use limitations, some areas should have been left as reserves having a minimum degree of artificialization. On the basis of the available information concerning the zone's soil potential, the project should have set aside at least some 100 000 hectares as reserves for the protection of the basins and soil, conservation of wildlife habitats, etc. Such reserve areas should be scattered among the areas to be devoted to agriculture and should incorporate ecological coherence criteria that foster an efficient use of the supply, which varies significantly from place to place.

Design of production plans for three farm models considering forestry, livestock and cropping production systems, both for on-farm consumption and for sale on local markets.

One flaw of these models was that they did not consider combinations of forestry, stock-raising and crop-farming uses, even though they did include these three types of production on each farm. The degrees of artificialization planned for crop-farming were excessively high and called for large quantities of inputs and technology that was too sophisticated. On the other hand, the degree of artificialization programmed for forestry and stock-raising activities was too low and involved an overly extensive use of resources while failing to include practices such as reforestation, stabling, the cultivation of fodder, etc., which would have helped to make the project sustainable. Another problem with the farm design was that their sizes should have varied according to the differing productivity of slopes and flatlands.

Design of project offices and housing and of a demonstration farm.

The studies done concerning the placement of the infrastructure for the administration of the project were not very detailed and consequently this infrastructure was set up in areas subject to flooding which later became focal points for the development of disease vectors such as malaria. More detailed studies would have avoided this problem.

Financial study:

Determination of financing requirements of spontaneous settlers and government-promoted settlers. Payment schedule in line with land allocation programme.

The project's budget was insufficient and seriously hampered the start-up and operation of the project.

Estimation of ISAR investment and operation costs and those of other organizations involved.

Economic study:

The internal rate of return was estimated at 18% and the net present value at US$16 million. Inputs and outputs were assessed at social (shadow) prices.

Institutional study:

ISAR was responsible for formulation and execution. In addition, a co-ordinating committee was established which included the other government agencies involved.

Non-governmental nature conservation organizations and institutions devoted to the defence of the rights of indigenous groups should also have been involved.

Environmental impact assessment:

The project did not conduct any environmental impact assessment. Despite this fact, the project was purported to serve the purpose of environmental conservation.

The project should have carried out an environmental impact assessment. Some of the negative impacts commonly seen in agricultural frontier areas and which therefore should have been considered so that appropriate control measures could have been taken are: a) the incentive for land occupation by spontaneous settlers, landowners and loggers who were not part of the project; b) the settlement of more land than was planned by the project; c) the invasion of national parks and indigenous territories; d) accelerated deforestation and over-hunting of wildlife; e) soil erosion as a result of the use of unsuitable land for agriculture; and f) the reduction of future development options.

Most of the above-mentioned adverse impacts occurred in the project area. The measures that should have been adopted in order to forestall them are discussed below.

3. Main problems encountered during implementation

The procedure for the selection of settlers was very slow and inefficient and was overtaken by waves of spontaneous settlers attracted by the presence of new roads and by the project. By the third year of project implementation, the pressure exerted by spontaneous settlers was so great that the selection procedure had to be changed to give priority to settlers already present in the sector. Some landowners from neighbouring zones also begun to demand land in the project area and loggers pressed permits to exploit the forest. This struggle over resources among the various social groups had an adverse impact on the security of land tenure and socio-structural stability in the project area. The situation was made worse by the fact that ISAR lacked a clear policy on such land disputes and often bowed to the interests of landowners and loggers, while the settlers found themselves in a helpless position. The deeding of more land to these landowners led to a great deal of land speculation which increased its value and thus made the distribution of land to settlers even more difficult.

The problem of spontaneous settlement and the occupation of land by other groups not involved in the project is perhaps the most difficult problem to avoid so long as the current power structure and legal provisions are not changed. However, the problem could have been mitigated in the following ways: a) efficient and rapid demarcation of plots and selection and settlement of farmers, as well as the granting of deeds to the land; b) appropriate selection of the land to be occupied, of the farm models to be developed, of technical and credit assistance, etc., in order to ensure adequate and sustainable productivity and an acceptable level of income for the settlers, thereby giving them more power and greater security; c) support for the organization of settlers; and d) legal support for settlers in defending their rights.

Another problem faced by the settlers was that the expected rate of technology adoption was too rapid and, in addition, the funds allocated for training were insufficient.

The difficulty the settlers had in adopting the technology designed by the project was compounded by the use of agricultural systems that were too sophisticated and led to excessive artificialization of the agrosystem.

The building of the main highway to Esmeralda through the Selva Alta National Park sparked an inflow of spontaneous settlers and the clearing of land in the park. Despite the high ecological value of the area due to the fact that it was not artificialized at all and contained a large diversity of species, it had neither been demarcated nor been made the object of a management plan at the time the project was developed.

An alternative routing of the highway was not a feasible solution. Nevertheless, the occupation of land in the park could have been significantly reduced if the area had been demarcated and managed under a plan which included the budget, equipment, forest rangers and legal backing needed in order to patrol and protect the park against such settlement before building the highway. Other important measures that could have been considered include: the placement of appropriate signs in the sectors liable to invasion and the demarcation of the park's borders along natural boundaries that would be easy to identify and guard. Although the above-mentioned measures are fundamental, the protection of an area in the long run depends on the support of the local population and the national community as a whole and on whether or not the population identifies with the objectives for which the park was established. This calls for considerable education and sensitization at the local and national levels.

Although on paper the project recognized the rights of the indigenous groups living in the extreme north of the project area, in practice settlers were assigned plots on indigenous land. Once the settlers realized that the project authorities were not providing effective support for the indigenous groups, they occupied even more of these groups' land than had been legally assigned to them. This resulted in many violent incidents between the two groups. After six years of project implementation, the indigenous population has been crowded out of the area, and many of its members have abandoned their traditional way of life and have become landless people who do seasonal work for settlers in exchange for food, clothing and other goods. Others live on charity.

This problem could have been avoided if land reserves had been established for the indigenous population prior to the project settlement process. An appropriate alternative would have been to establish a protected area for conservation purposes in one of the categories which would also permit the use of the area's resources by the indigenous population. The recommendations relating to demarcation, management, patrolling, etc., made in connection with the Selva Alta National Park would also apply in this case.

The acculturated indigenous population should be allowed to establish collective land ownership schemes and the State should support them so as to protect them from exploitation and ensure that they have a satisfactory standard of living. Similarly, they should be given support in organizing themselves.

Insufficient health, education, postal and telecommunications services were provided in the project area, and this adversely affected the standard of living of its inhabitants. One especially critical problem was the high rate of malaria and schistosomiasis among the population, which lacked the necessary infrastructure and resources to prevent and cure these diseases.

Although the rural programmes of the Departments of Health, Education and Telecommunications provided such services, they were insufficient due to the remoteness of the project area and the inadequate budgets of the programmes. The health problems were so serious that ISAR was forced to make a special effort of its own to control the above-mentioned diseases. In planning to settle 2 400 families, the appropriate departments should have been consulted in order to establish and finance projects to ensure that the inhabitants of the project area would be provided with adequate services.

The arrival of spontaneous settlers, landowners and loggers in the project area triggered a serious process of deforestation and forest degradation. This process was heightened by the area's socio-structural instability and the need to establish legal ownership of the land as soon as possible. Under the legislation in force, the State recognizes ownership of land that has been cleared and prepared for agricultural use. Ten years after the beginning of the project, an assessment carried out by a non-governmental conservationist organization concluded that the project had resulted in the deforestation of 340 000 hectares. This land area is almost three times the total area initially covered by the project and over six times the size of the area that was slated for agricultural use. The project also led to the impairment of 70 000 hectares of forest as a result of selective logging. The study also found that approximately 70% of the volume of timber in the deforested areas had not been used; this is a clear indication of the extent to which resources were wasted. Although a precise evaluation was not prepared, the study estimated that rapid soil erosion had begun to occur in at least 30% of the deforested area.

A study commissioned by ISAR found that after 12 years, the project had given permanent land deeds to only 1 500 of the 2 400 settlers initially planned for, but it estimated the total number of settlers in the area at 4 000. It was also found that 40% of the land legally assigned to settlers was located on slopes and had serious use limitations that made it suitable only for stock raising or extensive forestry. The report also detected such problems as a decrease in soil fertility in cropland and pastures and the invasion of weeds.

Productivity in terms of both crop yields (rice, maize, beans and cassava) and livestock was lower than expected. This was due to the problems of low soil potential, the slow introduction of technology and socio-structural instability already described above. The settlers' lack of sufficient resources to apply fertilizer on a continuing basis and to control unwanted vegetation was also a contributing factor. It should be noted that such practices are absolutely necessary in order to maintain the productivity of the ecosystems artificialized by the project, since most of this land has use limitations.

The problems of deforestation and forest deterioration in this case are extremely complicated and difficult to resolve since these processes are concomitant with a settlement project under the conditions already described. The main ways of minimizing the deforestation process triggered by the project would have been: a) to establish reserve areas interspersed among the areas to be settled according to the potential of the soil; b) to control spontaneous settlement and the influx of landowners and loggers by means of the mechanisms already discussed; c) to provide training and promote the use of techniques that would increase the sustainability of forest development; d) the above measures, coupled with environmental education efforts, could enhance the social value of forests in the eyes of the local population, which in the long run is the best means of ensuring the conservation of forest resources. Outside the framework of the project, it would be desirable to modify the law, which is indirectly promoting deforestation by conferring ownership on those who clear forested land. This would also help to stop the occupation of land by spontaneous settlers and large landowners.

A failure to achieve these goals is due to the fact that the project was poorly planned and implemented. The mechanisms for dealing with these problems have already been discussed.

The degree of infrastructural complexity was also inadequate, since the poor condition of the roads considerably added to the cost of transporting inputs to the farms and agricultural products to markets, with the result that in many cases production was unprofitable. In addition, the roads were not usable for three or four months a year, which made it impossible to transport agricultural inputs and products during that period. The settlers had to make up for this shortfall in income by felling more trees and hunting more wild animals for their skins or for sale as live specimens. The high prices fetched by timber and the possibility of floating logs down the Viejo River made the timber trade more profitable. The hunting of wildlife was even more profitable because a large market existed for hides and live animals and, although there were great difficulties involved in transporting these items, they fetched a very high price per unit by weight or volume. The harvesting of timber and wildlife far exceeded productivity, and this caused considerable damage to the ecosystems in the project zone. Another activity which played a significant role in the deforestation of vast areas was extensive ranching, which proved to be attractive to settlers and landowners because of the unsuitability of a substantial portion of the land for crop farming and because of the low capital requirements of this activity.

The highways and roads built by the project were very unsatisfactory because the budget for these works was insufficient. Other types of infrastructure such as bulking centres, silos, etc., could also have improved the transport of goods to regional markets.

The production problems that the settlers faced on their farms forced some of them to work for loggers and landowners in exchange for low wages. This contributed to the proletarianization and pauperization of a considerable portion of the settlers, who, in extreme cases, found it necessary to move out of the project zone.

These agricultural production problems and their consequences could have been minimized had production systems requiring fewer inputs been used and had more training and technical assistance been provided.

There was also a lack of co-ordination among the various participating agencies during the implementation of the project and in many cases there was open antagonism among the institutions involved.

Such problems could have been lessened if the various agencies which were represented on the co-ordinating committee during the implementation of the settlement project had been involved in the project formulation phase as well. The co-ordinating committee should have been more active in trying to ease friction among the institutions concerned and to encourage them to pool their efforts to ensure that the project operated smoothly. However, in part these problems were beyond the control of the project, since the authorities of the various agencies reflect the prevailing power structures. For example, the Department of Environmental Affairs has fewer economic, human-resource and jurisdictional resources than INCRA, and therefore its pro-conservation stance with regard to the tropical forest carries less weight in decision-making.

Overall evaluation of the project:

The project was able to place only 60% of the number of settlers initially planned. The number of spontaneous settlers without land deeds increased from 800 to 4 000 in the project area. The project's production targets were not attained either. While the initial project area amounted to 120 000 hectares, 340 000 hectares were deforested. Some of the land that was cleared was part of the Selva Alta National Park, and the project also had an adverse impact on the indigenous population of the area. Furthermore, as a result of the project's activities, the activities of guerrilla groups actually increased rather than decreasing because of the support they received from settlers who began to place their hopes on armed struggle as a reaction to the Government's failure to solve their serious economic and social problems.

The poor performance of the project is closely linked to its failure to incorporate the environmental dimension. The lack of appropriate environmental criteria was especially critical in the following areas: a) the failure to take the spatial heterogeneity of the environmental supply into consideration, which would have led to the design of interspersed land use schemes involving the transformation of some areas and the preservation of relatively unartificialized ecosystems in others; b) the selection of unsuitable farm models and production systems which made no provision for the integration of farming, stock raising and forestry uses, and which called for an extremely high degree of artificialization in crop-farming activities and a very low one in stock raising and forestry; c) the failure to incorporate considerations of sustainability in regard to land use; d) insufficient infrastructural complexity; e) a lack of socio-structural stability; and f) the excessive degree of uncertainty and risk associated with all the project's activities. In order for the project's objectives to have been attained, an environmental impact assessment would have been required, as well as the necessary resources and action to avoid and control its adverse environmental impacts, which were clearly foreseeable on the basis of existing information. Significantly more financing should have been secured for health, education and other public services as well as for the construction of road infrastructure and for training and technical assistance. In conclusion, the results of this project highlight the crucial importance of incorporating the environmental dimension into settlement projects and of planning them adequately, in view of the great danger that such projects may trigger highly dynamic processes having profound environmental consequences such as spontaneous settlement, deforestation, the invasion of indigenous lands, etc. The approach outlined above would help to curb the historical tendency of settlement projects to omit environmental criteria, to rely on improvisation and, in many cases to fall short of their proposed objectives.

C. "INDUFOR" NATURAL FOREST DEVELOPMENT PROJECT

CHARACTERISTICS OF THE PROJECT	COMMENTS

1. Identification

Origin of the idea:

National Forest Development Plan

Agencies involved:

The "INDUFOR" enterprise, the National Industrial Development Institute (NIDI), the Forestry Service and, in connection with the design of roads, the Public Works Department.

Objectives:

To increase the production and export of lumber made from choice woods.

To increase the production and export of wood chips made from various types of short-grained tropical timber.

Financing:

INDUFOR is a semi-public company; 40% of its capital comes from private sources and the other 60% from NIDI, 50% of which was provided by an IDB loan.

Government priorities:

To increase exports of forest products, to increase employment in rural areas and to reduce rural emigration.

Description of the area:

The project covers an area of 153 000 hectares made up of land whose relief ranges from rolling hills to very steep slopes at altitudes of between 300 and 1 000 metres above sea level. The soil is shallow and nutrient-poor. The vegetation is mostly that of tropical rainforests and includes over 85 species of trees. The average volume of wood in the area is estimated at 90 m^3 per hectare, of which an average of 15 m^3 per hectare corresponds to saw-timber of valuable woods such as cedar, mahogany, virola and others. Seventy-five per cent of the area is made up of virgin forest which therefore exhibits a low degree of artificialization; 18% are forests where a selective cutting has taken place and 7% of the area corresponds to formerly forested land that has been cleared and replaced with pasture.

The wildlife in the project area is abundant and varied and commercial hunting for hides and live specimens is currently the main activity in these ecosystems.

The climate is tropical and rainy with annual precipitation of 2 700 mm and a two-month dry season.

Almost all the land in the area is owned by the State.

Project profile:

Investments: Total: US$123 million

Chip mill, sawmill, offices, camps: US$78 million.
Forest exploitation and acquisition of standing timber: US$45 million.

The budget for the technical studies necessary for the formulation of the project was inadequate. More funds should have been armarked for mapping, for studies on forest ecology and forestry systems and for environmental impact assessments.

Period of implementation: 15 years

Employment: 1 500 people at full capacity (63% unskilled labourers).

Main construction works: Construction of a sawmill to produce lumber from valuable woods. Construction of a chip mill to produce chips from various types of short-grained wood. Construction of 1 100 km of roads for the exploitation of the forest. Construction of offices, camps for workers, an electric power plant and other project infrastructure.

Production targets: 72 000 m^3 per year of sawn wood from valuable timber.

270 000 long tons of air-dried chips from various types of short-grained tropical wood (ALDT).

Annual felling area: 10 200 hectares (5 900 hectares by clearcutting and 4 300 hectares by selective logging or culling).

Volume of annual felling: 674 000 m^3.

2. Formulation

Technical study:

Orotopographical base map at a scale of 1:250 000 with contour lines every 200 m.

Thematic mapping at a scale of 1:50 000 using a photographic enlargement of the base map and covering: types of forest (5 categories), hydrography, gradients (3 categories), stands to be logged each year using one of the two forestry methods selected, and the planned routes for logging roads. Studies based on pan-chromatic aerial photographs at a scale of 1:60 000 taken seven years prior to the preparation of the current study. Forest inventory to estimate the volume of valuable species of saw-timber and the volume that is suitable for conversion into chips.

The orotopographical map should have been drawn on a more detailed scale (for example, 1:50 000) for the preparation of the gradient maps. Given the appropriate instruments and personnel, such a map could have been prepared on the basis of existing aerial photographs. A more detailed study employing a larger number of categories should have been conducted on the types of forests in the area. A soil-erosion study and maps also ought to have been prepared. The inventory should have been more detailed and should also have assessed at least the timber productivity of the forest in order to design an adequate plan for the selective exploitation of the forest.

The budget for technical studies was too small. More funds should have been allocated for mapping, studies on the forest ecology and forestry systems, and environmental impact assessments.

The forest management plan prepared was as follows: exploitation of 5 900 hectares per year using clearcut methods, with an expected annual volume of cuts of 530 000 m^3, of which 85% would be used for chips and 15% for producing sawn lumber from choice woods. The areas where the clearcut method was to be used were to be replanted with various species of Eucalyptus and Pinus caribea. Replanting with the above-mentioned species had never before been attempted in the project area. The plan also provided for selective cutting or culling of an additional area of 4 300 hectares, on which an annual average volume of 64 500 m^3 would be extracted, which would be equivalent to felling an average of 15 m^3 per hectare. The areas to be cut selectively are slopes having gradients of more than 30% and land situated less than 50 m from watercourses, where, for reasons of soil and water conservation, clearcutting was deemed inappropriate. The total area to be logged per year by the project was therefore 10 200 hectares.

The plan really amounts to a logging --rather than a forest management-- plan; it is not based on a knowledge of the ecology and productivity of the natural ecosystems to be artificialized or of the ecosystems resulting from such a transformation. Although it is useful to consider two systems of exploitation depending on the use limitations of the land, many intermediate options between the two extremes of clearcutting and culling were overlooked which could have permitted the sustained production of timber and chips. The project should have carried out basic studies on the dynamics of the natural forests and on the fundamental factors involved in the management of such forests. Using this background information coupled with the available literature on the subject, a plan could have been designed which met the following requirements: a) sustainability; b) the production of timber and chips on a continuing basis; c) maintenance of the ability of the ecosystems to produce other goods and services (such as food, game, soil conservation, recreation, etc.); d) minimization of the risk of failure; e) maintenance of the possibility of choosing different development options in the future. The artificialization process used to arrive at this type of ecosystem also needs to be technically feasible and profitable. Forests of varying sorts of structures and composition could meet the above requirements. Some of the forest management systems that could be used are: selective cutting based on a thorough knowledge of the forest, selective cutting coupled with the planting of native or new species to improve the forest, protective felling and reproduction under canopies, and even clearcutting in small areas (e.g., less than five hectares) and replanting of species present in the area. Experience will show which of the systems are the most appropriate. Also, some areas should be left untouched as forest reserves so as to form a patchwork of untouched and exploited areas. Some of these reserves should be sited in areas with use limitations and others in zones without such limitations to ensure that the requirements mentioned above for the project area as a whole are met. An artificialization process of this type would lead to ecological coherence and a sustainable ecosystem. The system of clearcutting and replacement with plantations is clearly inappropriate because it is highly inconsistent with the principles discussed here. The type of selective felling proposed under this project meets some of the above-mentioned requirements but is nonetheless inadequate due to the project's failure to assess the ecosystem's productivity and to compile basic data on the forest's ecology, as well as the plan's provision for the use of heavy machinery.

Engineering design of the sawmill, chip mill, electric power plant, roads, housing, offices and other project infrastructure.

Financial study:

Estimation of investments, log production costs, processing costs, flow of expenditure/earnings, and cash flow.

The log production costs were underestimated, which led to the overcutting of timber in the areas near the sawmill in order to reduce these costs; this resulted in the deterioration of the forest.

Economic study:

A market study was conducted in regard to the lumber and wood chips to be produced; the internal rate of return was estimated at 23%.

Institutional study:

INDUFOR would be set up as a mixed enterprise using both public and private capital. Logging and road construction would be done by contractors. The provincial office of the Forestry Service would be in charge of enforcing the regulations and standards pertaining to logging.

To be able to monitor such a large project properly, the provincial office of the Forestry Service would have had to hire extra staff and be given more resources.

The project would have benefited greatly from the involvement of the Forestry Research Institute and the National University, which have a fairly large amount of experience in the management of tropical forests.

Environmental impact assessment:

No environmental impact assessment was carried out. However, in order to forestall criticism from ecological groups, INDUFOR commissioned a study by a group of consultants. The study argued that the project was going to maintain the forests on 40% of the land area, which would be developed on the basis of selective cutting, thereby ensuring the continuation of the animal and plant species of the area; an inventory of these species was prepared. The report also claimed that erosion problems and adverse impacts in respect of the water resources in the area would be avoided, while the trees planted in the areas to be clearcut would prevent erosion. The study further argued that natural forests of poor quality having a small volume of timber per hectare would be replaced with plantations of fast-growing, more productive species which, once mature, would yield a greater volume of usable timber.

The project should have carried out an environmental impact assessment. The EIA should have covered at least the following potential adverse impacts of the project in order to prevent or minimize them: a) the destruction of forests in disregard of the management plan; b) a reduction of the diversity of plant species; c) a deterioration in the forest's composition, structure and timber potential; d) a decrease in the number of wildlife species; e) a narrowing of the range of future development options; f) illegal settlement of land unsuitable for agriculture; g) increased soil erosion; h) pollution of water by organic and industrial wastes; and i) an increase in work-related accidents.

Many of these impacts did, in fact, occur in the project area. The measures that should have been taken to control them are discussed in the following paragraphs.

3. Main problems encountered during implementation

Inadequate supervision of the contractors and problems with respect to the supply of logs during the rainy season resulted in a failure to follow the management plan from the very beginning of the project. Thus, areas with steep gradients were clearcut, as were areas around watercourses where, under the management plan, only selective cutting should have been done. Also, in order to reduce the costs of supplying logs to the mills, in the areas where selective felling was carried out, the volume of logs extracted exceeded the planned level. These processes were particularly intense in the areas located less than 20 km from the industrial plant.

The following measures would have been required to carry out the management plan: a) ensuring that the project had the necessary infrastructural complexity to maintain a steady supply of raw materials; b) making an adequate assessment of the costs of this higher degree of infrastructural complexity; c) establishing efficient systems for supervision of the management plan by INDUFOR and by the Forestry Service; and d) setting up annual evaluation mechanisms to permit early detection of problems in implementing the management plan so that appropriate corrective measures might be taken.

An assessment carried out in the fifth year of the project's implementation concluded that the composition and structure of the forest in areas subjected to selective felling had deteriorated significantly. The trees with the best timber-yielding characteristics among the more valuable species had been cut and heavy machinery (bulldozers) had damaged the replanted trees and some of the original trees left in the forest. Thus, the forest's future production potential had been impaired as a result of the decrease in the proportion of valuable species and in the timber-yielding capacity of the forest.

The proper application of the selective method would have required: a) knowledge of the ecology and productivity of the forests to be exploited; b) a detailed cartographic study and inventory of the forest; c) adequate systems for the enforcement and periodic evaluation of the plan; d) extraction of a volume per hectare equal to the forest's productivity within the felling cycle (e.g., 15 years); e) division of the area to be cut selectively into a number of plots equal to the number of years in the felling cycle so as to ensure sustained yields; f) allowing an adequate number of well-formed, healthy trees to continue growing so that they might be harvested later; g) the use of logging systems that minimize the impact on the remaining trees and especially on reproduction; h) felling a specific number of trees in each size category above a specified minimum diameter; i) felling or ringing trees of over a given diameter, not so much with a view to using them as to eliminating unhealthy trees and those with poor timber-yielding qualities that hamper the growth of younger and more productive trees. Clearly, the application of the selective cutting method on the basis of technical criteria designed to ensure the sustainability of the forest is quite a complicated task. Other forestry management systems which preserve many of the characteristics of natural forests but which involve greater artificialization may be easier to apply. Some of these systems are mentioned in the comments made with respect to the management plan.

A group of researchers found that there had been a number of rare plant and animal species living in the flatter areas that were being clearcut which had not been present in the areas where selective logging was being practised. Therefore, the project was harming the zone's genetic resource bank, since it was reducing populations of rare species that were not found in the relatively protected areas where the forest was merely being culled.

Had studies on the vegetation and fauna been undertaken in the course of the preparation of the project, areas of low artificialization could have been created which would have permitted the conservation of all the ecosystems and species present in the project area.

The large-scale replacement of considerable areas of natural forest by plantations also reduced the diversity of the environmental supply. Forests which were potential sources of various foods (fruits, mushrooms, honey, game, etc.), medicinal substances, hides and live animal specimens, firewood and timber were being replaced by plantations whose main product was only one species of wood. Moreover, the original forests were better suited to other functions of forest ecosystems such as soil conservation and water production, as well as to the development of tourism and recreational activities. The substitution of the natural ecosystems also had the effect of reducing the range of future development options.

As has already been discussed in connection with the management plan designed for the project, the use of other forest management methods would have made it possible to maintain the diversity of species and products in the area, in addition to being compatible with other functions of forest ecosystems.

The Eucalyptus spp and Pinus caribea plantations proved to have low yields and replanting therefore had to be carried out over a very large area. By the fifth year of the project, these species had become relatively well established in some 60% of the areas planted, while the remaining 40% was being taken over by tree and shrub species native to the area. In addition, the growth rate of the species that were introduced was lower than had been expected.

This problem could have been avoided if forest management systems involving less uncertainty and risk had been used. Such systems would use native species that were present in the area or would introduce species based on the results of experimental plantings to determine the growth patterns of such species in the area.

INDUFOR encountered a problem of unplanned settlement in the zone, which was stimulated by the construction of roads and the arrival of workers in the project area. INDUFOR and the Forestry Service did not have the capacity to halt this process and, as a result, settlers established themselves on project land despite the fact that it was unsuitable for farming.

The problem of unplanned settlement was very difficult to avoid due to the strong demographic pressure on the new land opened up by the project. Nevertheless, the problem could have been minimized had the following measures been used: a) appropriate signing; b) establishment of control points along access routes to the project area; c) securing personnel and resources to ensure that the area was properly guarded. Clearcutting was an additional stimulus to settlement since it resulted in completely cleared land that was thus open to use for farming or stock raising. Therefore, the use of other less artificialized forestry methods would also have helped lessen the problem of unplanned settlement.

Soil erosion increased in some of the areas that were clearcut and in those sectors where the selective logging method was applied incorrectly and the remaining leaf canopy was consequently too low. The use of caterpillar tractors for logging operations also added to the erosion problem, as did unplanned settlement. Many of the logging roads built by the project which were later abandoned became major focal points for erosion.

This problem could have been avoided if forest management methods other than clearcutting had been used which preserved a greater amount of vegetation cover. More detailed gradient maps and maps on erodibility are crucial to the selection of the proper forest management methods and the appropriate degree of artificialization in each case in order to avoid erosion. The use of animal power for logging operations on steeply sloping land would, for example, contribute to soil conservation in such areas. Narrow roads which leave a more extensive leaf canopy and which are within the specified gradient limits, coupled with proper maintenance, would have reduced the erosion caused by the road infrastructure.

The sewage water from the camps built to house project workers flows directly into the Claro River, polluting its waters. This increased the incidence of intestinal infections, hepatitis and typhus, particularly among the children, who often swam in the river. Sawdust and other waste wood are also dumped into the Claro River, making it even more polluted.

A small sewerage treatment plant could have avoided the pollution of the Claro River with sewage. Industrial waste pollution could have been prevented by designing systems for the recovery of sawdust and other wastes for use as a source of energy.

Overall assessment of the project:

The project attained 60% of its production goals; this was partly due to problems in connection with the supply of raw materials and to the fact that the quality of the timber was poorer than had been indicated by the inventory. As a result, the project's rate of return was lower than the rate estimated during the formulation stage.

The project's main failing from an environmental standpoint lies in the design of the management plan and in the inadequate supervision of its implementation. The management plan provided for only two forestry systems (clearcutting and selective logging) which, given the way they were applied, were not compatible with the achievement of sustainable production or sustainable ecosystems. Consideration should have been given to other types of management systems involving an intermediate degree of artificialization somewhere between the two extremes of clearcutting and selective logging which would have permitted sustained production and a diversified use of the forests and which would have been more compatible with other functions of forest ecosystems, such as soil conservation, water production, recreation and tourism.

The project had the following negative environmental impacts: a) a steep decrease in the diversity of species and of the goods and services provided by the ecosystems that were transformed; b) the triggering of the unplanned settlement of land not suitable for agriculture; c) soil erosion caused by the inappropriate exploitation of forests, unplanned land settlement and the construction of roads; and d) the pollution of watercourses by organic and industrial wastes.

D. FORESTATION PROJECT IN THE CHIVILCAN RIVER VALLEY

CHARACTERISTICS OF THE PROJECT	COMMENTS

1. Identification

Origin of the idea:

National Forest Plan.

Agencies involved:

Forestry Service, National Planning Office, Regional Development Promotion Agency.

Objectives:

To increase the amount of land planted with eucalyptus trees.

To supply raw materials for the expansion of the wood panel and veneer and pulp industries.

To increase the value of extensive areas of relatively unproductive land and to rehabilitate eroded land. To raise the standard of living of owners of small and medium-sized plots in depressed rural areas.

Financing:

Central Government through the Regional Development Fund (30%) and the Multilateral Co-operation Agency (70%).

Government priorities:

Substitution of imports of forestry products, developing marginal rural areas and eliminating extreme poverty.

Description of the area:

The project area covers 200 000 hectares in the midportion of the Chivilcan River basin. Of this area, 93 000 hectares are to be reforested. The land, which is between 400 and 800 metres above sea level, ranges from rolling hills to steep slopes. Its soils are granitic, fairly deep, poor in nutrients and affected by varying degrees of erosion. The dominant vegetation is that of pastureland and savannahs cleared by fire and second-growth deciduous Mediterranean forests that provide varying degrees of ground cover. Currently, 85% of the land is used for extensive stock raising and for the production of firewood, charcoal and poles. The remaining 15% is devoted to unirrigated cereal crops.

The climate is temperate with a five-month dry season and annual rainfall amounts to 1 100 mm.

Eighty per cent of the land is privately owned and 20% is community owned. Most of the plots are small and medium-sized properties of under 200 hectares each. There are five large estates of between 5 000 and 10 000 hectares which represent 40% of the area.

Project profile:

Investments: US$31 million.

Period of implementation: 15 years.

Employment: The equivalent of 1 240 permanent jobs per year.

Construction and other works:
Establishment of four forestry nurseries. Construction of offices for the administration of the project. Construction of temporary camps for the workers.

Production targets:
Surface area to be planted annually: 6 200 hectares.
Total surface area to be planted: 93 000 hectares in 15 years.
Annual production of plants: 16 million.

2. Formulation

Technical study:

Orotopographical base map at a scale of 1:50 000 with contour lines every 50 metres. Thematic mapping at a scale of 1:50 000 covering: a) soil use groups; b) properties; c) areas that could produce wood for use in the production of wood panels and veneer and pulp.

In addition, an economic and social study should have been carried out on the property owners, their main production systems and product lines, problems, etc. This would have permitted a better design of the plantations. The study on zones to be replanted posited the forestation of too large an area on each farm (in many cases, over 70% of the farm's surface area). The percentage should have been considerably lower, since the small landowners needed to continue conducting their other production activities (mainly extensive stock raising), which are incompatible with the high-density plantations provided for by the project.

Financial study:

Tree nursery construction costs, plantation costs, projection of the price of rough wood.

Economic study:

Internal rate of return estimated at 16% with a discount rate of 8% at shadow prices. Study of future demand for lumber-grade and pulp-grade timber in the region.

Institutional study:

The Forestry Service will be responsible for the execution of the project. The reforestation work will be carried out by private contractors under the supervision of the regional office of the Forestry Service. The tree plantations will be established under agreements with property owners whereby the Forestry Service will finance all the costs of planting and managing the plantations in exchange for 50% of the marketable volume of timber obtained from culling and from the final felling.

The scheme for the execution of the project should have been based on a knowledge of the types of landowners in the zone and should have provided for their involvement. The scheme was very rigid and left open few opportunities for initiative on the part of landowners, who basically were called on only to hand over their land for planting.

Environmental impact assessment:

Since the designers of the project claimed that it would contribute to the conservation of the environment, an environmental impact assessment was not carried out.

Despite the fact that soil conservation was one of the project's objectives, an environmental impact assessment should have been carried out. The main impacts that should have been considered are: a) the effects of a change in land use on current production activities and employment; b) a reduction of the diversity of the landscape and of genetic diversity; c) the impact on the fauna of the area (species whose populations should be increased and those that should be controlled); and d) toxicity and pollution as a result of the use of poisons, pesticides and herbicides.

3. Main problems encountered during implementation

The first problem encountered during the implementation of the project was the fact that landowners with less than 100 hectares (55% of the plots) were reluctant to believe that it would be to their advantage to sign reforestation agreements. Those small landowners who did sign such agreements allowed the use of a smaller proportion of their land than planned for by the project (generally less than 15%). Moreover, a firm engaged in the production of pulp acquired land from small and medium-sized landowners with the aim of planting the land with trees and thereby ensuring its supply of raw materials in the long term. By the tenth year of project implementation, it was estimated that at least some 25% of the small landowners had sold their land to firms and had migrated to urban areas.

Many more of these landowners might have participated in the project had an appropriate study been carried out on the landowners' typology, requirements and expectations, and if effective mechanisms for encouraging them to participate had been established. This could have significantly improved the standard of living of the small landowners.

The incentives offered for the establishment of plantations and the lack of incentives for other activities (such as the improvement of rangelands and the management of natural forests) led, in many cases, to the forestation of land suitable for livestock raising and the replacement of natural forests which could have been managed instead of being eliminated. Ironically, a significant proportion of the eroded land suitable for forestry was in the hands of small landowners who continued to let the land deteriorate as a result of grazing and the lack of tree cover.

The lack of ecological coherence characterizing the implementation of this project could have been avoided if, when the maps of areas suitable for planting were being prepared, vegetation map overlays had been used. This would have permitted the areas with the least vegetation (and hence those most liable to soil erosion) to be selected for planting and would have prevented the elimination of natural forests. This more careful selection of areas to be forested, coupled with incentives for the management of natural forests and adequate supervision of the project's implementation, would have helped to conserve the natural forests.

As a result of the planting of continuous areas of up to several hundreds of hectares, large expenditures were required for fire and pest control programmes. During the twelfth year of project implementation, an invasion of borer insects had to be combatted with insecticides sprayed from aircraft, and this caused problems of toxicity in bee-keeping activities, which are an important local industry.

Such problems could have been avoided if a limit had been placed on the maximum continuous surface area to be forested and if tree plantations had been interspersed among other land uses suited to the potentials and limitations of each site. Toxicity problems could be minimized using integrated pest control systems which reduce the use of pesticides and ensure their proper application.

Overall evaluation of the project:

By the fifteenth year, only 71 000 hectares had been forested, which amounted to 76% of the target figure. This was largely due to the fact that the small and medium-sized landowners, who were the majority in terms of the total number of owners, found the project inappropriate and unattractive.

The poor implementation of the project was largely due to the improper design of plantation models, which did not adequately reflect the actual situation and expectations of the landowners or the environmental supply. The project failed to achieve its aim of assisting small and medium-sized landowners because it was too rigid and did not provide for participation by the target population. In order to overcome these problems, the plantation models should have had the following characteristics: a) the inclusion of various land-use objectives (energy production, timber, a combination of forestry and livestock activities, etc.); b) provision for different densities in line with the above; c) insofar as possible, compatibility with other land uses (e.g., grazing); d) the setting aside of a sufficient proportion of land which, instead of being planted, would be reserved for other, ecologically coherent uses. This, in turn, would reduce some of the undesirable consequences of single-cro farming (e.g., decreased diversity, a greater risk of attack by pests and of fire, etc.).

V. CONCLUSIONS

From the foregoing analyses of four typical agricultural development projects, it can be concluded that in order to incorporate the environmental dimension more fully into such projects, the following action is required:

1) All forestry and agricultural projects should be based on an approach that ensures their sustainability, i.e., one that provides for a steady or increasing level of productivity and resource endowments. This can be attained through the use of appropriate ecosystem management methods involving rates of harvesting that are in keeping with the ecosystem's productivity and/or the addition of inputs to make up for any losses of certain elements such as soil nutrients.

2) Forestry and agricultural development projects should employ methodologies and indicators that permit an accurate assessment of the environmental supply and of changes in this supply in space and over time in areas where such projects are implemented. Similarly, the use potentials and limitations of the various ecosystems involved should be assessed carefully.

3) A crucial period for the inclusion of considerations of environmental supply is during the project identification phase. Integrated resource studies can help to determine the potential of the various ecosystems in relation to different products and production systems, and this would, in turn, help to prevent many potentially advantageous land-use options from being discarded at the very outset, as occurs in the all-too frequent cases where only one or two production activities are selected at the beginning of a project.

4) Environmental supply often varies considerably from one area to another. Such variations should be taken into account in designing the land-use systems to be adopted by a project so that they will be consistent with the potentials and limitations of the different ecosystems. This would ensure that ecosystems are used in an ecologically coherent manner.

5) The general criterion that should be used in the transformation of ecosystems is that the degree of artificialization should be directly proportional to the potential of a given ecosystem and inversely proportional to its use limitations.

6) The extent of artificialization and the production systems to be adopted should also be in keeping with the entrepreneurial ability, experience and know-how of the landowners on such systems. The more limited the entrepreneurial capacity of the operators, the lower the degree of artificialization that should be adopted. The selection of an excessively high level of transformation in cases where the producers have a limited entrepreneurial capacity would force them to adopt technologies which are too sophisticated and too expensive, since they require a constant flow of inputs. The result may be a failure to attain production goals and, worse still, the deterioration of the ecosystem.

7) In selecting systems of production and management techniques, preference should be given to those systems and techniques that minimize negative environmental impacts.

8) Forestry and agricultural development projects should carry out an environmental impact assessment during their formulation phase. Similarly, such projects should include measures for reducing or avoiding any environmental impacts and an adequate budget for implementing them.

9) The systems and methods selected for use in the transformation of ecosystems should involve as little uncertainty and risk as possible, in addition to leaving future development options open. Such criteria should be particularly strict in the

case of the transformation of mature ecosystems exhibiting little or no artificialization (for example, virgin forests), whose rehabilitation, in the event of their impairment, could prove to be technically and economically unfeasible.

10) Development projects should emphasize training activities and introduce new technology gradually over sufficiently long periods of time so as to ensure that the proposed management systems and methods are successful and environmental sustainability is attained.

11) Production systems should be designed in such a way as to ensure a proper integration of the knowledge and experience of peasant or capitalist producers with the intended innovations to be introduced into such systems.

12) Effective participation in the various phases of forestry and agricultural development projects by the different social groups involved in such projects is very important in preparing a balanced design so as to achieve a greater incorporation of environmental criteria. Such social groups include government agencies, non-governmental organizations, producers' associations, associations of businessmen, peasant unions, etc. Since some of these groups are bound to be affected by given adverse environmental impacts and/or tc benefit from the incorporation of environmental criteria, they will advocate designs that are more desirable from an environmental standpoint. For these reasons, their participation in project formulation, decision-making and negotiations can be highly advantageous.

13) The incorporation of the environmental dimension into agricultural development projects may not only minimize project's adverse environmental impacts and ensure the sustainability of the ecosystem, but can also make an effective contribution to the achievement of the project's objectives. Therefore, the greater costs involved in incorporating environmental criteria into such projects are justifiable not only from the point of view of society but also from that of the institutions or firms that implement them.

14) An important step towards the incorporation of the environmental dimension would be to prepare methodological manuals based on the general recommendations put forward in this document.

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