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FRAGILE LANDS

A Theme Paper on Problems, Issues, and Approaches for Development of Humid Tropical Lowlands and Steep Slopes in the Latin American Region

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SUMMARY AND CONCLUSIONS

This paper presents a framework for thinking about the problem of fragile lands, using the steep lands and humid tropical lowlands of Latin America and the Caribbean (LAC) as its point of departure. Although the paper is directed to LAC region needs, the nature of the fragile lands problem is universal. The concepts developed have equal applicability outside Latin America. The paper focuses on concepts useful as a guide for selection of a solution strategy, giving minimal emphasis to description of the nature of the problem.

USER'S GUIDE TO THE THEME PAPER

The first four sections give a brief summary of the fragile lands problem, its causes, and impacts. Development professionals familiar with land degradation problems in Latin America may wish to skim these sections quickly and focus on those relating directly to fragile lands programming. It is suggested that those with limited time read the section on issues (V) closely, review the section on practical approaches (VI) for an overview of the different types of action possible at the country level, and read the section on program formulation (VII).

THE NATURE OF THE PROBLEM

The fragile lands problem can be understood only as a subset of the general problem of rural underdevelopment. Fragile lands become a problem when the social and economic factors associated with underdevelopment are combined with a land resource that is subject to rapid deterioration under human use. This combination leads to a pattern characterized by low and often declining output, degradation of the resource base and loss of future productivity, and harmful effects off-site.

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In Latin America, most of the land is potentially fragile. Sloped lands account for over one-half of the arable land, and much of the remainder lies in the humid tropical lowlands. Nearly all of the small farmers are dependent on fragile lands.

From the point of view of society as a whole, off-site impacts, such as siltation and flooding, are often more important economically than on-site degradation. The success of development programs in nonfragile areas can be measured by comparing increases in income relative to project cost, and therefore does not necessarily require that a large area be included in the program. A fragile lands program, however, cannot be a success if it does not have an impact on degradation off-site. Except in certain critical locations, this generally requires that the program cover a large area.

THE NATURE OF THE SOLUTION

Although some fragile lands users exploit the land destructively by choice and are able to escape negative consequences, most know of no better alternative to destructive use and are themselves victims of the subsequent deterioration. As a corollary to the principle that small farmers allocate resources efficiently, it can be argued that fragile lands users do not willingly destroy the basis of their survival. Their land use system is likely to be the least destructive one available, given their resource constraints, income needs, and the technologies and institutional arrangements available to them. In only a few

cases will marginal changes in the allocation of small farmer resources bring about a sustainable land use system that produces a net income equal to or greater than the current one.

The search for solutions must therefore begin from an understanding of the land user's decision regarding the allocation of resources, which may be summarized by the following diagram:

Allocate Resources		to produce Outputs
Land	\	/ Current income
Labor	\	/ Future income
Technology	>	< Changes in resource quality
Institutions	/	\ Off-site impact
Other inputs	/	\ Community benefits

The land user's decision has three basic components, given resources constraints:

- Selection of a land use system (including annual crops, pasture, protective reserve, and agroforestry);
- Selection of a specific set of production technologies to implement this system; and
- Selection of protective measures, if any, to be implemented within the system (contour plowing, for example).

The key variable from a fragile lands perspective is the intensity of land use, which is embodied in the user's selection of the level of resources to apply to each unit of land. Except in those rare instances in which a fixed pool of resources can be rearranged to provide more protection for the land resource with no negative effect on the land's production, an improvement in fragile lands management must be based on one of two fundamental approaches:

Basic Strategies

Strategy:	An increase in intensity	A decrease in intensity
	The application of additional resources (including, in particular, labor) to achieve protection with no loss in production	Transfer of resources to an alternative productive use, reducing stress on the land and degradation
Key issues	What is the source of the the additional resources?	Are their alternative uses for these resources?
	Is their allocation economically, socially, and technically feasible?	Will the alternative use yield an income equal to that forgone?
	Is their allocation to this use attractive?	How will the production forgone be replaced?

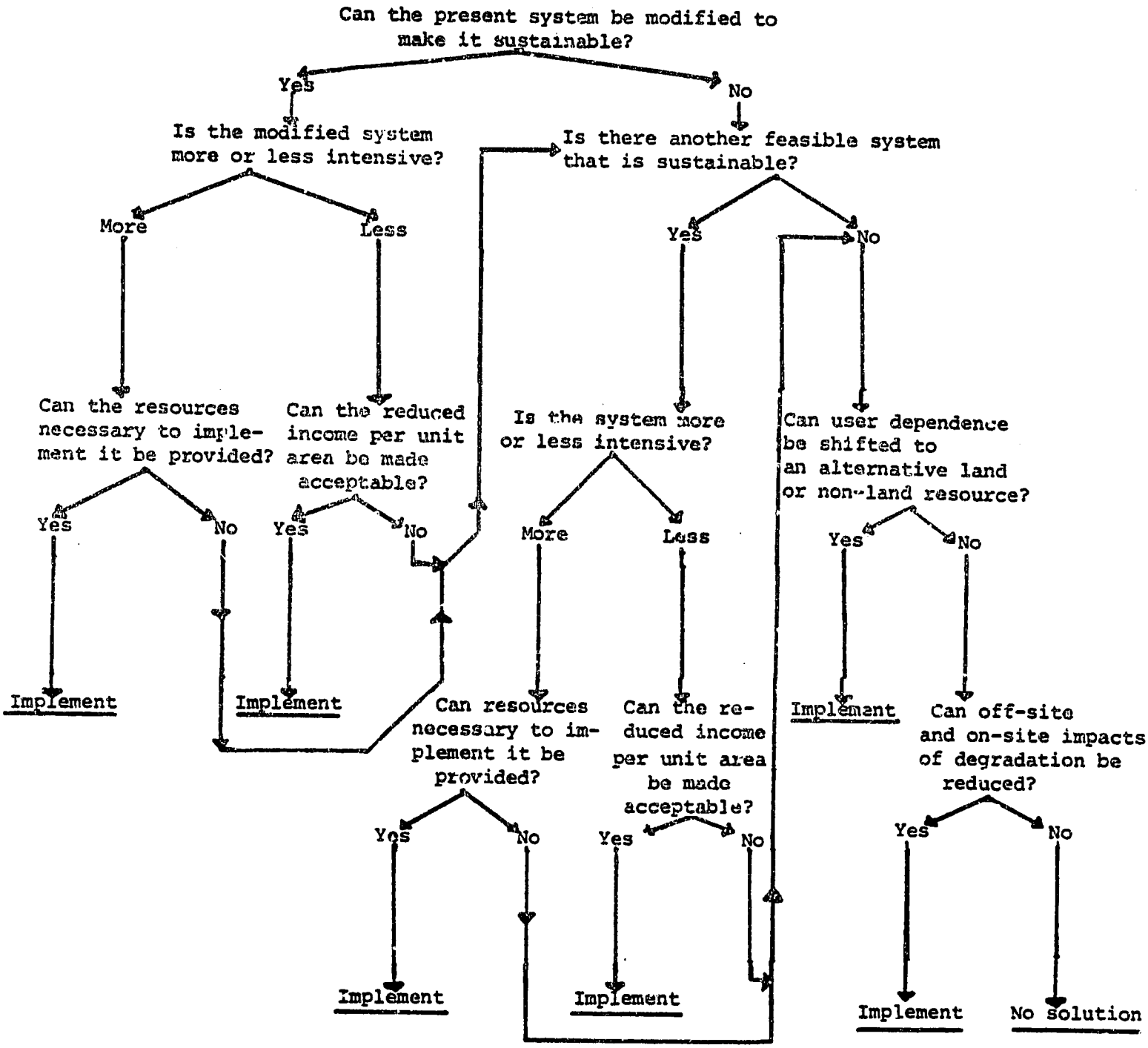
Figure 1 presents these two strategies in decision-tree form.

MEANS FOR ACHIEVING A SOLUTION TO THE FRAGILE LANDS PROBLEM

Although changes in land management to achieve sustainability and income goals must take place at the local level, the means of bringing about these changes do not necessarily involve on-site action. Many factors underlying land mismanagement do not originate at the local level. Broader issues, ranging from the institutions that generate technologies to the economic incentive structure that determines their acceptability, are equally central to the cause of the problem and therefore of equal or greater relevance to its solution. Underutilization of nonfragile lands, in particular, is a major factor underlying overuse of fragile lands in Latin America. At base, fragile lands mismanagement is not a local problem, and therefore the solutions are likely to involve action off-site.

FIGURE 1

FRAGILE LANDS DECISION TREE



Past programs have relied too heavily on direct attempts to influence on-site behavior at the local level. Where successes have been achieved, they have thus been limited to those few localities in which the program was implemented. Overall, past interventions have not had a measurable impact on the problem, nor have they led to the wide-scale adoption of on-site technologies that would be necessary to achieve this impact with on-site programs.

When change has come about, it has not been due primarily to interventions directed at fragile lands management, but has instead been the product of broader changes in the economy and society that have drawn off labor and other resources, relieving the stress on the land. Future programming should build on this experience by identifying and dealing with the underlying factors influencing land management decisions.

PROGRAMMING OPTIONS

Alternative approaches to solving fragile lands problems fall into three basic categories:

1. Direct interventions in fragile lands. Soil conservation programs and other investments to maintain the productivity of the land resource base seek to reduce degradation directly by encouraging the land users to protect their land. A second approach relies on substituting a different and less destructive production system for that currently used. This approach can be implemented in conjunction with land maintenance to provide the economic incentive for the latter, or it can be used instead of

land maintenance to institute a sustainable system that does not require as much investment in land maintenance as that currently practiced.

2. Indirect interventions in fragile lands. Efforts to change the environment in which decisions concerning the use of fragile lands are made may be more effective than direct contact with farmers to influence their decisions so as to promote sustainable use of fragile lands by farmers and other users. Indirect measures include generation of technologies for sustainable production, measurement and monitoring of the resource base, reform of the landholding system, and land use planning. Policy reform to remove disincentives to sustainable land use may be more effective than interventions in the fragile lands and, in addition, may be a prerequisite to successful on-site programs.

3. Interventions outside of fragile lands. The ways in which the fragile lands resource is used are directly influenced by how nonfragile land is used and by the existence of more attractive alternatives for the labor and other resources devoted to fragile lands agriculture. Consequently, the creation of options to fragile lands use, such as off-farm employment or intensification of nonfragile lands use, may have a significant impact on fragile lands. If fragile lands degradation cannot be reduced by direct or indirect means, the only remaining alternative is to attempt to reduce the impact of degradation off-site by, for example, dredging waterways to remove silt deposits. This final approach must be viewed as a stopgap measure, a less attractive

but occasionally necessary alternative when preventive measures fail.

PROGRAM FORMULATION

A program to address the fragile lands problem must deal with the factors underlying degradation, rather than surface symptoms such as erosion. Whether the program is intended to address a specific location, a region, or the country as a whole requires that program designers look beyond the obvious to identify the specific set of factors promoting degradation and, within this set, those factors that can be affected by direct, indirect, or off-site measures. Alternative measures for influencing these factors can then be compared, using the familiar set of feasibility criteria (economic, technical, social, financial, institutional, and environmental) to identify a set of actions that will have the maximum feasible impact on the factors underlying fragile lands degradation.

I. INTRODUCTION

The problems associated with degradation of fragile lands in the developing world have received growing recognition in recent years, resulting in increased allocations of development funds to the search for solutions. This search has yielded both successes and failures, but two central facts have become clear: fragile lands degradation has far-reaching impact both on-site and throughout the economy, and the problem of the fragile lands is not a single problem but a tightly interwoven complex of problems with no easy or quick solutions.

This paper is intended to serve as the basis for discussing a regional program for the Latin America and Caribbean (LAC) region to address the fragile lands problem. Its aim is to provide a framework for thinking about the problem of fragile lands and to present the ways available to deal with it.

The paper focuses on the steep lands and the humid tropical lowlands -- the two fragile land areas judged to have the highest priority in the LAC region in terms of geographic extent, economic and social importance, and severity of off-site impacts. The paper first briefly describes the fragile lands degradation problem, causal factors, and related problems. Second, alternative approaches are identified that, singly or in combination, represent candidates for inclusion in programs to address the fragile lands problem. Finally, 10 issues that relate to formulation of programs are discussed and a broad approach to program formulation is outlined.

The paper offers ideas and concepts for consideration rather than definitive answers. In accordance with the terms of reference for this effort, it is not intended to present a detailed discussion of the fragile lands problem, since an extensive literature is already available documenting the extent of degradation and discussing causes and associated problems. Nor is the paper intended to present recommendations for action or review what has been tried or what has worked or not worked in the past.

II. NATURE OF THE PROBLEM

WHAT ARE FRAGILE LANDS?

As used in this paper, the term "fragile lands" refers to lands that are highly subject to deterioration under common agricultural, silvicultural, and pastoral use systems and management practices, as demonstrated by one or more of the following:

- Declining short-term production;
- Loss of the long-term potential productivity of the resource base;
- Serious off-site impacts from environmental degradation of the site; and
- Slow recovery of the soil, water, plant, and animal resources after being disturbed by human beings or nature.

The fragile lands problem arises when destructive patterns of use are combined with a natural resource base subject to deterioration; both elements must be present for the land to be meet the definition. Three points should be highlighted:

- Any land can be destroyed by inappropriate management practices, even deep fertile soils on well-drained plains. These lands, however, are not fragile because, in general, they are not highly susceptible to deterioration under prevailing use systems.
- Lands that have a high potential for deterioration are not included in the definition if there is no immediate threat that they will be subjected to destructive use. Uncleared tropical rain-forest land is not fragile as long as it remains uncleared and is not threatened by incursion; it is not a problem until inappropriate use or the threat of this use begins.
- Potentially or formerly fragile lands that are managed in a sustainable way are excluded from the definition. In effect, they are no longer fragile, although they may become so again if the management system changes.

WHY SHOULD FRAGILE LANDS BE DEFINED AS AN AREA OF CONCERN?

Development attention has traditionally focused on areas in which the resource base has the greatest potential to generate increased production and incomes. Within agriculture, emphasis has therefore been given to such areas as development of cash crops in fertile areas (such as flood plains) and expansion of irrigation systems. There are four reasons why fragile lands merit and are receiving increased attention in the LAC region.

First, Latin America's endowment of good lands is extremely limited. A large portion of production derives from areas that are either degrading rapidly or subject to degradation. Few unexploited areas remain that do not have major resource constraints (although too many decision makers and others believe the opposite to be the case). Expansion of production and agricultural employment will increasingly depend on raising the output of existing cultivated areas or drawing production from less favorable lands.

Second, the region's rural poor are concentrated disproportionately on the least productive lands and those most subject to degradation. Their activities account for a large share of food crop production, which is being assigned a higher priority as food security becomes an increasing concern.

Third, the focus on small farmer systems during the past decade has revealed that few are as stable, unchanging, and isolated as they were assumed to be. Under pressure from such factors as population growth and economic change, traditional systems are being transformed from sustainable to unsustainable

land use systems, bringing land degradation, income loss, and destruction of resources both on- and off-site.

Fourth, the off-site impacts of fragile lands deterioration, particularly increased runoff, irregular stream flow, and siltation caused by hillside erosion, are imposing high costs on agriculture and other social and economic activities downstream.

MAJOR CATEGORIES OF FRAGILE LANDS IN LATIN AMERICA

This study focuses on two types of fragile lands that are common in the LAC region:

- Uplands and steep slopes: those lands with a slope of more than 8 percent or an elevation above 1,000 meters.
- Humid tropical lowlands: areas with mean annual temperature above 24 degrees Celsius, elevation below 200 meters, and mean annual rainfall that is above 2,000 mm. and exceeds potential evapotranspiration.

The geographic boundaries of these two types must be viewed only as indicative. Various authors use "steep" to mean a slope over 10, 15, or even 20 percent, for example. Depending on local usage, premontane regions with average temperatures of 18-24 degrees Celsius may be considered humid tropical lowlands. These distinctions are largely academic. However defined, these two types account for the vast majority of the fragile and potentially fragile lands in the LAC region (and, indeed, most of the total area). This paper gives more emphasis to the steep lands, which are more extensive in those LAC countries in which AID is active.

It must be stressed that other fragile land areas are also at risk in the LAC region, although their total extent and economic importance are less than the two types of fragile lands chosen for emphasis. These include mangroves and coastal zones,

unique ecological systems and genetic resources, some irrigated areas, and parts of the semi-arid and arid regions.

MAJOR TYPES OF LAND DEGRADATION

Four major types of degradation will be considered in this paper: erosion, declining soil quality, deforestation, and change in the mix of species. All four types occur in both steep lands and humid lowlands, but with key differences.

Erosion

Erosion is a natural process and occurs on all soils regardless of slope or other characteristics. Erosion becomes a problem when soil loss endangers future productivity or causes damage downstream. Three factors come together to cause rapid erosion:

- A susceptible soil resource (such as steep slope or easily erodable soils);
- Climatic stress (such as high or intense rainfall or wind); and
- Destructive human use patterns that disturb the surface or structure of the soil (through tillage practices, for example), remove vegetative cover, or actually move soil (to harvest a root crop, for example).

Erosion tends to be a more serious problem on steep lands for two reasons: steep topography raises the velocity of water and soil moving across the surface, increasing their damaging power; and soils in steep areas tend to be thinner than lowland soils, with a shallower layer of fertile topsoil. Erosion in the uplands is a special concern because of the greater potential to create problems downstream.

Declining Soil Quality

Agriculture creates stress on soils, removing nutrients in the form of crops or forage for animals, affecting soil chemistry, and subjecting soil structure to damage (by compaction from farming operations or animal traffic, for example). This stress may not be reflected in lost productivity if the soil's initial fertility is high, lost nutrients can readily be replaced by chemical or organic additives, and the soil structure can be maintained or allowed to recover during fallow periods.

These stresses are less manageable under humid tropical conditions than in the temperate zones because tropical soils are more easily damaged and initial nutrient levels are lower. Under natural tropical conditions, most nutrients are held in the biomass rather than in the soil. Once the natural cover is removed, the soil may support cropping for only one or two seasons before accelerated leaching, chemical change, and the demands of the crop exhaust the remaining nutrients in the soil or make them unavailable. Poor farmers in remote areas are also less able to apply practices needed to maintain soil quality.

Deforestation

Although deforestation contributes to both erosion and decline of soil quality, it constitutes a separate form of degradation. Tropical forests are themselves a resource that, once destroyed, cannot be replaced quickly or easily, if at all. As a self-renewing system producing timber and other products, as an environment supporting a range of animal and plant species not found elsewhere, and as a critical element in the water cycle, tropical forests constitute a unique and productive resource.

Change in the Mix of Species

Overuse or inappropriate use of fragile tropical lands may set in motion the progressive replacement of productive economic species with plants that are less useful to human beings. Overgrazed pastures degenerate as inedible and low-nutritive species replace desirable grasses, legumes, and other plants. Hardwood forests give way to scrub species with little economic value. Agricultural lands become increasingly overrun by weed species that flourish in the new environment created by forest clearing. These changes may be as effective as erosion in converting a land resource into one that cannot be used by humans. In some cases, they also constitute ecological blind alleys, which cannot be repaired by humans and will require decades to recover to their original productivity, even if left undisturbed.

CURRENT EXTENT OF THE PROBLEM

Both steep land and humid lowland problems are extensively documented in the literature and do not require repetition here. Major sources are cited in the bibliography. Country-specific information is also found in AID's Environmental Profiles prepared for the LAC region and most major missions.

Degradation in the Steep Lands

It has been estimated that between 60 and 75 percent of the world's humid tropics are hill lands (Plucknett). In Latin America, steep lands account for over 50 percent of the total land area, ranging from a low of 40 percent in Colombia to a high of 80 percent in Haiti, the Dominican Republic, Honduras, and Panama (Posner and McPherson).

There is no consensus on the proportion of the steep land area that is degraded, how severe the damage is, or how rapidly it is progressing, although there is universal agreement that the problem is widespread and growing worse. Posner and McPherson cite estimates that 42 percent of Mexico is affected by "accelerated erosion" while 77 percent of El Salvador suffers from "severe" erosion, but note that the degradation implied by these estimates is inconsistent with the continued intensity of land use.

Deforestation of critical watersheds is also proceeding more rapidly than even 10 years ago. The effective life of hydroelectric dams has been reduced by up to one-half by siltation greatly exceeding estimated levels. For example, the silt load in the Dominican Republic's rivers increased 300 percent over a 12-year period (Santos). Deforestation and mismanagement of agricultural lands have jointly contributed to this problem.

Degradation in the Humid Lowlands

Deforestation, declining soil quality, and changes in the species mix all affect the humid lowlands. FAO estimates covering 23 countries (excluding only some of the smaller Caribbean states) suggest that 5.6 million ha. are deforested annually in tropical America, equivalent to 0.63 percent of the total area now remaining. Tropical America has more forest than any other world region, with 53 percent of its area still forested, but it also has the highest rate of deforestation (FAO, 1982). FAO cites shifting cultivation as the major cause of deforestation, accounting for roughly 35 percent of the area deforested. In many cases, the timber and other resources are lost by burning

when the land is cleared for agriculture. Clearing for ranching and commercial logging also account for large areas, but with fuelwood harvest, planned colonization, and other commercial uses are relatively unimportant causes. Deforestation is widely believed to be accelerating, but the rate of increase is subject to active debate (Hecht). The rate of reforestation is insignificant in comparison with that of forest clearing. Excluding Brazil, only 1 ha. of tropical America's forest is replanted for every 35 ha. cleared (FAO, 1982).

The degradation that follows deforestation in tropical areas, taking the form of declining soil quality and conversion of pasture into unproductive scrub, has not been documented on an area-wide basis. Although both types of degradation are known to be widespread, only fragmentary evidence is available to estimate their extent.

VARIATION ACROSS REGIONS

Examination of the data indicates that Latin America's subregions are not a useful unit of analysis for the fragile lands problem. Although there are sharp differences between countries and within countries, there are no clear patterns that differentiate fragile lands degradation in the Caribbean from degradation of similar sites in Central America or the Andean countries. Table 1, based on tables in Posner and McPherson, demonstrates the degree of variation across countries and the major role of steep lands in agriculture throughout the region.

TABLE 1

CONTRIBUTION OF STEEP SLOPES TO AGRICULTURAL OUTPUT OF TROPICAL AMERICA IN THE MID-1970s (%)

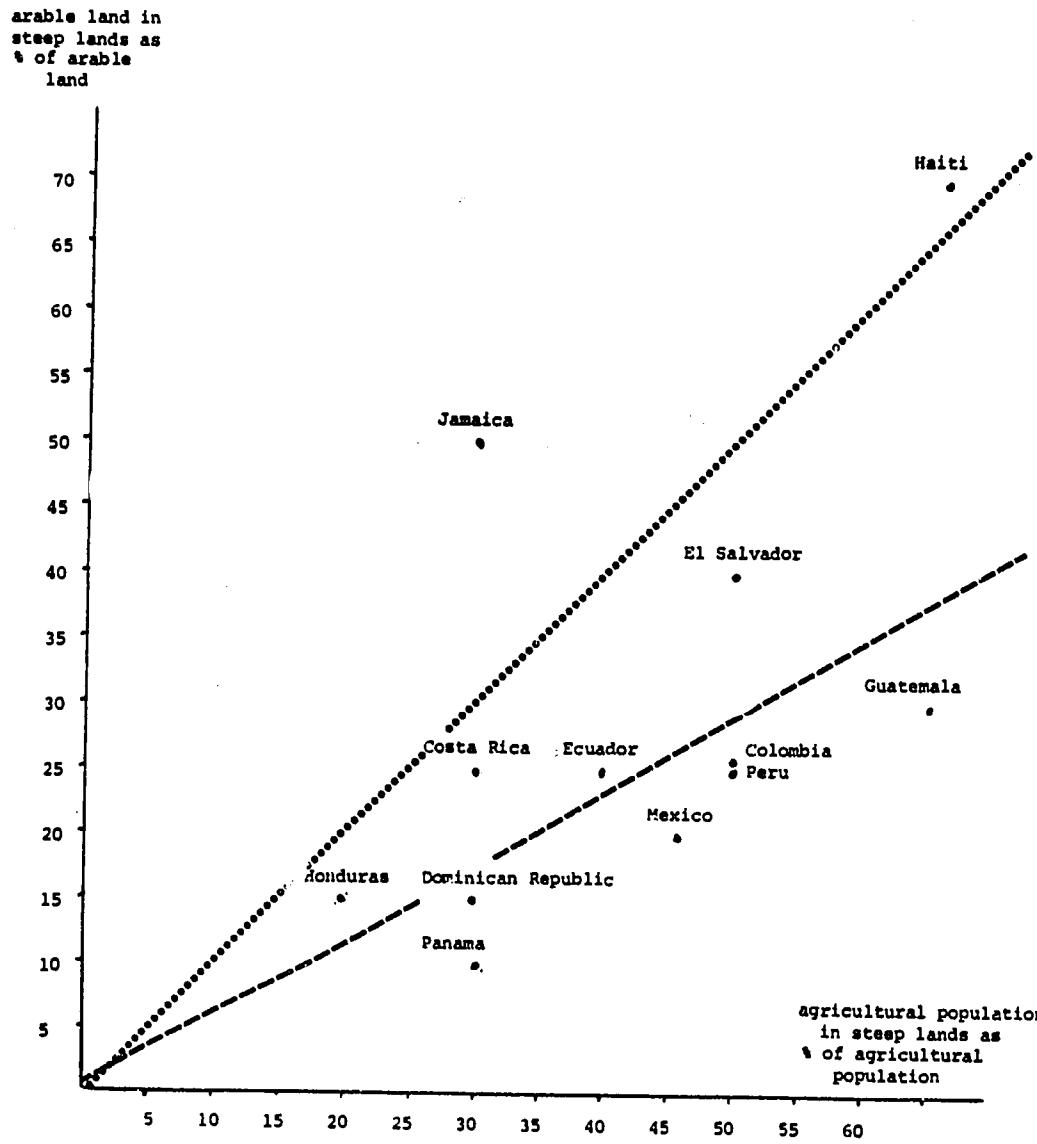
Country	Steep Land as % of All Arable Land	Contribution to Total Agricultural Prod'n	
		Including Coffee	Excluding Coffee
Andes			
Ecuador	25	42	33
Colombia	25	38	26
Peru	25	22	19
Central America			
Guatemala	30	45	26
El Salvador	40	75	18
Honduras	15	38	19
Caribbean			
Haiti	70	50	30
Dom. Rep.	15	43	31

To the extent that regional differences exist, they lie in how the impact of degradation is felt, not in the pattern of degradation as such. The relatively small size of the watersheds in Central America and the Caribbean, a function of the smaller land masses involved, tends to magnify the proportionate impact of degradation in any given part of the watershed. The central role played by tourism in the Caribbean means that damage to the coastal environment has the potential to cripple the national economy; this is not the case in the larger countries. These differences affect the priority attached to different parts of the problem, but are not related to either the cause or the nature of the degradation itself.

Figure 2 compares the importance of steep lands in the agricultural system of 12 LAC countries, in terms of the percent of the agricultural population living in these areas and the percent of arable land that is steep. In countries below the dotted line, the density of the agricultural population is higher on steep land than elsewhere. In all but two countries (Jamaica and Haiti), the agricultural population is concentrated in the steep lands, with lower densities in the nonsteep lands. No clear regional pattern is evident.

FIGURE 2

COMPARISON OF STEEP LANDS AND AGRICULTURAL POPULATION IN 12 LATIN AMERICAN COUNTRIES



Source: Data from Posner, 1982, p. 342

III. CAUSES AND ASSOCIATED PROBLEMS

OVERVIEW

The problem of fragile lands mismanagement is not a single issue, but rather a complex of closely related problems that interact with and mutually reinforce one another. Small farmer poverty in fragile land areas contributes to mismanagement of the land, is in part the result of the land's low productivity and fragility, and is clearly a problem itself.

In a real sense, it is incorrect to view the fragile lands problem as separate from that of small farmer agriculture. Nearly all small farmers in the LAC region are located on fragile lands. The institutional and technological deficiencies that limit their income also force them to follow destructive patterns of land use. Mismanagement is by no means limited to small farmers, however. The degradation caused by commercial logging operations and large-scale farmers is superficially similar to that created by small farmer activities, but the causes, and therefore the solutions, are fundamentally different.

This section focuses on the major problems associated with fragile lands mismanagement, both as causes and as underlying problems made worse by the mismanagement. The distinction between these problems (causes) and those identified in the next section as resulting from mismanagement (impacts) is inevitably somewhat artificial.

INCREASING POPULATION PRESSURE AND OTHER DEMOGRAPHIC FACTORS

Demographic Increase

Population growth is often cited as a cause of fragile lands mismanagement. However, an increase in population alone does not

lead to misuse of the land. To result in mismanagement, the increase must result in increased use of easily degradable lands without appropriate protective measures. If, for example, the growing population is diverted into other economic activities that do not draw on the land resource, land use may be unaffected. Similarly, if population growth and other factors raise the value of land and the profitability of agriculture sufficiently to motivate increased land conservation, population growth may spur conversion of fragile lands into areas of high sustainable output (Java's terraced rice lands, for example).

These favorable scenarios have occurred too rarely in Latin America, where demographic increase has been extremely rapid among poor rural populations and has not been accompanied either by economic alternatives to increased fragile lands exploitation or by measures to raise sustainable production.

In-migration

In addition to raising the pressure on already-cultivated fragile lands, population growth has spurred the incursion of farmers and others into new areas through organized and spontaneous colonization. This process has opened up hillsides and humid lowlands that are highly subject to rapid degradation.

The dramatic and well-documented process of incursion into marginal areas is only part of the problem, however. Equally important is the invisible spread of unsustainable land use practices within a single area, as population pressure forces small farmers and landless laborers to move into poor land adjoining their existing areas of operation. Each year, these

groups bring into cultivation (or use for grazing or firewood) lands farther up the mountain slopes, with disastrous results.

Demographic Change

As part of the process of rural change, the demographic mix is undergoing rapid transformation in many areas of the LAC region, particularly the Caribbean. These change are characterized by a rise in the average age of farmers (estimated to have reached as high as 55 years in the Jamaican hillsides, for example); an increasing proportion of female-headed households, as males migrate seasonally or permanently in search of work; and fewer young people committed to the land. Together, these changes reduce the willingness of land users to apply sound management practices and the users' ability to supply the labor needed to implement them.

LACK OF FRAGILE LANDS TECHNOLOGIES

Current Lack of Technologies Suited to Marginal Lands

Research and testing to develop improved agricultural technologies have focused heavily on lowland areas most resembling the temperate zones. These areas have been assigned a higher priority by research institutions because they have a higher productivity under modern use systems and are often associated with agrarian subsectors closely linked to the research network (such as larger farmers or those located close to the cities). The technologies developed for these areas are rarely relevant to the uplands and humid tropics. Worse, their use may lower production and promote rapid deterioration of the productive resource base. Conversion of tropical forests to extensive monocropping systems is the classic example of misapplication of

temperate zone technologies to tropical conditions.

The result of inattention by researchers to the uplands and tropical lowlands is a lack of verified and widely available techniques to improve the output and sustainability of current systems or offer alternative approaches. This shortage is aggravated by the high degree of heterogeneity in fragile lands systems and situations, implying that technologies developed for one type of location may have limited applicability elsewhere.

The lack of technologies should not be exaggerated. In many specific cases, suitable technologies are available as a basis for action and sound fragile lands use. In addition to a growing supply of technologies developed by ongoing research programs in the uplands and humid tropics, indigenous methods offer a wealth of technical approaches with potentially broader applicability. This information will be lost if researchers do not analyze these methods before they are modernized into oblivion.

Lack of Systems to Develop Suitable Technologies

Neither public sector research networks nor researchers affiliated with private sector input suppliers are oriented toward the fragile lands. The historical pattern of inaction in fragile lands, their low productivity, the poverty of their inhabitants, and the low importance previously attached to food crops have all contributed to a lag in research programs focused on the needs of fragile lands. Facilities tend to be located in the best lands and close to the cities, where short-term gains and professional reputations can be made, not in remote or fragile areas.

Promotion and Application of Inappropriate Technologies

When technological change has been promoted in fragile areas, the emphasis has too often been on transforming existing systems through modern technologies, including replacement of complex, multi-crop systems with monocropping and substitution of chemical inputs for organic approaches (including fallow).

Inadequacies in technology generation are paralleled by the weakness of extension and other systems for informing fragile lands users of improved technologies. Served by poor road and transport networks, plagued at times by civil strife, and often remote and inhabited by politically weak ethnic minorities, fragile lands have been slow to benefit from the spread of government services, including extension.

LACK OF ACCESS TO INPUTS, CREDIT, AND OUTPUT MARKETS

The distance of many fragile land areas from key market centers and the economically marginal position of their inhabitants have combined to hinder the advance of economic support systems into these areas. Even when fragile lands are not far from major population centers, social distance and political priorities have delayed the growth of service networks. Underdeveloped markets for inputs, credit, and outputs make it more difficult to adopt appropriate land management technologies and reduce their profitability. Market underdevelopment may be reflected in lack of physical facilities, poor information flow, disorganization or lack of competition, unreasonably high prices, or simply little market activity.

Lack of credit is a special problem. Without ready access to both production and long-term credit, small farmers and other

fragile lands residents are not able to invest in production systems with a delayed pay-off. Lack of credit forces farmers to depend on crops with a low cash input, to reduce investment in land improvement, and to limit their participation in long-term productive activities such as silviculture. The weakness of credit systems in remote areas is worsened by requirements for registered land titles and other formalities that cannot be met by many fragile lands users.

TENURE ARRANGEMENTS

The land tenure system is often identified as a major factor underlying mismanagement of fragile lands. The tenure issue on fragile lands goes beyond the well-known problems associated with unequal land distribution in the LAC region to include the specific landholding mechanisms in fragile lands that exert pressures on land users promoting misuse of the land resource.

Lack of Access to Alternative Lands

Where fragile land use systems lead to overexploitation of land, an ideal solution would be to make less-fragile lands available, reducing intensity of land use on steep slopes and other fragile areas. In reality, this solution may be politically or practically impossible to implement:

- It may require redistribution of valuable land from the powerful to the politically marginal.
- Lands potentially available for redistribution may be insufficient to meet the needs of more than a small fraction of current fragile lands users.
- The social, economic, and political cost of land reform and settlement schemes has proved prohibitively high for broad-scale application of these approaches.

- Weak or nonexistent land markets (and supporting credit markets) may slow or prevent free market transfer of lands to their most productive use.

Insecure or Incomplete Control Over Fragile Lands

Security of tenure and control over land use are often viewed as necessary to permit and encourage land maintenance investments or adoption of multi-year production systems. Fragile lands users may lack this security and control because:

- They are illegal users of government or private land (including forest reserves).
- Formal titling has not been practiced in small-farmer or ethnic minority areas and is expensive and complex.
- A degree of management control is exercised by absentee landlords (who may prohibit planting of permanent crops or refuse to share investment costs).
- Land rental systems (such as sharecropping) prevent land users from reaping the full benefit of their outlay.
- Tenants fear loss of their land, especially if they increase its productivity or plant permanent crops.
- The viability of traditional systems requires that land users shift their operation periodically, but formal tenure systems are inconsistent with this practice.

INAPPROPRIATE DEVELOPMENT POLICIES

Land development and agricultural policies can pose a serious barrier to effective use of the national land resource, fragile and nonfragile. Five policy areas having the potential to cause major problems for fragile lands use are listed, together with examples of problems in each.

1. Land development policies: failure to foresee and plan for secondary effects of new land development (such as settlement of squatters following road construction); policies encouraging inappropriate expansion into fragile lands; emphasis on rapid expansion rather than sound use of existing land; emphasis on

costly government-sponsored settlement programs rather than on managing spontaneous land development affecting much larger areas; implicit reliance on fragile lands resources (such as the watershed above a hydroelectric dam) without appropriate actions to safeguard the resource. Ecuadoran law, for example, requires that land be cleared to maintain title; this has forced small, shifting cultivators to clear land they otherwise would not have.

2. Pricing policies: credit policies that limit availability through overly restrictive interest rate structures; pricing policies for agricultural goods that artificially limit the profitability of food crops, thus reducing income and potential investment in food crop production areas.

3. Fiscal policies: tax policies favoring short-term land mining; tax policies encouraging landholding as a hedge against inflation or for speculative gain; land taxes that do not penalize destructive use of the land or fail to promote full utilization of nonfragile lands; fiscal and monetary policies causing inflation and indirectly serving as disincentives to long-term investment, including investment in land and trees.

4. Tenure and other legal structures: land titling or claiming laws that require land to be cleared to establish or maintain title; tenure laws permitting landlords to reclaim land without compensating tenants for improvements.

5. Investment and overall development policies: low priority to fragile land areas; poor understanding of land mismanagement and environmental problems, their extent, impact, causes, and potential solutions, leading to misallocation of

resources to fragile lands and nonfragile lands dependent on them.

MULTIPLE AND MARGINAL INSTITUTIONS

The long history of neglect of fragile land areas and policies favoring unhindered exploitation of empty lands has not fostered strong institutions for fragile lands management. Often a multiplicity of local, regional, and national organizations with conflicting or overlapping roles are active in a single location (including, for example, the forestry service, local and provincial governments, Indian or ethnic affairs agencies, and area development authorities). Specific problems include:

- Unclear jurisdiction over remote areas and natural resource management;
- Civil strife, leading to an emphasis on control rather than development;
- Proliferation of institutions, without sufficient budgetary allocations for any to operate effectively;
- Lack of institutions able to manage common-resource problems (such as management of communal grazing lands) or to mediate between parties when externalities exist (for example, to transfer resources from valley farmers who benefit from reduced flooding to finance sound management by those residing in the uplands).

ADDITIONAL INFORMATION NEEDS

Although the causes of fragile lands mismanagement and problems associated with it have been extensively documented, there is still a need to identify the ways in which these factors affect land management decisions, both singly and in combination. For example, migration patterns have been the subject of intensive study, but little information is available on how the absence of working-age males affects land use in rural communities. Similarly, although lack of credit is often identi-

fied as a cause of underinvestment in land, few studies have demonstrated how much land maintenance investment would increase if credit were made available (alone or in combination with other support).

A second area in which additional information is needed is the analysis of traditional technologies and land management practices. The purpose would be to identify technologies that could be brought back into use (or introduced into new areas) and to explain what caused their abandonment in the first place to gain insight into the land management decisions of small farmers.

IV. IMPACT OF LAND MISMANAGEMENT

This section summarizes impacts on the agro-economy and natural systems, leading to a review of impacts on social services and society at large.

AGRO-ECOLOGICAL IMPACTS

The most immediate results of fragile lands mismanagement are stagnant and declining production, both on-site and downstream. The impact on agricultural production is most direct, but the non-agricultural economy and natural environments are also affected.

Short-term Effects

Declining Production and Increasing Costs

As the fragile lands resource deteriorates, production of crops, livestock, and tree products per unit area declines. For example, yam yields on slopes under traditional management have been estimated to drop by 50 percent over a four-year period (Rankine). Even if total output from the land does not decline, farmers may experience declining production per acre and per farmer. As the fallow period shortens with increasing density of slash-and-burn farmers, for example, individual plots are cleared and cultivated before soil nutrient levels have regenerated through recycling of nutrients in the subsoil and forest biomass. As a result, average production per cultivated acre declines (although total production may continue to rise temporarily due to the increase in area planted).

Silvicultural and pastoral production are also affected. Conversion of Amazonian forests to pasture by burning leads to a short-term rise in soil nutrient levels, but the carrying capac-

ity and animal weight gain from these grasslands decline rapidly, particularly under heavy stocking rates designed to achieve maximum short-term gains. In Paragominas Province in the Brazilian Amazon, for example, stocking rates fell 75 percent as pasture quality declined over a five-year period following clearing, placing severe economic pressure on ranchers. By 1978, over three quarters of the ranches in the province had failed, caught between falling cattle production and rising costs, especially for weed control and fertilization (Hecht).

Forest production also declines as fragile lands are misused, allowing inadequate time for regeneration and leading to gradual replacement of high-value species with less desirable trees. The cost of extracting forest products also rises as forests close to roads and population centers are destroyed and harvesters must move on to forests at increasing distances.

Plantation tree crops (such as rubber and cacao) offer the potential of high, sustainable productivity, but only if the needs of the fragile tropical soil resource are met. Clean cultivation results in erosion and changes in soil chemistry that may lead to production declines as dramatic as for annuals.

Falling production is particularly damaging to fragile lands economies, because these areas tend to be less productive than the subhumid lowlands. When producers in these areas must compete with those on better lands situated closer to markets and enjoying better services, they are already at a severe disadvantage and can ill afford the production lost as the land resource deteriorates. They are then even less likely to apply

conservation measures that reduce their short-term profits.

Damage to Natural Habitats

Although not as visible as lost agricultural production, destruction of natural habitats has serious economic as well as ecologic consequences. Transformation of forests and coastal swamps leads to decline of the animal and fish populations dependent on these ecosystems. Immediate economic results include falling fish catch; damage to hunting; loss of medicinal and other valuable wild plants; and diversion of pests to neighboring farms, as pest-host and pest-predator balances are upset.

Long-term Impacts

Permanent Losses in Productivity

Once damage to the underlying resource base has passed a certain point, it cannot regenerate, even if the disturbing influence of human beings is removed (or the time required to regenerate rises to generations rather than years). If the topsoil is completely lost, formation of new topsoil from the subsoil or parent material takes centuries. A heavily eroded slope may reach a point at which it cannot sustain even unproductive grasses and will continue to erode, whether or not farming and grazing are stopped.

Permanent losses in productivity can also be caused when mismanagement sets in motion a destructive transformation process. Typically, a stable natural system that is unused by human beings or yields a low but continuing stream of benefits is destabilized and transformed by human action into an unstable system. This in turn evolves into a new natural system that is economically and ecologically less valuable than the original.

This final state may be permanent, or the site may recover slowly to its original state.

Loss of Productive Resources

Tropical and montane forests in their undisturbed state are themselves a valuable resource that cannot readily be replaced. Reforestation programs may be an important component of an integrated management strategy but do not substitute, either economically or ecologically, for preservation of standing forest. Moreover, the immediate need for tree cover and the practical requirements of reforestation tend to lead to uniform plantings of fast-growing species. The resulting forest will not contain the high-value hardwoods found in the original stand, nor can it necessarily serve as a habitat for the original forest's wildlife. Deforestation for agriculture is particularly costly, since the timber resources are often wasted in the process. In Costa Rica, for example, it has been estimated that the timber resources are recovered from only one in five acres cleared.

Reduced Flexibility of Output Mix

A less obvious but potentially vital impact of land degradation is the narrowing of economic choices as the resources lose productivity. Whereas high quality land can produce a wide range of products, permitting land managers to adjust their output mix to meet changing economic conditions and preferences, declining land quality progressively limits the feasible crop and livestock options, often eliminating high-value products more quickly than low-value crops and livestock products. As a result, economic productivity declines not only through drops in yield but also

through elimination of valuable products from the farmer's operation. High quality range capable of meeting superior cattle's high nutrient needs gives way to lower quality range supporting less productive breeds or, finally, only goats.

The shrinking set of economic options increases the exposure of managers to market and environmental risk, since they are less able to adjust their system to change. Risks also rise, as reduced variety and flexibility in the product mix make the farm more susceptible to a single pest or other damaging factor. Declining productivity for each crop can reinforce this process, leading the farmer to devote larger and larger areas to subsistence and forcing cash crops out of the mix.

Permanent Loss of Habitats

Habitat loss carries the risk of long-term costs in the form of permanent disappearance of plant and animal species, including those not yet known to be useful to man. The worldwide biosphere reserve program, coordinated by UNESCO, sponsors the formation of protective reserves in representative ecosystems, but this program labors under a double handicap:

- It cannot be known with certainty how large a reserve is needed to ensure the survival of all species found within it, including those currently unidentified.
- The diversity of micro-habitats within, for example, the Amazon Basin, makes it impossible to ensure that all potentially valuable or ecologically important species are represented in a given set of reserves.

Practical problems also plague the biosphere program and other efforts to create protected reserves.

Off-site Agro-economic Impacts

Off-site impacts may well be more important economically

than those on-site because of the higher productivity of the lands and economic systems affected. Off-site impacts of upland degradation are particularly important.

Flooding and Siltation

Degradation of steep slopes and other uplands leads to increased flooding in the lowlands via three related processes:

- Loss of vegetative cover reduces water infiltration and transpiration in the uplands, increasing runoff and concentrating it during a briefer period of time, causing a wide variety of problems downstream.
- Soil eroded from the uplands silts up rivers, irrigation canals, hydroelectric reservoirs, and other waterways, increasing the risk of flooding, reducing their usefulness, and raising maintenance costs.
- Silt carried in the floodwaters can cover more valuable and productive soils in the lowlands. The silt itself can also damage turbines and other facilities.

Impact on Coastal Fisheries, Waterways, and Ports

The silt and increased seasonality of stream flow can harm coastal fishery resources and damage economically valuable ecosystems. For example, silt deposits on reefs kill the coral, ultimately eliminating the food source of tropical fisheries. Decreased regularity of river and stream flows may convert freshwater areas near the sea into saltwater areas, with complex effects on fish life and water supply. (More rarely, increased silt flows may enrich agricultural land and coastal waters and thus raise agricultural and fishery productivity, as was previously the case in the Nile River system).

Siltation of ports and navigation channels also results from erosion upstream. Siltation may accelerate the eutrophication of lakes and other water bodies downstream, with undesirable economic consequences for fisheries, tourism, water supply, and the quality of life in nearby areas.

Reduced or Less Regular Stream Flows

In addition to increased risk of flooding, higher and more concentrated runoff create problems downstream through changes in the flow and hydroperiod of streams and rivers:

- Concentration of runoff in the rainy period makes water unavailable in the dry season when it is most needed for irrigation, drinking water, and industrial uses.
- Lower dry-season stream flow can raise pumping costs for irrigation or other water uses, reduce the generating capacity in hydroelectric systems (or sharpen the tradeoff between generation and irrigation), and create navigational problems in streams and rivers.
- Greater seasonal fluctuations in water flow may give rise to changes in the water levels in streams and lakes, with potentially serious consequences for tourism, water quality, and water body ecology.
- Seasonal or year-round reductions in aquifer recharge promote saltwater intrusion in coastal areas, raise pumping costs, and water availability.

Downstream Erosion and Soil Quality

In addition to the damage caused by silt from upland erosion, increased and more seasonal water flow promote erosion downstream. Floods may lead to collapse of terraces, levees, and other important structures. Landslides and other erosion problems can result along watercourses far removed from the original site of soil loss. A shortage of irrigation water may make proper water management more difficult, indirectly causing a decline in soil quality (uncontrolled floods may help counter this problem, but hardly constitute an optimal strategy for controlling salinity).

IMPACTS ON SOCIETY

The agro-ecological impacts outlined above have direct con-

sequences for the social and economic well-being of populations immediately dependent on fragile lands and those downstream.

Immediate Impact on Land Users

Declining Agricultural Incomes

As the resource base becomes degraded, production levels decline and costs may increase, leading to a fall in agricultural incomes (broadly defined to include income from crops, silviculture, hunting and gathering, and animal husbandry activities). Progressively greater levels of labor and other inputs are needed to maintain a given level of production.

The downward pressure on agricultural income itself forces other changes in the economy of the affected area. Depending on the availability of inputs and alternative sources of income not reliant on the deteriorating resource base, land users will:

- Intensify their exploitation of the land, attempting to maintain income by increasing inputs;
- Extend their operations to unused land, if available; or
- Gradually reduce their dependence on the land in favor of relatively more profitable activities.

Thus, the existence of economically attractive alternatives is a critical factor in determining whether environmental degradation is self-correcting or self-accelerating.

Deteriorating Quality of Life

Fragile lands users are dependent on the land resource for a wide variety of consumer goods, in addition to relying on it in their income-generating activities. Deterioration of the land resource can reduce the supply of these goods and damage the household and its economy. This aspect of environmental degrada-

tion, while less discussed in the literature, undoubtedly is of importance to residents of fragile land areas. Examples include:

- Deterioration of water quality for domestic use and reduced or irregular water supply;
- Damage to houses, public facilities, and livestock; injury; or loss of life due to increased runoff, floods, and landslides; and
- Reduced availability of firewood and other energy sources, increasing the cost of gathering and fuel purchase or forcing an overall reduction in fuel use.

Secondary Impact on Land Users

Depopulation of the Affected Area and Rural Impoverishment

If deterioration of the resource base proceeds unchecked, the area will cease to be able to support its population, and some or all of the residents will ultimately migrate to the cities or to other marginal areas. Although the remaining population may constitute a sustainable human carrying capacity, the reduced density tends to increase the area's isolation. The cost of delivering services rises, and the political importance attached to these services declines, making it difficult for the people to obtain marketing and social services.

Whether or not fragile land users ultimately migrate from heavily degraded sites, the remaining land users may well be caught in a cycle of poverty and increasing degradation, unless actions are taken to arrest and reverse the deterioration of the resource base on which they depend. Since the populations resident in the uplands and the humid tropical lowlands are already among the poorest groups, their further impoverishment is a source of serious concern and potential social unrest.

Increasing Cost of Services

Degradation of the land resource tends to raise the cost of basic service delivery by adding to the maintenance and repair requirement, sometimes dramatically. Floods, landslides, and erosion undermine road, water, and electric systems, further burdening already strained operational budgets. When, as usually happens, repairs are slow, the deterioration of basic infrastructure increases the cost of other services dependent on these networks, including health, education, and social services as well as economic support such as marketing and transport.

Depopulation and rural impoverishment indirectly raise the cost per person of service delivery, thus aggravating the cost increase imposed by deterioration itself. Moreover, the need per capita for these services among fragile lands residents increases as the able-bodied depart to seek work, leaving behind the aged, children, and those unfit to migrate.

A final social cost is a decline in nutrition levels as food production and income fall. Loss of soil nutrients may be reflected in a drop in nutritional quality of the food produced.

Downstream Economic Effects

The mechanisms whereby fragile lands deterioration causes problems downstream have been briefly sketched above. Each impact, of course, carries a direct or implicit economic cost, often of huge proportions. The impact on the country's economy is reflected in lower total output from both fragile and nonfragile lands, higher costs for basic services, damage to basic productive resources, and greater economic dislocation. These in

turn may reduce the supply of raw materials for processing, lower foreign exchange earnings, increase the burden on social service agencies, and force importation of greater amounts of food and other products.

In addition to these critical economic impacts, degradation of fragile lands generates undesirable social and political impacts off-site. These include social and political unrest caused by declining income and employment in rural areas, more rapid migration to the cities by displaced populations, accelerated degradation of other fragile lands as migrants move onto them, and increasing inequality within the society.

Declines in off-site environmental quality and social services are also important. The damage to water systems outlined above is reflected in lower water quality and reduced supply in urban areas. Destruction of wildlands and other natural areas imposes a cost on the society as a whole, in addition to the effect on tourism and production based on these areas.

The list of off-site impacts cannot be complete without mention of the indirect benefits of unsustainable fragile lands use. These accrue in the short term and must be balanced against the serious long-term consequences outlined above:

- An adequate if temporary source of income for marginal populations who would otherwise pose an immediate problem for the urban areas, needing employment and social services;

- Production of food crops in the short term, leading to a temporary saving in foreign exchange and in some cases a temporary source of foreign exchange earnings;

- Production of beef and other pastureland products under extensive, and therefore low-cost, systems;

- Timber and other raw materials extracted as part of the advance of exploitation into new areas; and
- Reduced political and economic pressure to redistribute more productive lands or increase the intensity of their utilization.

These benefits are, of course, due to fragile lands utilization rather than to its degradation as such. However, when current use systems cannot be replaced with sustainable systems that are equally productive and employment-generating (in other words, the resource is now overused as well as misused at present), the degradation is inseparably linked to the benefits cited.

ADDITIONAL INFORMATION NEEDS

The greatest need for additional information regarding the impact of fragile lands mismanagement is in the area of off-site impacts. As the long list of negative impacts suggests, fragile lands degradation affects downstream systems in complex and potentially costly ways. A better understanding of these processes is, realistically, a prerequisite to generating the political and economic will to address the fragile lands problem. The rising urgency associated with urban water supply and overall water quality suggests that water-system interactions should receive priority for study and economic quantification.

V. MAJOR ISSUES AFFECTING CHOICE OF AN INTERVENTION STRATEGY

OVERVIEW

Given that the fragile lands problem increases in complexity the more closely it is examined, there is no simple way to formulate a strategy that is universally applicable across the LAC region. The following sections present an approach to organizing and thinking about a fragile lands strategy that can be applied to the specific country, region, or part of the problem being addressed.

This section discusses 10 issues of major importance to the development of sound fragile lands strategies. These concepts supplement standard rural development principles, which are not reviewed here (for example, acceptance of new technologies requires secure markets for inputs and outputs). For each issue, a set of concepts or propositions is presented, all of which are subject to argument or at least refinement.

SITE SPECIFICITY, SITE CLASSIFICATION, AND COMMONALITIES

1. **Despite the commonalities inherent in the fragile lands situation, there is a very high degree of variation across different sites.**

This variation is reflected in differences in the nature of the problem (different types of erosion, at different rates), in its impact (depending on the location of the site relative to downstream activities, for example), and the efficacy of alternative solutions (such as the degree of erosion control achieved by contour ditches may be adequate for one site but not another). Major sources of site variation include:

- Physical variation: soils, slope, rainfall, temperature regime, altitude, existing cover, and dominant production patterns;

- Variations in social systems: ethnic identification, equity of wealth distribution, pattern of individual and communal landholding and use, traditions of common action; and

- Variation in economic conditions: location, person-land relationship, price of outputs and inputs, marketing system.

2. **Given the variation across sites, apparently similar patterns of degradation may be due to very different underlying factors. Development of appropriate strategies requires an understanding of underlying differences as well as differences in the problem perceived.**

A cover of unproductive woody shrubs and unpalatable grasses could arise in any of the following ways, with different implications for site management:

- Partial recovery of a site within a sustainable shifting cultivation system, with full recovery to be anticipated before it is cleared again;

- Partial recovery of a site that will be cleared for annual crops again before full recovery;

- Natural pattern on sites characterized by low rainfall, high temperature, and poor soils; and

- Climax succession on tropical forest cleared for pasture and degraded by overgrazing and chemical change.

3. **Despite variation, patterns of degradation can be identified.**

Fragile lands, by definition, are in transition. Assuming no outside interventions or changes in the factors driving the process, the degradation process tends to follow a route from stability to degradation to a new, unproductive equilibrium or to another stage in the cycle leading back to recovery. Common patterns are discussed below.

Shortened Fallow in Slash-and-Burn Systems

Fallow periods in a stable slash-and-burn system become shorter as population rises or the area available is curtailed.

Incomplete recovery of soil nutrient, chemical change, or increasing toxicity levels leads to falling yields. The system takes one of several paths:

- Departure of some of the population, leading to a return to the previous stable state;
- Intensification of the farm system and conversion to continuous cultivation to maintain (or try to maintain) output per family; or
- Permanent degradation of the site, followed by departure of most of the inhabitants, possibly leading to an eventual return of tropical forests.

Complete Deforestation

In this pattern, a forest is gradually cleared by settlers, possibly in cooperation with loggers. After one or two seasons, falling yields force the settlers to move on, and they are replaced by extensive cattle operations. Continued decline of the range reduces cattle production. Eventually, the ranchers desert the land as well, leaving it to recover slowly to its original state or, if degradation has proceeded too far, to remain tropical scrub wasteland.

Hillside Marginalization

A highly diversified hillside system, characterized by high labor use, self-sufficiency at a modest level, and ongoing land maintenance activities, is destabilized by large-scale outmigration. Land maintenance falls of leading to gradual deterioration of output levels. As transportation and market links to the lowlands improve, hillside agriculture cannot compete with the better-endowed lowlands. More labor leaves, and productivity deteriorates further. Eventually, smallholder land many be lost to large landholders, converted to extensive pasture, or simply

go out of production. This process occurred historically in the Andes and is now under way in parts of the Caribbean.

Collapse of Colonization

Remote tropical forests are opened up to colonization, with land sold to smallholders on credit. Since the land is not readily suited to permanent cropping, colonists cannot produce sufficient income to repay their debt and support themselves. Denied outside employment, they desert their land, sell to large landholders (who may convert the land to pasture or leave it idle), or become impoverished squatters and tenants.

4. Classification systems aid in matching sites, sustainable uses, and appropriate technologies, but existing systems are far from perfect guides to action.

The best-known classification scheme is the Holdridge Life Zones system, which defines climatic zones in terms of natural vegetation patterns as the product of altitude, latitude, temperature, evapotranspiration, and rainfall. These variables define 37 main Life Zones (with a further breakdown of 59 in the tropics). The Life Zone system has major advantages (Tosi):

- The variables required to identify a Life Zone are readily measured, even without on-site measurement.
- A site can generally be classified based on natural vegetation alone, even if other values are not known.
- Climax vegetation patterns are a good indicator of potential agricultural use in each Life Zone, permitting preliminary determination of potential land use and agronomic needs from vegetation patterns.
- The Life Zones constitute large-scale recommendation domains (to borrow a term from FSRE), with agronomic systems having broad replicability within a given zone across widely separated locations (a concept similar to that underlying the benchmark soils program).

- The system places heavy reliance on the distinction between moist zones (where rainfall exceeds potential evapotranspiration) and dry zones (where the reverse is true). This distinction is critical to understanding and dealing with soil-water relationships, nutrient balances, and soil chemistry.

- Most Latin American countries have been mapped based on the Holdridge Life Zones system and modifications of it tailored to LAC needs.

Classification systems developed for nonfragile areas have limited usefulness for fragile lands. Taiwan was forced to reject the standard USDA system, for example, since it classified most of the land as VII (inappropriate for crops), including many areas under intensive and stable use (Sheng, 1982).

The universal soil loss equation (USLE) estimates potential erosion damage due to steepness, length of slope, rainfall, soil type, protective practices, and vegetative cover. This method is in theory applicable to tropical soils, but development of coefficients for Latin American conditions has barely begun.

APPROPRIATE USE OF THE LAND RESOURCE

1. Suitability is a function of technology.

The idea that each piece of land has a single best use to which it should be put is potentially misleading. A given land use may be inappropriate under one technology but not under a different one. Annual cropping that is destructive on a given slope can become sustainable if soil-conserving practices are followed. On the same site, grazing (a less-intensive use) may be inappropriate at stocking rates above a given level. Most sites have many appropriate uses, depending on the technology employed.

2. **The most appropriate use is not necessarily the least damaging use; not all destructive uses are inappropriate.**

Most agricultural use takes some toll on soil quality (erosion proceeds even under natural cover). The decision concerning what constitutes acceptable damage on a given piece of land depends on availability of alternative land for this use, expectations regarding future use of the land, and land pressure. A country with a relatively high person-land ratio, an urgent need to reduce food imports, and a shortage of flat fertile land may choose to use its land more intensively, accepting a higher rate of deterioration, a higher rate of investment in land maintenance, or both. Given a choice between destructive use of the land that ensures short-term survival and use that sustains the land but not the people, preference must be for the former.

3. **For each type of land use, there is a maximum sustainable level of production, given site characteristics and available technology.**

For nearly all sites, the maximum sustainable level is below the maximum production obtainable in a single period. A critical element in identifying desirable changes for use of a given piece of land is whether the maximum sustainable production level is above or below the current production level, under existing and potential land uses.

If the current production system is not sustainable, there are three possibilities:

- A sustainable variation of the current system exists that is economically and technically feasible, and produces income at least equal to the current level.

  A different system that is sustainable and feasible exists and would produce equal or greater income.

- The highest sustainable production level based on available technology yields a net income below the user's current income.

In the third case, sustainable production is not feasible, unless parallel measures are taken to maintain user income and profit, or coercion is applied. For example, it is not possible to shift to a sustainable annual cropping system that is less productive than a current destructive system without a parallel effort to raise production on other, less fragile land under the user's control or provide alternative off-farm income.

LAND USE INTENSITY AND SUSTAINABLE USE SYSTEMS

1. **The concept of land use intensity provides a rough comparison of very different land use systems on the basis of the total level of inputs used per unit area.**

The total level of inputs per unit of land is probably the single most important variable describing human land use. This measure -- the sum of the value of physical inputs, such as labor, seed, fertilizer, and animals -- is more useful in understanding the system than output measures because output on the same site can vary widely by year for reasons outside the user's control. Intensity is more useful than simplified descriptions of the system (crops, silvo-pastoral, etc.) because it directly compares very different use patterns. At the same time, economic criteria ensure that intensity as measured by inputs will be closely reflected in output and net income.

2. **As a broad generalization, annual crop systems are most intensive, followed by permanent crops, livestock systems, and production of trees for wood.**

This generalization applies most strictly to use of comparable land, but it also applies to the agricultural sector as a whole. Nonetheless, there is tremendous variety in intensity

within each of the four broad use patterns, and intensity levels overlap across them. Extensive grain-based systems may use fewer total nonland inputs per unit area than intensive orchard production, for example.

3. **On a local or a national basis, there is a tendency to move toward greater intensity, unless prevented from doing so by degradation of the land or diverted from doing so by better opportunities elsewhere.**

Within agriculture, the level of inputs tends to increase over time as farmers attempt to increase output or counteract degrading conditions. Similarly, in the absence of declining land quality, agriculture tends to shift toward horticulture, annual crops, and the more intensive forms of livestock production as population density increases.

The opposite pattern holds in the economy as a whole: land use moves gradually away from agriculture and toward production systems using more inputs per unit area of land (but producing more). The balance between these two tendencies may cause agriculture to become less intensive over time.

At the national or local level, these trends are not fixed. Intensity declines in periods of recession, for example, and intensification in one region may draw off resources from other areas, leading to localized declines in intensity.

4. **Systems rarely move easily from more intense use systems to less intense use systems.**

Once a fragile area has reached a given level of intensity, land users are unlikely to move willingly to a less intensive system, since this almost always means less income. Intensity will, however, decline if:

- The land becomes so degraded users have no choice;
- Alternatives outside of agriculture attract labor or other resources to other uses, reducing land pressure; or
- Part of the group gains control over the land and excludes other users, increasing the average holding, reducing total output and output per unit area, but increasing income per holding.

The last scenario applies not only to acquisition of the land by a few landlords, but also to cases in which some smallholders leave and those remaining acquire use of their land, spreading their resources across a larger average holding and lowering intensity across all holdings. This generally desirable outcome can be obtained only if the land market or customs make emigrants' land available to those who stay behind.

5. **Shifts in intensity from one farming system to another or within a single system are a central element of many strategies to improve fragile lands management.**

Strategies identified to improve fragile lands management often call for a shift in intensity in one of two ways:

- A shift toward a <u>less intensive system</u> (from annual crops to tree crops, for example); or
- A shift within a system to a <u>more intensive</u> version of the system (from annual crops on open hillsides to annual crops with contour ditches or other additional protective measures, for example).

Both shifts run counter to the inherent logic of intensification. The first generally implies a drop in income and idles formerly productive resources (particularly labor). The second requires not only that outputs increase by more than inputs (which is difficult to achieve) but also that farmers have access to inputs in addition to those now available. This raises serious difficulties, particularly regarding additional labor.

6. High intensity systems are not necessarily less sustainable than low intensity systems.

The sustainability of a given system depends on the relationship between the level of land maintenance required and the level of this activity that the system will support. Intensive, high-input, high-output systems require more land maintenance activities, but they also permit the farmer to afford more, and may therefore be sustainable. Figure 3 presents a simplified typology of sustainable and unsustainable systems, based on this relationship.

FIGURE 3

IDEALIZED RELATIONSHIP BETWEEN OUTPUT, INPUT, SUSTAINABILITY, AND LAND MAINTENANCE EXPENDITURE

INPUTS	OUTPUTS: LOW	OUTPUTS: HIGH
HIGH	Type 1 -- Unsustainable -- Example: traditional systems under degrading environmental conditions -- Need land maintenance, but do not provide income to support it	Type 2 -- Sustainable -- Example: intensive systems, such as vegetable production on terraces -- Need high land maintenance, but provide income to support it
LOW	Type 3 -- Sustainable -- Example: traditional systems such as low-density slash and burn -- Little land maintenance but little required	Type 4 -- Unsustainable -- Example: extractive systems such as logging without replanting -- Need land maintenance but do not provide it

Within this admittedly oversimplified typology, movement tends to take place in certain patterns:

Degradation:

Type 2	\	Type 3
Type 4	/	Type 1
Type 3	-->	Type 1

Improvement:

Type 3	-->	Type 2	(with additional technologies and inputs, but there may be little incentive to do so)
Type 1	-->	Type 2	(may require increasing land maintenance expenditure and other inputs simultaneously)

Recovery:

Type 1	-->	Type 3

THE RELATIONSHIP BETWEEN COST OF LAND MAINTENANCE INVESTMENTS AND VALUE OF PRODUCTION

1. **Fragile lands are generally capable of producing less than nonfragile lands, as measured by value of output.**

On average, the steep lands and humid lowlands are capable of producing less per unit of area than the flat, subtropical lands. Lower production on fragile lands is due to such factors as the relative poverty of fragile lands residents, lower input levels, and reduced use of improved technologies, as well as the lower inherent productivity of these lands. For example, small farmers in the Peruvian sierra have yields 30-60 percent of those on the coast, whereas steep-land grain yields in Ecuador and Guatemala are estimated at only 60 percent of those on flat land (Posner and McPherson).

This does not imply that fragile lands actually produce less

than nonfragile lands under current patterns of use or that fragile lands are producing at their potential (or closer to their potential than relatively nonfragile lands).

(This generalization clearly does not apply to the set of high-value products grown only under steep land or tropical lowland conditions, such as coffee or certain fruits.)

2. **The cost of investments and maintenance outlays needed to maintain fragile lands productivity tends to be higher than for better lands.**

To stabilize production levels, steep lands require investments that are not necessary on more favorable lands, such as terracing and contour ditching. Humid lowland soils, with their characteristic low fertility and poor chemistry, require greater investments to maintain fertility. The humid areas also tend to be more susceptible to incursion by noneconomic species, affecting both pastureland and cropland.

3. **The cost of land maintenance cannot necessarily be justified by the additional production made possible by these expenditures.**

Since fragile lands already tend to produce less net income per unit area than good lands devoted to comparable uses, and require more land maintenance expenditure, economically feasible technologies are difficult to identify. Four main situations are:

- Land maintenance raises productivity enough to justify all expenditure involved.
- Land maintenance technologies raise productivity by an amount sufficient to cover their operating cost, but not enough to cover the cost of necessary investment.
- Land maintenance investments do not raise productivity and therefore reduce net income if implemented.

- Land maintenance lowers production, at least in the short run, and can be applied only with full subsidy.

Table 2 demonstrates the problem. Production levels above those of the traditional technology are underscored. Note that in no case does the improved (sustainable) technology produce a higher average yield than traditional technology. In most cases, the yield is substantially lower in the first years, making the technology particularly unattractive to a farmer practicing shifting cultivation according to the traditional method.

TABLE 2

PRODUCTION OF YELLOW YAMS FROM RUNOFF PLOTS, JAMAICA
(tons/hectare/year)

	Year				
Treatment	1	2	3	4	Average
Traditional Method					
Total prod.	56.3	53.1	33.1	26.4	40.0
Salable prod.	31.6	37.8	22.0	16.8	26.9
Bench terraces					
Total prod.	35.3	44.2	32.6	37.8	37.5
Salable prod.	18.5	30.4	21.0	23.2	23.2
Hillside ditches and contour mounds					
Total prod.	37.5	44.5	39.8	37.3	40.0
Salable prod.	20.5	29.6	26.2	23.2	24.9
Hillside ditch and hills					
Total prod.	43.2	47.2	37.1	35.3	40.1
Salable prod.	24.9	33.3	25.2	23.5	26.7

Source: Adapted from Rankine, quoting T.C. Sheng and T. Michaelson, "Run-off and Soil Loss Studies in Yellow Yams." (emphasis added)

4. **The value of additional production obtainable through sound land management is highly dependent on the technologies available to increase sustainable production and markets, off-site impacts, etc.**

The maximum investment that is economically justifiable to maintain the productivity of a given piece of land is directly related to the value of production, including the production of the land itself and of that affected by off-site impacts. If it is possible to increase steep land productivity, the farmer will then be able to make a larger investment in protecting that productivity. This has been demonstrated in Haiti, where introduction of fertilizer motivated farmers to increase terracing to ensure its beneficial impact on crops (Murray, 1980, cited in Posner and McPherson).

Non-agronomic measures that raise the farmer's receipts also increase motivation to apply land maintenance practices. These range from changes in price policy to tenure reforms that increase the farmer's share of net income to marketing programs that increase the profitability of a given level of production.

Since the investment needed to maintain productivity tends to increase as one moves from less fragile to more fragile lands, while the productivity tends to decrease, one expects to find the maximum economic return to these investments (ignoring off-site impacts) not on the most fragile lands but on lands that are intermediate between the best and the worst (most fragile).

5. **Despite the theoretical validity of subsidies to encourage behavior that benefits society more than the individual user, experience with subsidy programs has been disappointing.**

Low-productivity fragile lands threatening high-productivity lands downstream create a situation in which society would

benefit from a transfer of income from users downstream to motivate the adoption of protective practices by those residing in the uplands. In theory, social benefit justifies the use of general tax revenues to subsidize conservation and land maintenance in the uplands. In practice, these programs often encounter serious problems of two kinds:

- Inappropriate application of conservation practices, growing out of a motivation to collect subsidies rather than protect productive land resources. (This has been observed, for example, in IRDP in Jamaica).
- Limitation of participation (and especially reduced participation in second phase activities) due to restrictions on the number of farmers who can be subsidized with available funds or a perception that the first group of adopters were motivated by subsidies rather than desire to improve their land. (This was observed in a watershed management project in the Philippines, for example.)

These problems imply that subsidies should not be used except in an environment providing adequate technical support, clear and justifiable policies on future subsidies, and adequate resources to support future subsidization.

More favorable experience has been reported with subsidies to speed adoption of technologies with readily observable benefits. A subsidy program supporting terracing in the Guatemalan hillsides, for example, has been successful, and even farmers who have not received subsidies have adopted the practices after observing yield increases of up to 140 percent for maize (Arledge).

Subsidies appear to be practical to cover the basic investment if the technology provides a return sufficient to cover operating costs; however, they are impractical when both investment and operation must be subsidized.

SOCIAL, COMMUNITY, AND INDIVIDUAL PERSPECTIVES

1. **The relative importance attached to immediate income rather than future income is likely to differ markedly between different groups in society and between society as a whole and individuals.**

Wealthier individuals and society as a whole are likely to attach greater value to future income than fragile lands residents. Society and its better-off members therefore in general would prefer that poor people invest more than they are willing or able to allocate.

2. **Off-site impacts may be more important socially, economically, and politically than on-site impacts, but markets are rarely effective in linking the two.**

In theory, markets should arise that enable downstream users to pay for better land maintenance performance by those upstream. In practice, transaction costs and other difficulties prevent the functioning of these markets; downstream losses do not generate effective demand for upstream land maintenance activities. (This form of market failure, in which significant costs and benefits remain outside the reach of the market, is called externality.)

Externalities can sometimes be brought back under the control of the market (in economic jargon, be internalized). For example, a landholder suffering erosion caused by his upland tenants can attempt to curb destructive behavior through rent reductions or labor payments. The political marketplace can also internalize externalities, by indirectly causing economic or noneconomic pressure on upland users.

3. **Smallholder conditions may require that the community replace the individual as the focus of resource management efforts.**

In many LAC situations, landholding patterns make it difficult to apply management measures effectively on a single landholding in isolation. It becomes necessary to treat the community or larger units as a whole to achieve effectiveness. This principle has long been applied in traditional Peruvian communities, where distribution of individual cropland parcels across several ecological zones and community management of grazing lands historically permitted high-input/high-output use of fragile upland resources (Brush).

This suggests a number of issues for strategy design:

- What is the minimum area within which the proposed use systems can be applied effectively?
- Who will decide which use system to promote and adopt: the individual farmer, a group of farmers, the community, or the government?
- Given the level at which the decision is to be made, what are the mechanisms to make the decision, put it into operation, and manage it?
- How does the necessary degree of cooperation (with other individuals, with the government, etc.) fit into the established patterns of the community?
- Is the overall strategy to influence individual decisions or to obtain individual compliance with decisions reached by the community or government?

INDIRECT, FUTURE BENEFITS AND PRESENT, DIRECT COSTS

1. **The impacts of fragile lands mismanagement are felt primarily in the future, whereas the cost of solving them must be borne now.**

The damage done by fragile lands mismanagement is felt over decades rather than years. Current mismanagement is only part of the cause of the currently observed problems of erosion, silta-

tion, and flooding. Economic markets are weak at transforming the savings generated by reduced future damage into resources that can be used to reverse current degradation. Political markets, as well, are ineffective in communicating the wishes of future citizens to motivate action in the present.

2. **Many fragile lands solutions require sustained action over years or decades; this is difficult to organize and finance.**

Investment budgets for donors, governments, and individuals are keyed to short periods of one to five years, not to the periods of 10 years or longer that may be required to establish a productive stand of trees or develop techniques for managing tropical soils. Soil experiments in Peru, for example, found that key deficiencies required five years or longer to become apparent; they could not have been uncovered in a short-term research effort (Nicholaides, et al.).

3. **Fragile lands programs require a commitment of real resources, but yield only indirect returns.**

When a reservoir silts up, the cost is felt as a reduced return on the initial investment and a need for new investments that would otherwise not have been required. Neither directly generates funds to prevent the siltation before it occurs. The initial investment is a sunk cost, and the reduced return to funds that have already been invested comes too late to affect present behavior. The opportunity to avoid costly investments in the future is too abstract for the market to handle effectively until the threat becomes immediate. At that point, however, the damage is done and it is too late for prevention.

TENURE AND STRUCTURAL INCENTIVES

1. **Tenure is one of a group of structural incentives that exert a powerful influence on farmers' and others' land management decisions.**

Structural incentives are those created by the economic system, as distinct from formal incentives established to influence land management decisions. Structural incentives include, for example, the structure of input and output prices determining the relative profitability of annual crops, livestock, and permanent crops and the incentive to substitute chemical fertilizers for manure. Fiscal incentives favoring livestock and land speculation have been identified as a major factor encouraging deforestation in the Brazilian Amazon (Hecht).

Structural incentives may have a greater influence than formal incentives -- planned or unplanned -- because they apply to broad groups in society, rather than to a limited group (such as in a project area). Thus, changing structural incentives is likely to be more effective than introducing special incentive schemes (but may or may not be cheaper).

2. **The tenure factor can be differentiated into tenure security, access to land, the division of returns to land, management control over land, and formal tenure rights, each with a different impact on land management decisions.**

Without tenure security, a land user may be unwilling to make long-term investments in the land, such as planting tree crops. Unequal access to land, as exists in nearly all LAC countries, promotes land use patterns in which relative intensity is disproportionate to land quality (that is, good lands are used less intensively than poorer lands). The system for dividing income derived from land (including sharecropping, fixed rent,

direct ownership, and communal division) and the share accruing to the land manager greatly influence investment and management decisions. Security of tenure does not necessarily imply management control over land (such as authority to convert a plot to permanent crops). Without formal title, land managers may be denied access to credit or other inputs needed to apply management practices.

3. **Secure tenure alone is no guarantee that sound management practices will be applied.**

Providing tenure security is not a cure-all for fragile lands management, although it may be a prerequisite to broad application of land maintenance investments. In particular, it will not compensate for a landholding size that is too small to yield a sustainable income sufficient for family needs. It can actually worsen the situation if, for example, it increases farmers' short-term return from inappropriate practices (if ownership makes overstocking more profitable than it had been for renters, for example). If the program instituted to secure tenure carries with it an increased rent or other payment (such as a mortgage for land previously used illegally), the program may actually promote uses that overexploit the land.

POLICIES AND LAWS

1. **Land use laws and land development policies are at least as important as any specific program directed at fragile lands in affecting the management of a country's fragile lands resources.**

Area-specific programs are not a substitute for establishing sound land laws and land development policies that guide land use nationwide toward sustainable patterns. A simple change in an

inappropriate colonization policy, for example, may eliminate millions of dollars in wasted investment, later expenditures for repair, and social costs associated with failed settlements.

2. **Unintended consequences of existing land-related policies and laws are a major factor in current fragile lands mismanagement.**

In each LDC country, policies and laws in existence encourage one or more of the following: overly rapid expansion into fragile lands; insecurity of tenure, especially in fragile lands; and imbalance between intensity of use and land quality. These policies retard, reduce, or even counteract the effectiveness of programs designed to improve fragile lands management.

TECHNOLOGY GENERATION AND SELECTION

1. **Technical efficacy is not a sufficient criterion for selection of a land management technology.**

Research establishments now recognize that the input level that maximizes economic return is not always the level that maximizes yield. Too many soil conservation programs continue to make the parallel error that the best technology is the one minimizing soil loss, rather than the most economically profitable means of limiting degradation.

2. **Site differences imply that a technology that is appropriate for one site may not be applicable to sites that differ in key characteristics.**

More expensive technologies (more intensive or using more inputs) are affordable only on better, more productive lands. This is true whether the land is more productive because of physical characteristics (better soil, etc.), economic charac-

teristics (near markets for high value crops), or social characteristics (used by smallholders without alternative employment possibilities). Two points deserve special emphasis:

- The applicability of a given technology cannot be evaluated on the basis of the physical characteristics of the site alone.

- The land most in need of protection (often land that is among the least productive) may not be the land best suited to application of the most protective technology. It may make sense to apply cheaper, less effective technologies on lower quality land and better, more costly approaches on higher quality land.

For example, farmers in one part of Jamaica have proved unwilling to implement terracing technologies on their land, despite technical assistance efforts and credit, whereas farmers in an area with better soils and located close to major urban markets have applied terracing with less assistance.

3. **Development of fragile lands technologies suited to smallholder needs has not been a research priority, with the result that suitable, field-ready technologies are not necessarily available for all cases. Technologies for the lowlands areas with moderate rainfall rarely work in the uplands and the tropical lowlands.**

Table 3 indicates how far an improved package for the uplands may diverge from the standard lowland package. In this case, a program based on a lowland ICA package required major modification to add a multi-year research effort. The final package differed little from the farmers' own practices.

TABLE 3

INITIAL AND FINAL RECOMMENDATIONS FOR MAIZE IN AN UPLANDS PROJECT (ORIENTE ANTIOQUENO, COLOMBIA)

Factor	Recommendation	
	Initial (1970)	Final (1980)
Variety	ICA	local
Plant density	45,000	33,000
System	monoculture	intercrop or relay
Lime/ha (tons)	2	none
NPK (kg/ha)	30 - 90 - 30	50 - 0 - 0
Weed control	herbicide	manual weeding
Planting date	specific dates	variable
Land preparation	yes	no
Pest control	pesticide	no

Source: Tobon

4. **Despite major gaps, sufficient technologies exist to make a start in many areas.**

It is difficult to generalize in a useful way about the availability of technological approaches for productive use of fragile lands. Nonetheless, a rough ranking of the different problem areas based on the literature suggests the situation shown in Figure 4. By no means should this chart be interpreted as implying that further technical work is not needed. Nor is any implication made that available technologies:

- Are economically viable under any or all conditions;
- Are socially or economically compatible with the needs of small farmers; or
- Can be applied using available organizational methods.

FIGURE 4

GENERAL STATUS OF TECHNICAL KNOWLEDGE FOR SUSTAINABLE USE OF FRAGILE LANDS

	Status of Technological Knowledge on Sustainable Production Systems	Type of System
1.	Workable technical approaches generally available	Humid Lowland Tropical forestry and wood production Steep land Tropical forestry and wood production Plantation tree crops Livestock production on moderate slopes
2.	Some approaches available, but not for all needs	Humid Lowland Continuous annual production Livestock production Plantation tree crops Steep land Annual crop production in low rainfall conditions
3.	Few workable technical approaches available	Humid Lowland Agroforestry Steep land Continuous annual production under high rainfall conditions Agroforestry Livestock production on steep slopes

5. **Changes within a system (e.g., protective measures within an annual cropping system) may be easier and less expensive to implement than larger changes (e.g., from annuals to tree crops). Thus, a successful strategy may make an efficient trade-off of reduced effectiveness in each site for a much larger area served.**

Ideally, each piece of land should be managed using the best technology (most productive, most profitable, and most sustainable) for that land. If reality must fall short of the ideal, there may be advantages to applying a less effective (but possibly more profitable, less costly, or less technically demanding) technology on a broad area.

BUILDING MANAGEMENT INSTITUTIONS

Sustainable management institutions for fragile lands have special needs in addition to the general requirements for sustainable institutions under any conditions (such as reliable funding, trained staff with incentives for effectiveness, established methods to resolve disputes). These special requirements -- in particular, the long-term nature of both the problem and many solutions -- have implications for the design of institutional delivery mechanisms for fragile lands technologies.

1. **The nature of fragile lands management requires a permanent institutional presence for effectiveness in the large majority of cases.**

Effective implementation of most strategies for fragile lands management requires an ongoing presence, often one that must be sustained over several years. Reforestation, for example, is rarely successful if it stops with the planting of the trees and does not provide mechanisms to protect them during early establishment, preserve them during maturity, and continue replanting.

Important exceptions to this generalization, however, arise when the need for an institutional presence continues, but the level of effort is much reduced over time. For example, titling

and registration require a major one-time effort, but thereafter a much lower level of activity will sustain the system.

2. **Institutional alternatives should include the full range individual, private sector, community, and public institutions.**

Realistically, it is difficult for the government to sustain activity in remote, low-income areas. Consequently, strategies requiring ongoing action must rely on private sector or community institutions, if sufficient incentives do not exist to elicit the desired behavior on the part of individuals.

Sustainable private sector activity, however, has its own set of requirements, including acceptable profitability and a market structure that does not favor undesirable changes (such as conversion of smallholders into tenants and or landless laborers). Community-based management has a different but equally essential set of needs, including a degree of community cohesion and social values permitting cooperative land management.

3. **Recurring cost implications of public sector or community approaches may require that a private sector or individual strategy be used, even at a cost of reduced effectiveness.**

When fragile lands interventions require continued effort over a long period and a choice exists between direct government action and indirect private sector action, it may be necessary to sacrifice a certain degree of control or technical performance for sustainability. For example, if the government cannot afford to reforest large areas under its control, it might be appropriate to sell the land to individuals who agree to establish forest on it, even if the government cannot enforce this contract in all cases.

VI. ALTERNATIVE APPROACHES TO PROBLEM SOLUTION

OVERVIEW

The following discussion of techniques for improving fragile lands management is intended to catalogue the range of approaches that have been or might be tried, not to provide a judgment on what works. It includes direct and indirect approaches, including some that are not usually considered in the context of fragile lands management. Activities intended to improve the well-being of fragile lands people but not related to land use, such as health campaigns, are not discussed. These activities may be justified for fragile lands, as for other sites, but are not fragile lands programs as such.

The techniques identified can be used singly or, more commonly, in combination to formulate a program to reduce fragile lands mismanagement. None is appropriate everywhere, none is a must for inclusion in any fragile lands program, and, obviously, no program could include them all. The discussion covers three types of intervention, ranging from the direct to the indirect:

- Direct Interventions in Fragile Lands
  - -- Investments in land maintenance
  - -- Investments in land productivity
- Indirect Interventions in Fragile Lands
  - -- Technology generation
  - -- Measurement and monitoring of resource status
  - -- Planning and policy reform
  - -- Tenure reform
- Interventions Outside of Fragile Lands
  - -- Alternatives to fragile lands use
  - -- Measures to reduce off-site impacts

Four basic approaches may be identified to applying these techniques:

1. Prevention of degradation before it occurs. Preventing future damage is usually more cost-effective than action after it has taken place. Preventative approaches apply to lands now being used as well as to expansion into new lands. This approach may not help those caught up in a cycle of degradation, however.

2. Reduction or reversal of degradation that is under way. Since degradation is proceeding rapidly in many areas, action cannot be limited to preventive approaches, unless social and economic analysis demonstrates that it is preferable to write such areas off to protect as-yet-undamaged areas.

3. Repair of heavily degraded sites. Investment to restore a site that has become severely degraded is a costly and often futile exercise, but must be considered when a degraded site threatens a critical resource (such as urban water supply).

4. Prevention or amelioration of negative impacts of degradation (whether on-site or downstream). Although it is preferable to prevent or halt degradation at its fragile lands source, economic circumstances or urgency may require interventions aimed at controlling the impact of degradation (such as lowland flooding) if the degradation itself (deforestation causing increased runoff, for example) is too expensive or difficult to stop.

Program planners must be clear on which approach they are emphasizing, but the distinction becomes blurred in practice. A given region is likely to have sites where degradation has not

yet begun, sites where it is under way but reversible, and sites that have been virtually destroyed.

Alternative approaches for improving fragile lands management lie along a continuum from those requiring little or no contact with the farmers to those dependent on individual communication with them. Major points along this continuum (and examples of each) include the following:

- Direct personal contact: extension and other technical assistance (with or without provision of inputs); some programs to provide inputs specifically for this purpose; implementation by government agencies on the farmer's land (such as construction of terraces, even if the farmer does not participate); training of future farmers.
- Indirect or limited contact: provision of inputs and credit generally supportive of land maintenance (such as on a national basis); training for extension agents and others working in fragile lands; incentive and cost-sharing systems requiring direct payment to individuals.
- Little or no contact: measures on government-owned or public land; incentive systems not requiring direct payment (such as tax incentives); training of future fragile lands professionals or strengthening of institutions involved in land maintenance.

INVESTMENTS IN LAND MAINTENANCE

The classic approach to stopping land degradation is through what may be termed investments in land maintenance. This term covers all expenditures to preserve, protect, or restore land productivity, including, but by no means limited to, soil conservation. Many of these measures increase production in the short or long run, and some are themselves production methods (such as reforestation). Others have no appreciable or immediate impact on agricultural production or may reduce it.

On-farm Measures

Technical Approaches

On-farm land maintenance investments consist primarily of constructing land- and water-control structures to limit erosion and promote soil productivity. Terracing is widely advocated and is among the most expensive and permanent appoaches. Although terracing has been practiced for thousands of years in Latin America and elsewhere, technologies for rapid, inexpensive terrace construction are still evolving in an attempt to achieve all or most of the benefits of the classic reverse slope bench terrace at reduced cost. Figure 5 (Sheng, undated) shows some of the terrace modifications developed by FAO for application under a wide variety of terrain, soil, and cropping conditions. Techniques have also been developed to spread the terracing investment over time, reducing immediate cost and labor requirements. Examples of the latter include the terracing technique used in the Guatemalan highlands (Arledge) and use of contour ditches, grass barriers, or walls to form terraces over time through controlled erosion (used with notable success by World Neighbors in the Philippine uplands).

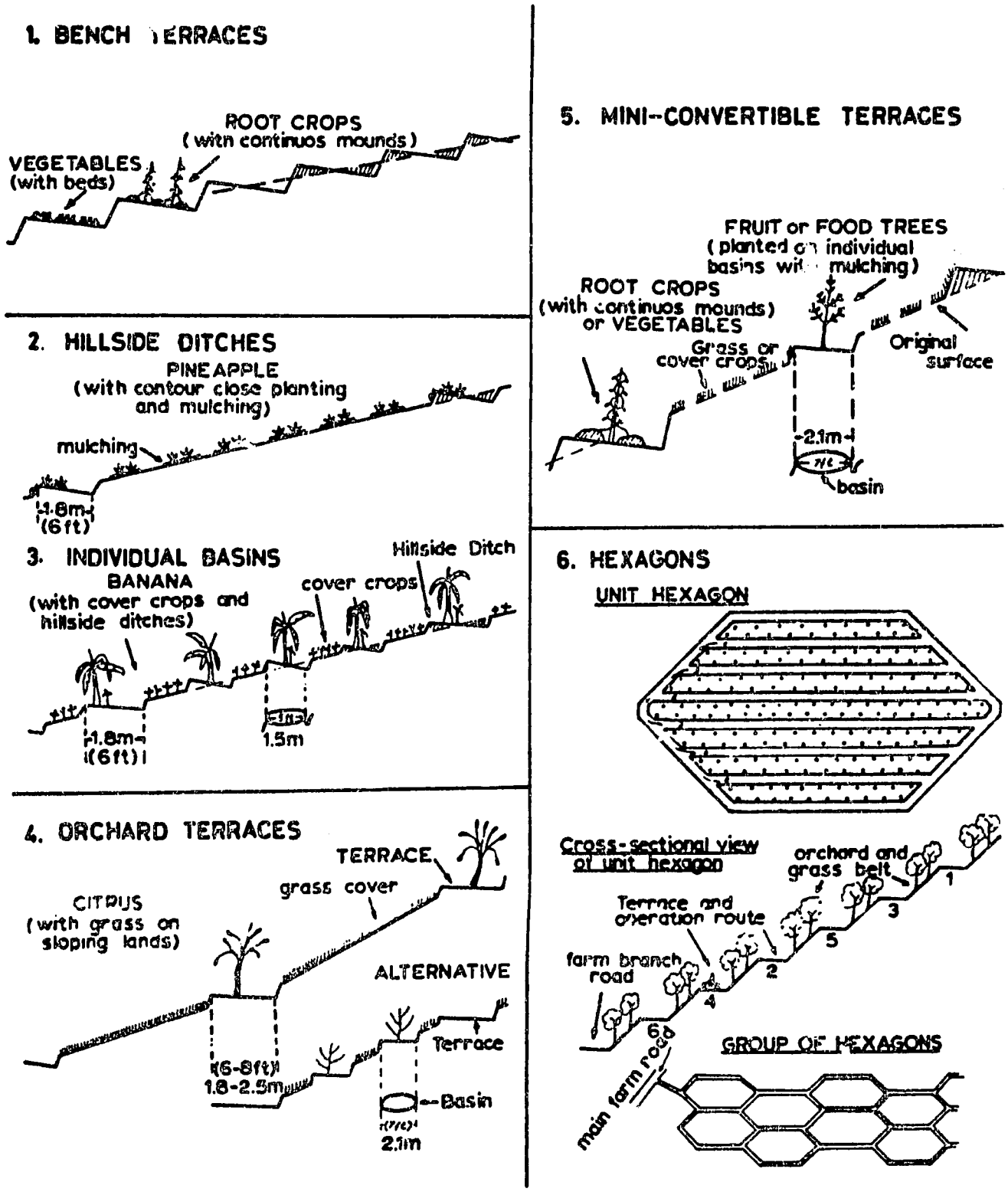
Several points regarding selection of a design (or designs) deserve special emphasis:

- Terracing, regardless of how it is done, is costly. Sheng estimates seven person-months of labor per hectare constructed. Alternatives to terracing should therefore be explored even if they are somewhat less effective technically.

- The economic return to terracing varies greatly between sites. Terraces do not always raise yields. The marginal value of soil moisture appears to be a critical factor, implying that terraces are much more attractive where retention of water can raise yields or permit a second crop.

FIGURE 5

CROSS SECTIONAL VIEWS OF SIX MAJOR LAND TREATMENTS



- The selection of a specific design must consider the need for annual maintenance, which may be up to 30 work-days (Sheng, undated), and whether the design will require farmers to change other parts of their system. Designs that raise labor demands (such as benches too narrow to plow by animal) are rarely acceptable.

- Keeping the topsoil in place is critical in motivating acceptance of terraces. Techniques have been developed to prevent burying the thin topsoil layer, whether construction is by machine or hand labor. (Arledge, for example, discusses techniques using hand labor.)

- Although techniques have been developed for constructing and using terraces on slopes steeper than those considered acceptable for terraces in the United States, even up to 60 percent, terracing cannot be used on the steepest slopes.

- Terracing increases the effective acreage of the farm if the risers are planted (to forage grasses, for example), but decreases available acreage by a factor that depends on the slope (by at least 11 percent on a 50 percent slope, for example, but only 3 percent on a 25 percent slope).

Where terracing is too expensive or inappropriate, a wide range of other land-shaping alternatives exist. These include grass barriers, which may be fodder species such as Napier grass; tree or shrub barriers, including agave and fast-growing leguminous tree species; placement of rocks, cut bamboo, or other materials across the slope; repair of gullies; placement of small checks in on-farm water-courses; and planting of grasses on fallow land or in waterways. Not all of these techniques interfere with the land under crops or require construction of erosion-control structures. All must be implemented in close cooperation with farmers or other land users.

Approaches to Implementation of On-farm Measures

Selection of the physical control technique (or techniques) is less than half the battle in implementing on-farm control

measures. The farmers must be convinced to put them into practice and provided the necessary support to do so. Technical assistance is often required, although fragile lands farmers may well be aware of techniques they cannot or do not want to apply.

In addition to technical assistance, a wide variety of other inputs can be used to promote acceptance of land maintenance investment. These include cash or in-kind subsidies to reimburse farmers for the labor involved; provision of inputs (such as hand-tools) not locally available; and credit to finance construction or replace forgone production.

Off-farm Measures

Not all land maintenance investments require the active cooperation of farmers or other area residents, although few can succeed without their tacit support. Measures that can be implemented without direct small farmer support include those on common land between farms (mostly roads and waterways); on non-farm lands (especially unowned fallow land); and on the government's own lands. Control of waterways, a central element in traditional erosion control, complements and to some extent substitutes for on-farm measures. Soil lost from farms can be kept from causing further damage downstream by check dams close to the site of the original loss, although this rarely benefits the land where loss occurred. Control of waterways, a necessity in any comprehensive watershed program, is extremely costly and must therefore be limited to critical areas.

Public sector construction, including especially road construction, itself may be a cause of upland erosion. Land-conserving construction techniques often cost more, but may re-

duce maintenance costs in the future and limit downstream impacts. An alignment following the contour rather than cutting across it, for example, may raise construction cost but reduce landslides later.

Biological control measures off-farm, including especially reforestation, may act as an off-farm land maintenance investment, a productive investment, or both. Designation and protection of certain areas as reserves (particularly those with standing forest) constitute another type of investment in which the land itself and its accompanying biota are invested to maintain the productivity of lands and other resources downstream. These reserves may also be justified for preservation of unique or endangered species or ecosystems, for esthetic reasons, and for scientific purposes.

Although mining is usually confined to a relatively small area, it is often tremendously destructive, both during mining and afterward. Less damaging mining technologies and site amelioration techniques generally exist, but are expensive to apply and have been developed primarily for temperate zones.

Although government-owned and other idle lands are quickly being converted to croplands and pasture throughout tropical America, huge expanses of these lands remain. Some do not fall within the definition of fragile lands, because they are not degrading or immediately threatened by degradation, but safely pristine areas are increasingly rare. Measures to prevent degradation of these lands deserve careful attention. These may include attention to the very large tracts that have been used by

farmers, ranchers, and others and simply deserted, especially in the Amazon. It is in the public interest for these lands to be stabilized if they present a threat to downstream areas, and, if economic and technically feasible, to undertake measures to speed their recovery to a state permitting resumed use, as an alternative to continued expansion into virgin areas. The cost of these measures is high, but may be lower than the cost of expanded degradation and continued off-site damage until these sites stabilize or recover naturally.

Institutional Development to Support Land Maintenance

Implementation of any approach described above requires a mix of government programs and modification of the incentive system to encourage private sector action. Both of these may require in turn an increase in institutional capacity to select, design, finance, and carry out the necessary actions.

Professional and formal education systems, such as rural secondary, technical, and agricultural schools, influence the shape of future actions by farmers and rural professionals. Action may be warranted to train both future foresters in small farmer concerns and practices and future farmers and extensionists in environmental concepts.

Agricultural extension systems are already overburdened in many LAC countries with educational and other responsibilities. When these systems operate with some effectiveness in fragile lands, an effort to increase their attention to environmental problems and technologies may be warranted; when this is not the case, it is unlikely that fragile lands concerns provide an appropriate focus for an overall effort to improve extension. If

this effort is planned, however, fragile lands concerns should be incorporated.

The comparative expertise of forest services, conservation services, and other natural resource organizations in reforestation and water-control measures implies that they should be directly involved in promoting on-farm measures as an extension of their established role off-farm, if the institution has a strong base for expansion. Traditional management structures and personnel preparation rarely favor this shift, however. Finally, to the extent that government activities such as road construction and mining are a problem, development of the public works and other institutions responsible may be necessary to ensure use of sound land maintenance practices.

INVESTMENTS IN LAND USE PRODUCTIVITY

A second major class of investments comprises those intended to raise the productivity of land use systems, including agriculture, silviculture, and pasture systems. These investments and their associated annual expenditures can improve land management both directly and indirectly. Investments that raise output and profit also generate income that indirectly encourages other land maintenance investments by making these expenditures affordable and by raising the value of the land and, in consequence, the desirability of preserving it.

The link between increased land productivity and increased use of conservation practices is not automatic, however; many techniques for raising short-term productivity increase environmental degradation. Without a parallel increase in land mainte-

nance efforts, measures to promote short-term production gains may be at the cost of long-term production. At the same time, many land maintenance technologies cannot be implemented economically in the absence of other measures to increase production in the short term. Two points deserve emphasis:

- The higher the income from the land, the greater the farmer's incentive to preserve the land and its productivity. This incentive does not guarantee actual adoption of land maintenance techniques (productive or otherwise), especially if the farmer lacks access to the necessary resources and information.

- Nonprotective techniques to raise production and income compete with protective techniques for the farmer's scarce resources, and income generated by the former may not be directed to investment in the land.

Improvement of Existing Crop, Tree, and Livestock Systems

Interventions designed to raise output and increase sustainability in existing sytems are too numerous to catalogue in detail. Defined broadly, they include all the technical approaches to raising traditional agricultural production, such as promoting greater use of fertilizer, introducting improved varieties, and assisting in storage. Not all techniques introduced in the name of improving existing systems either increase net income or improve sustainability, however. Techniques developed for lowland, temperate agriculture have rarely constituted a step forward from existing traditional methods. Some approaches mistakenly advocated for these areas, such as indiscriminate use of herbicides, have instead promoted hillside erosion or the more rapid deterioration of tropical lowland soils.

Introduction of Improved Crop-based Systems

The distinction between modification of an existing system and introduction of a new system is somewhat arbitrary, but nonetheless useful. Introduction of improved crop-based systems to replace existing crop-based systems (or land use systems not based on crops, such as pasture and closed forest) presents a broad range of alternative approaches, only some of which can be sketched out here. Briefly, alternative crop-based systems may include alterations in one or more of the following elements of the existing system:

- Land-clearing methods (such as controlled or improved burning to reduce damage and increase retention of nutrients and organic material; systems permitting partial retention of natural cover; mechanical systems reducing disturbance of the upper soil layers).

- Cover management (such as systems that reduce the time that the soil remains unprotected by vegetation by incorporating permanent crops into the system; systems that limit the removal of existing cover prior to planting of the crop).

- Rotation and crop mix (such as crop rotations that protect or build up nutrients in the soil; systems of relay cropping, multiple cropping, intercropping, and other rotations that limit soil exposure and raise total output).

- Tillage and planting methods (such as conservation tillage systems to reduce costs and limit soil disturbance or make use of plant residues to promote rapid establishment of the following crop, by, for example, using corn stalks as supports for a following bean crop).

- Harvesting methods (such as systems that maximize the amount of material left in and over the soil without damaging subsequent crops; staggered planting and harvesting to maintain some cover over a longer period).

- Chemical use systems (such as use of fertilizer, pesticides, and herbicides in safe and environmentally sound ways to raise output, reduce labor inputs, and limit the need for soil disturbance).

Introduction of Improved Agroforestry and Livestock Systems

Whether or not existing systems are based on crop production, fragile land areas are often better suited to uses that do not rely on crops or rely on them only in combination with permanent cover in the form of trees or grass. It remains an open question, and one resolvable only on a case basis, whether a noncrop system exists that is also economically and socially more suited to a given fragile lands area than crop-based systems. Noncrop systems include those based on trees, trees in combination with crops, livestock, livestock in combination with crops, or all three together.

Few traditional systems are in reality exclusively crop based. Livestock is estimated to account for 30 percent or more of family income in the Andean highlands, for example (Brush). Trees, whether planted in small gardens near the house or left on the edge of fields for harvest of firewood and other products, are also important in both upland and lowland systems.

Tree-based Systems

Tree-based systems include increased production from natural forest (interplanting of productive species in existing forests; more stable extractive systems that permit continued forest production; food forest systems) and tree crops (including fruit trees, firewood trees, and fast-growing timber species).

Agroforestry

Agroforestry systems integrate productive trees into an agricultural system incorporating livestock, annual crops, or both. (Authors differ on whether a system must include fuelwood

or timber trees -- as opposed to fruit trees -- to be classified as agroforestry, but this seems an academic issue.) Agroforestry is attracting increasing attention as an alternative to reliance exclusively on annuals and livestock, particularly in the humid tropics. Incorportion of trees as a major element in the productive system offers advantages, including better protection of the soil, recycling of nutrients from deeper levels, and reduced pressure on surrounding forests. Examples of agroforestry systems include coconut with cattle (with or without annuals); fruit trees intercropped with annuals; leguminous trees for fodder, timber, and firewood (used as fences or vegetative barriers within croplands or pastures); and woodlots planted in combination or rotated with annual crops.

Livestock-based Systems

Pasture is the predominant use in the higher Andean lands and large parts of the Amazonian basin, as well as some areas in Central America and the Caribbean. Many of these systems are low-input, low-output systems not suited to the needs of the small farmer. Many, notably those on steep slopes in Central America and the tropical lowlands, are not sustainable as currently managed. Development of sustainable, high-output livestock systems for the tropics has proved to be exceedingly difficult, even on an experimental basis. Promising opportunities are offered in the following areas:

- Incorporation of leguminous shrubs and trees into grassland pastures in the humid tropics;
- Improved systems of controlled rotational grazing that alternate intensive grazing with recovery periods to raise total output; and

- Improved breeds of cattle and other ruminants that can make productive use of successional cover.

Mixed Systems

Systems combining annuals, trees, and livestock mimic the diversity of the natural environment and have long been the base of traditional land use in the tropics. These systems are generally characterized by lower output in each product considered alone but may offer a higher total output when all products are considered together. Mixed systems also tend to increase total vegetative cover across the seasons, spread risk, and balance labor requirements over the year. Mixed systems, however, are not a panacea: they may also greatly increase marketing problems, make it more difficult to incorporate off-farm labor into the system, and limit farmer interest or ability to make technical improvements in any one area.

Off-farm Measures to Raise Profitability of a Given Level of Production

The farmer's net income, the value of his land, his ability to invest in his land, and his willingness to do so are all dependent to a large degree on economic systems wholly outside his control. One strategy for raising profitability (and thus encouraging land maintenance investments as well as increasing income) is, therefore, to strengthen these off-farm support systems, particularly markets for inputs, credit, and outputs. These may be addressed by programs such as those discussed below.

Institutional Strengthening

Institutional strengthening covers a broad range of programs to improve critical rural economic market systems such as those supplying fertilizer, other agricultural chemicals, seeds and

planting stock, technical and market information, credit, tools, livestock, machinery service, transport service, and marketing services. Possible programs include technical assistance, legal reform, and provision of equipment and infrastructure.

Measures to Raise the Efficiency of Output or Input Use

The price that a farmer receives for his output and the price he can afford to pay for inputs are both dependent on how efficiently these materials are used. If post-farm storage losses decline, for example, the price to the farmer and therefore his profit may rise. If he uses fertilizer more efficiently, he may save resources that can be redirected to land maintenance without reducing total profit. Programs in this area include technical assistance and material and financial support to raise efficiency and quality.

Policy Reform

Policies that restrict domestic prices or limit access to key export and import markets reduce the farmer's profit. These policies have historically discriminated against the marginal farmer, including those on the hillsides, in favor of urban dwellers, large-scale producers of export goods, and ranchers. Programs to encourage policy reform include support to national analytic capacity and reform-incentive schemes (such as sector or program loans).

The programs listed above may seem far removed from efforts to improve fragile lands management, but in reality they may have a far broader and more significant effect on farmer practices than programs specifically directed at the land. The importance

of markets is indirectly supported by the frequency with which low farm profitability is cited as a factor contributing to the failure of conservation programs.

Two caveats limiting the impact of market development on the adoption by farmers of land-maintaining practices must be stressed:

- If farmers believe that increased opportunities for profit are only temporary, they may be encouraged to exploit their land more destructively.
- If farmers do not have access to environmentally sound practices (due to lack of technical information, other supporting inputs, etc.), they may increase the intensity of their operation without implementing the maintenance activities needed to sustain higher output.

Institutional Support to Raising Land Productivity

In addition to programs designed to bolster the working of rural markets, two types of programs can contribute to farm profitability by improving access to technology:

- Extension systems: extension systems tend to be weakest in the fragile land areas, where national packages may not work and where roads and other supports are lacking. Thus, the need for programs to improve extension is strongest in the fragile lands, if increased farm profitability is part of a strategy to promote sound land use.
- Agricultural education: farmer training, including basic adult literacy, traditional formal education, and non-formal education, can improve farmer knowledge of and willingness to apply profitable technologies.

Delivery Mechanisms for Raising Land Productivity

The foregoing implies that a focus on public sector service delivery as the main means of improving farm productivity and profit is too narrow. An analysis of the system as a whole, rather than only those parts falling within the purview of government, may assign a higher priority to national-level policy reform or support to private sector markets as the key to farmer investment in the land.

TECHNOLOGY GENERATION AND RESEARCH

Research Priorities

Approaches to technology generation for fragile lands center on four closely related but different technological issues:

- What is the state of the resource base and our knowledge of it?
- Do technologies exist for controlling erosion and productivity loss that are profitable under prevailing economic conditions?
- Do technologies exist to raise the sustainable productivity and sustainable net income that can be achieved from the land resource base?
- Do research systems exist that can continue to develop the necessary information and technologies in ways that ensure their relevance to fragile lands users?

The last question may be the most important. Without a recognition of why research has failed to address fragile lands needs and what the special requirements of this research are, it is not possible to establish operational priorities for action: strengthening or redirecting the research establishment may itself be a priority within total support to research.

Research on the State of Fragile Areas

The following areas are repeatedly identified as priorities for improving knowledge of the state of fragile areas:

- Development of better classification systems to determine the maximum sustainable use in different areas.
- More accurate and timely information on deforestation and soil erosion rates.
- Accurate information on current use patterns, including better measurement of the actual extent of hillside farming and slash-and-burn farming in the lowlands.

- Development of techniques for quick on-site measurement of soil loss and estimation of erosion coefficients under various tropical conditions.

Land-Maintenance Technologies

Although development of specific technologies remains a priority, emphasis should be given to on-farm testing, methods to increase farmer acceptance of soil conservation, and analysis of technical and socioeconomic factors affecting the farmers' choice, especially in the following areas:

- Low-cost methods of constructing terraces that minimize soil disturbance and need for nonlabor inputs;
- Techniques for rehabilitating slopes and lowlands that have deteriorated into unproductive grasslands or scrub;
- Comparative economic analysis of various land maintenance approaches (such as terraces and contour ditching) under varying physical and economic conditions; and
- Evaluation of the impact of cash and noncash incentives in motivating initial acceptance and continued use of land maintenance technologies, including the impact on those not receiving the incentives and on how farmers apply technologies.

Fragile Lands Productivity-Raising Technologies

Development of sustainable, high-output management systems for fragile lands is at least as important as improving land maintenance technologies, and the two are highly interdependent. Specific priorities include the following:

- Improved understanding of soil-plant interactions and nutrient availability over time in tropical soils;
- Analysis of interspecies relationships and other factors making natural systems in the tropics sustainable, as the basis for developing manmade systems that mimic them;
- Low-resource systems for continuous cultivation of humid tropical lowlands, with or without incorporation of livestock and tree crops;
- Agroforestry systems for sloped areas that meet local food requirements and increase income;

- Techniques to maintain productivity in tropical pastures;
- Techniques and practical approaches for converting shifting systems to viable permanent systems; and
- Rapid, low cost methods for surveying or otherwise demarcating small parcels as the basis for titling.

Fragile Lands Research Institutions and the Supply of Technologies

Institutional development programs to produce a long-term source of fragile lands technologies must be designed to overcome the difficulties of developing fragile lands technology, including the long-term nature of the problem, the low priority allocated to fragile lands in the past, and the complexity and diversity of fragile lands systems. With this important caveat, all of the standard approaches to institution building are potentially appropriate, including technical assistance, promotion of interdisciplinary techniques, long-term training, facility development, and strengthening of research management and coordination.

Research Approaches

The high degree of site-specificity in fragile areas implies that the traditional separation between off-site research and on-site extension must be blurred to address the needs of fragile lands. Technology-generation programs for fragile lands should therefore consider each of the following approaches, as well as various combinations of them, in preference to assuming that on-station alone will yield viable solutions:

- On-station research: appropriate when no preliminary recommendations are available, but must give greater attention to reproducing the farmers' technical conditions, to testing techniques for social and economic acceptability, and to considering how each crop or production practice fits into various farm enterprises.

- On-farm research: particularly valuable when farms are diverse or differ from available station conditions. Views differ on how closely on-farm research can meet traditional research requirements for control and accurate measurement.

- Field testing of technical approaches: necessary to verify that research results remain valid when applied on a wide scale and to determine the range within which techniques remain valid as farmer conditions vary.

- Field testing of institutional approaches: valuable to test methods for promoting adoption of appropriate techniques developed, such as farmer organizations and incentives for farmers or field workers.

MEASUREMENT AND MONITORING OF RESOURCE STATUS

A clear picture of the current status of the resource base and trends affecting this status should, in theory, be a prerequisite for designing programs to address fragile lands. In practice, the cost of obtaining detailed information on whole regions or countries may prohibit any attempt at perfecting this type of data base. In the past, programs have too often gone beyond the point at which additional information collection and analysis impede rather than support action. Specific program elements may include remote sensing, mapping and land classification, cadasters, and systems for monitoring changes in land and water resources.

The need to improve information on changes in the resource base, particularly in critical areas such as important watersheds, creates numerous openings for government- or donor-supported programs, including particularly institutional strengthening of organizations charged with natural resource monitoring and introduction of cost-saving monitoring techniques.

PLANNING AND POLICY REFORM

Managing the use of fragile lands requires a better understanding of their capabilities and a clearer picture of how their use relates to use of other lands. The answer to the fragile lands problem may lie not in the fragile lands themselves, but in better use of nonfragile lands.

Land Use Planning

Although now somewhat out of vogue, land use planning can guide decision makers in directing development efforts toward a more rational use of national resources. These planning efforts are not useful, however, if they are designed on so grandiose a level that data collected can never be analyzed or if the efforts do not extend beyond specification of an ideal to identify policies and incentives to motivate adoption of the desired pattern.

Land Development Policies

Governments actively contribute to the fragile lands problem by colonization schemes and efforts to open up frontier areas by building roads and creating fiscal incentives. Re-examination of these policies, particularly the selection of areas in which settlement is to be encouraged and the desired rate of spread, may be a major step toward reducing later fragile lands problems.

Multisectoral Regional Planning

With OAS support, the multisectoral regional planning approach has been applied as a resource-use planning tool in several Latin American countries. The OAS approach draws on a thorough survey of resource use and capability to prepare a set of pre-feasibility studies for a recommended investment program consistent with optimum use of resources (OAS).

Agricultural Sector Policies

Policies in the agricultural sector may reduce (or, more rarely, increase) the profitability of fragile lands farmers, skew their choice of a product mix away from perennial systems, or encourage their use of undesirable technologies and inputs. Rationalization of policies that affect fragile lands users (whether or not directed at them) may have a far greater impact on fragile lands than a dozen fragile lands projects.

Other Development and Macro-economic Policies

Fragile lands development is directly affected by macro-economic conditions. For example, inflationary policies discourage long-term investment and encourage speculation in high-quality land (especially near cities) over productive use. Allocation of investment and credit funds to agriculture, infrastructure, and job creation has an indirect but important impact on fragile lands use and users.

Policy Capacity

Development of policies that encourage appropriate fragile lands use -- whether directly or indirectly -- may require that the government's apparatus for policy analysis and formulation be strengthened to permit full consideration of the economic and environmental implications of proposed policies.

Decision Maker Understanding of Fragile Lands

Sound management of the fragile and nonfragile lands resource is impossible if decision makers view fragile areas as a boundless untapped frontier awaiting development or as unimportant, marginal areas whose problems do not significantly

affect the country and can safely be ignored. When one or both of these misconceptions are widely held, it may be necessary to increase decision maker understanding of the role that fragile lands play in the economy, the consequences of current management patterns for their future productivity, and, in particular, the high cost that fragile lands degradation imposes on society in terms of off-site degradation and reduced return from major infrastructure investments. This understanding may be a prerequisite to allocation of the resources necessary to make a significant impact on the problem.

Coordination of Fragile Lands Programs

The institutional responsibilities for fragile lands programs are typically spread across numerous agencies, making it unlikely that the funds allocated to fragile lands will be applied in an effective manner. Concentration of efforts in high-priority areas will require coordination among national agencies and donors. Mechanisms for this coordination are now rare, as evidenced by situations such as that in Honduras, where a major hydroelectric investment (el Cajon) is being implemented without watershed management, while an AID-funded watershed management program is under way in the less critical Choluteca watershed.

TENURE REFORM IN FRAGILE LANDS AREAS

The specific ways in which land is owned and used have a significant impact on land use, including investment behavior and land management in general. One approach to encouraging desired management behavior is therefore to improve the tenure situation of fragile lands users, by making it more secure; regularizing it

legally; making it easier to sell and buy land; or changing the structure of land rents, taxes, and other payments. This may involve actions such as titling and registration; improvement of land markets and related credit markets; and restructuring of incentives created by existing tenure, legal, and tax systems.

ALTERNATIVES TO USE OF FRAGILE LANDS

Historically, only two situations have led to a reduction in the intensity of land use: destruction of the land and transfer of resources to more attractive uses. Land users cannot be convinced to reduce land use intensity without an alternative that yields a greater income, since reduced intensity nearly always means reduced income. Alternatives are discussed below.

Resettlement and Colonization

In theory, resettlement of fragile lands users to more favorable locations would reduce the burden on fragile areas. In practice, the supply of unused, nonfragile areas is adequate for only a small fraction of fragile lands residents and the cost associated with resettlement, particularly in virgin areas, is excessively high. Transferring farmers from one fragile area to another yields only short-term gains at best.

Increased Transformation of Local Products

More intensive (and income-generating) use of the land's products can substitute for more intensive use of the land itself. For example, processing of local products provides an alternative to agricultural work and can encourage use of less intensive systems (fruit trees cattle) over more damaging annual crop systems. More efficient transformation of output may also

be helpful, such as improved methods of making charcoal to alleviate the destruction of nearby forests.

Off-farm Employment

Non-agricultural employment provides an alternative to destructive use of the land. Anecdotal evidence suggests that land around Mexico's industrial cities is reverting to more sustainable natural cover as rural residents take jobs in nearby cities. This approach is effective whether or not rural residents actually move to less fragile areas.

Land Reform in Nonfragile Areas

Where nonfragile lands are held in large, unproductive holdings, redistribution of these lands to fragile lands holders will reduce the pressure on fragile lands. Land reform is no panacea, however, because there are not enough underutilized lands to meet all users' needs; lands distributed through a reform tend to be the more fragile parts of large holdings; and poor design of parcel size, credit, and titling in the reform may lead to misuse of lands by land reform beneficiaries.

Other Measures to Raise Intensity of Land Use on Relatively Nonfragile Lands

Measures to reduce loss of good lands through urban sprawl are particularly important in this regard. More intensive use of high-quality agricultural land pulls people away from fragile lands by creating jobs (but can also push those remaining in fragile areas toward destructive practices as they become increasingly marginalized).

Off-site Sources of Replacements for Fragile Lands Products

Replacement of fuelwood with kerosene or electricity at a

competitive price, for example, may reduce the destruction of forests by commercial fuelwood operations. This becomes more feasible as the effective price of fuelwood climbs and the distance to wood sources grows. Fuelwood cutting, however, is not a major source of deforestation in the LAC region.

MEASURES TO MITIGATE OFF-SITE IMPACTS

In some cases, it may be more practical to limit the downstream impact of fragile lands misuse than to try to stop the destructive practices at their source. These measures, however, do not help fragile lands users. They encourage further delay in addressing fragile lands problems and tend to provide only a temporary solution, possibly at considerable cost. Nonetheless, they may be justifiable, particularly if the need to halt downstream damage is urgent. Examples include dredging of hydroelectric reservoirs and protective levees, in the floodplain, and check dams and other control structures downstream of affected areas.

ADDITIONAL INFORMATION NEEDS

Three high-priority needs for better information may be identified, among the many suggested by the foregoing discussion:

- Additional information on how these alternative approaches have performed in the field. Comparison of various means of encouraging sound fragile lands management (through extension, incentives, research, and policy change) is a particular priority.

- Better quantitative estimates of the downstream cost of mismanagement to motivate governments to assign greater importance to reducing destruction of fragile lands.

- Better understanding of sustainable natural and traditional systems as the basis for developing more productive use systems, especially in view of the rapid disappearance of these systems.

VII. AN APPROACH TO PROGRAM DEVELOPMENT

OVERVIEW

This section provides a brief overview of a proposed approach to program development for fragile lands, emphasizing how it differs from standard approaches to programming for agricultural development. The approach presented provides a means of thinking about the problems and possible solutions that can be applied to each particular case; it does not offer a set of packaged programs applicable across the board. It is meant to precede, not replace, the familiar procedure of project design.

The approach is discussed in general terms to be applicable to local programs (whether action or research oriented) and to broader approaches involving policy, resource monitoring, or other national or regional activities. Specific solutions must be tailored to meet the needs of each specific case, drawing on the commonalities discussed in previous sections.

The approach presented here consists of six steps:

<u>Assessment</u>

- Identification of goal and desired outcome;
- Needs assessment;
- Assessment of resources;

<u>Program Formulation</u>

- Selection of factors for program targeting;
- Selection of approaches for addressing these factors; and
- Formulation of the program strategy and content in broad outline.

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BARRIERS TO EFFECTIVE PROGRAMMING FOR FRAGILE LANDS DEVELOPMENT

Programs to reduce fragile lands degradation and promote sustainable and productive management of these areas must overcome four barriers to effective action in this area by donors and host governments. These barriers are discussed below.

1. Marginalization of fragile lands. The residents of fragile areas typically have little political or economic power. Although fragile lands are in reality a major source of food and other agricultural products, they are perceived as economically marginal. Often they are physically remote from centers of population and decision making, with weak linkages to the national economy.

2. Poor understanding of the impact of degradation. The effects of fragile lands degradation on the economy off-site are poorly understood by decision makers, who consequently do not assign the priority to fragile lands problems that they would if they realized the impact of fragile lands on urban and industrial water supplies, tourist sites, irrigated lands, and hydroelectric systems.

3. Failure to see degradation as more than a local problem. Past programs have been based on a belief that the problems originate in the fragile lands and can best be solved by actions in those locations. Fundamental relationships between degradation and basic deficiencies in land allocation and use nationwide, in agricultural policy, and in investment decisions are not perceived. As a result, fragile lands programs are defined too narrowly.

4. Fragile lands solutions require a long-term commitment. Many of the actions needed to combat degradation can be implemented successfully only if funding and political support are maintained for several years. Basic research in tropical soils and tree crops and establishment of agroforestry systems, for example, may not show results unless they receive continued support for a decade or more. Both the donors and the host governments have difficulty mobilizing resources or maintaining political commitments for long periods, particularly when there may be little visible return during the early years. The emphasis on a high rate of return in the short run, reinforced by traditional methods of project evaluation, mitigate against approval for these long-term programs.

IDENTIFICATION OF GOALS AND DESIRED OUTCOMES

The importance of off-site impacts makes clear identification of the program goal more important than is usually the case in agricultural-sector programs. The primary intent may be to:

- Benefit fragile lands users by protecting their resource base and raising their short-term income;
- Prevent flooding downstream and protect major dams and water systems; or
- Increase production of agricultural goods (including animal and forest products) in fragile areas.

Clear thinking on program formulation requires that a single goal be selected as the primary program objective. Vague combinations of "all of the above" will tend to obscure the real choices among different means of achieving the primary goal.

As part of this process, the desired outcome for the fragile lands area in question should be specified clearly. This may

take the form of a short description of the land use pattern that will prevail if the program is successful. If the goal is to prevent flooding, for example, possible desired outcomes are conversion of half the watershed area to permanent crops or application of soil conservation practices on 70 percent of the annual crop area. These might differ from the outcomes that would be identified as consistent with a goal of increased agricultural production or increased short-term income and sustainability for small farmers.

NEEDS ASSESSEMENT

Needs assessment must be limited to information directly needed as a basis for action, since otherwise data collection may hamper rather than assist problem solution. Assessment should focus on two areas, as they relate to the achievement of program goals:

- Identification of areas (defined by geographic or other characteristics) in which actions to address the fragile lands problem have a high priority; and
- Examination of the nature of the problem in these areas, including the causes and impacts of fragile lands degradation.

Identification of Priority Areas

Since action must be limited, a clear specification is needed of which areas have priority relative to the goal chosen. These areas may be identified geographically (such as a set of critical watersheds) or by other criteria (for example, those areas in which average family income is below a certain target).

Priority areas are not necessarily those in which degradation is most severe, as usually defined, but may instead be one of the following:

- Where a problem can be arrested or prevented;
- Where degradation is accelerating;
- Critical areas with regard to downstream impact; or
- Where the threat of future productivity loss is greater.

Priority areas must be identified even if action is to focus on policy reform, research, or institutional capacity. This specification is necessary, for example, to clarify which policies need to be examined.

Identify Nature of the Problem

The examination of the nature of the problem must maintain the specific area focus; priority areas may well not be typical of fragile lands nationwide. For example, steep lands in critical watersheds may be located near major population concentrations and therefore have economic and social characteristics different from steep lands elsewhere. Problem identification should include:

- Specification of the major symptoms of degradation, preferably in quantitative terms and including their physical, biological, and socioeconomic aspects;
- Identification of causes or those factors believed to be causes, including physical, biological, social, political, institutional, and economic causes; and
- Identification of information gaps and needs.

ASSESS RESOURCES AVAILABLE FOR PROGRAM IMPLEMENTATION

The third step is to analyze the resource base available for implementation of programs to address the problem areas chosen. This includes analysis of three factors: the information available on the status of the resource base in the high priority areas identified; the capacity of international, national, and

sub-national institutions that might participate in program implementation; and the approaches available to address the problem and their potential applicability under the specific circumstances of this case. At this stage, analysis of approaches involves only a preliminary screening to identify the alternatives available for future consideration.

PROGRAM DEFINITION

The next step is to identify alternatives for action, by analyzing:

- The factors that have an impact on the targeted resource degradation problem and that are subject to modification through donor-supported intervention; and
- The approaches that can be expected to have an impact on these factors and that are appropriate for donor-supported action at this time.

Figure 6 presents a hypothetical example of an analysis of the factors underlying siltation of a critical reservoir. Ideally, the analysis would proceed another level back along the causal chain. For example, why are there no technologies in place for permanent cultivation? Is this due to a lack of research capacity, an inability to extend technologies, failure to identify these technologies as a research priority, or use of research techniques poorly suited to developing small farmer technologies?

Figures 7 and 8 present a guide to classifying causal factors and possible approaches in the form of decision trees. The first step is to classify the factors as to their impact on the problem and their tractability, that is, the possibility of affecting them through donor action. The factors falling into categories three and four are potential intervention targets.

The available approaches are then categorized to identify those suitable for inclusion in a program, based on their feasibility and their expected impact on the factors identified as targets for intervention.

Once the factors for targeting and the feasible approaches to address these factors have been identified, a strategy can be formulated to address the specific problem area chosen as a priority. The strategy should define the following, based on the resources available:

- The level of action: will approaches be implemented primarily on the policy, regional, or local levels, or some combination?
- Overall approach: will the approaches selected consist primarily of those directed at technology generation, policy change, institution building, or local-level implementation of action programs?
- Delivery mechanism and implementing agency: given the approaches, what mix of public and private institutions should be involved in implementation and which should play leadership roles?
- Resource requirements: what are the needs for funding, personnel, etc., and how will the provision of these resources be divided among the host government, donors, other agencies, fragile lands users, and others?

FIGURE 6

EXAMPLE OF FACTORS UNDERLYING A LAND MISMANGEMENT PROBLEM

Underlying Factors	"Causes"	Problem
Unequal dist. of land		
Poor markets for high-val. tree crops	Annual crops on steep land	
	Erosion on farm lands	
No technol. for protect. measures		
Income too low, no credit	Lack of soil protective measures	
No access to valley land		
No access to off-farm empl.	Clearing for agriculture	
Technol. for permanent cult.		Siltation of hydroelectric reservoir
Technol. for perm. past.		
Crop prod. leaves no land for pasture	Clearing for pasture	Deforestation
No altern. fuel	Fuelwood shortage	
Poor logging policy with few controls	Logging practices	
Mining technologies	Mining-linked damage	
Road const. techniques	Road construction	Erosion on public lands
No pasture improvement	Public grazing	
No control of grazing		

FIGURE 7

DECISION TREE FOR CLASSIFICATION OF FACTORS AFFECTING PRIORITY FRAGILE LAND PROBLEM

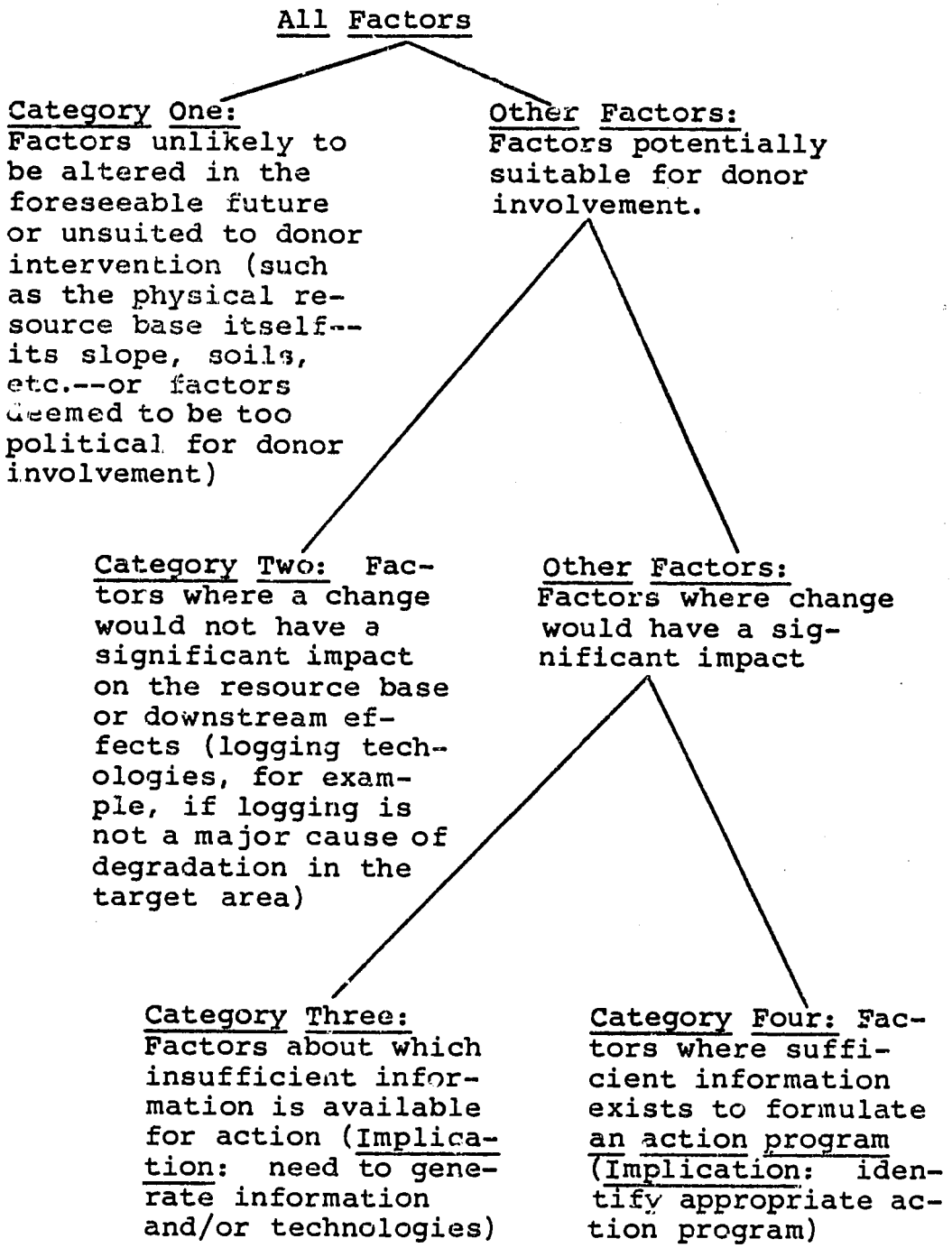
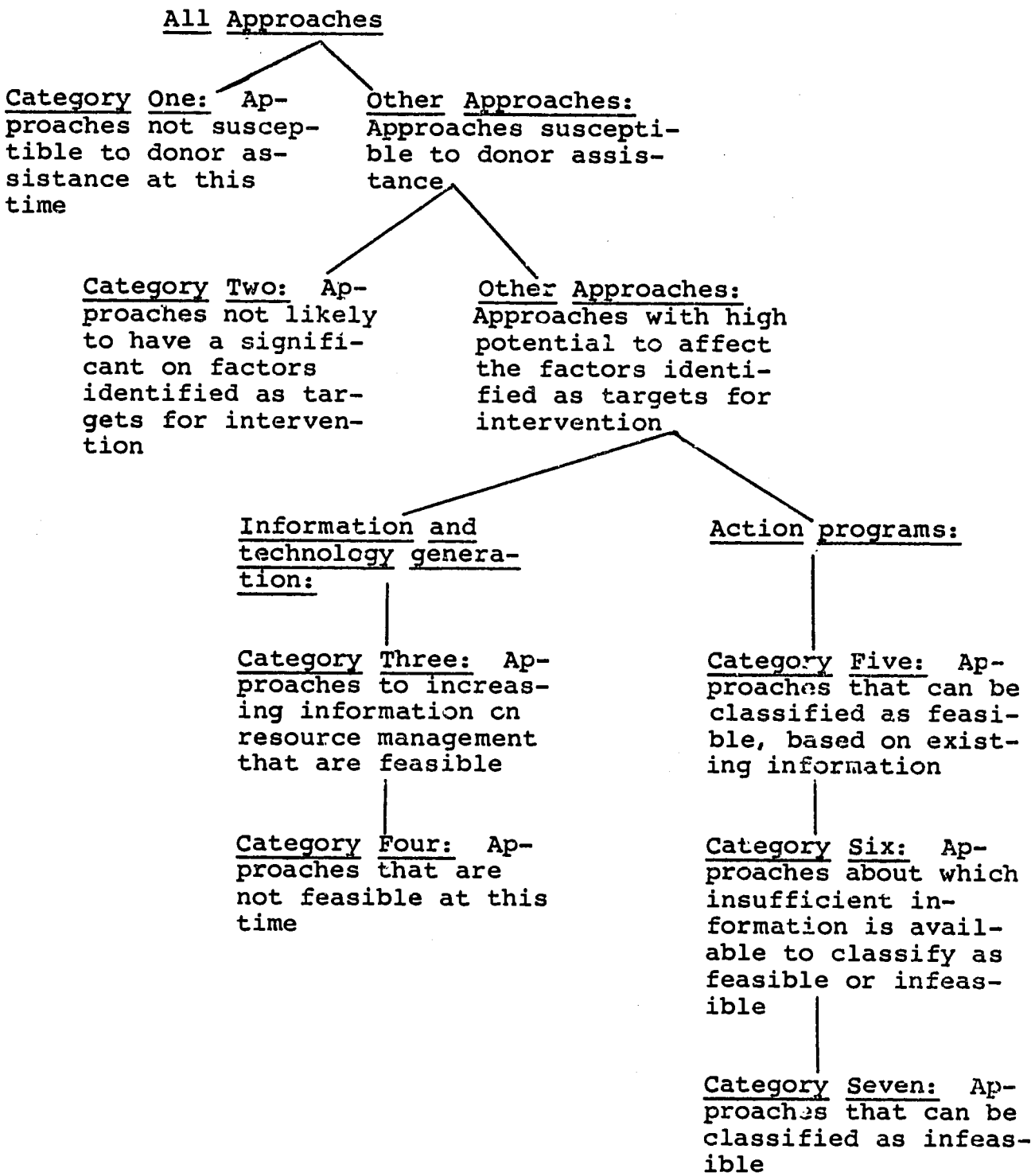


FIGURE 8

DECISION TREE FOR CLASSIFYING APPROACHES



ANNEX A

REFERENCES CITED IN THE TEXT

ANNEX A

REFERENCES CITED IN THE TEXT

Arledge, Jerome, 1980. "Final Contract Report; Guatemalan Small Farmer, Soil Conservation Regions I and V Project 520-T-026. Guatemala: U.S. Department of Agriculture Soil Conservation Service, mimeograph.

Brush, Stephen, 1976. "Andean Culture and Agriculture: Perspectives on Development." In Hill Lands: Proceedings of an International Symposium, J. Luchok, J. Cawthon, and M. Breslin, eds. Morgantown, W. Vir.: West Virginia University Books.

FAO, 1982. Conservation and Development of Tropical Forest Resources. Rome: FAO.

FAO, 1982a. Tropical Forest Resources. Rome: FAO.

Hecht, Susanna, 1983. "Cattle Ranching in the Eastern Amazon: Environmental and Social Implications." In The Dilemma of Amazonian Development, Emilio F. Moran, ed. Boulder, Colorado: Westview Press.

Nicholaides, J., W. Couto, and M. Wade, 1983. Agronomic-Economic Research on Soils of the Tropics: 1980-81 Technical Report. Raleigh, N.C.: North Carolina University Soil Science Department.

Organization of American States, 1984. Integrated Regional Development Planning: Guidelines and Case Studies from OAS Experience. Washington: OAS (draft).

Posner, Joshua, and Malcolm McPherson, 1982. "Agriculture on the Steep Slopes of Tropical America: Current Situation and Prospects for the Year 2000." World Development, May 1982, Vol. 10, No. 5.

Plucknett, D.J., 1976. "Hill Land Agriculture in the Humid Tropics." In Hill Lands: Proceedings of an International Symposium, J. Luchok, J. Cawthon, and M. Breslin, eds. Morgantown, W. Vir.: West Virginia University Books.

Rankine, L.B., 1976. "Economic Evaluation of Food Crop Production on Hillsides--The Caribbean Experience." In Hill Lands: Proceedings of an International Symposium, J. Luchok, J. Cawthon, and M. Breslin, eds. Morgantown, W. Vir.: West Virginia University Books.

Santos, Blas, 1981. "El Plan Sierra: una Experiencia de Desarrollo Rural en las Montanas de la Republica Dominicana." In Agricultura de Ladera en America Tropical, Andres Novoa and Joshua Posner, eds. Turrialba, Costa Rica: Centro Agrogonomico Tropical de Investigacion y Ensenanza.

Sheng, T.C., undated. "Protection of Cultivated Slopes: Terracing Steep Slopes in Humid Regions," mimeograph.

_____, 1982. Soil Erosion and Conservation in the Tropics. ASA Special Publication No. 43. Madison, Wisconsin: American Society of Agronomy and Soil Science Society of America.

Tobon, Jose, 1981. "Experiencias en Cambios Tecnologicos y su Transferencia en el Proyecto Oriente Antioqueno de Colombia." In Agricultura de Ladera en America Tropical, Andres Novoa and Joshua Posner, eds. Turrialba, Costa Rica: Centro Agrogonomico Tropical de Investigacion y Ensenanza.

Tosi, Joseph, Jr., and Robert Voertman, 1964. "Some Environmental Factors in the Economic Development of the Tropics." Economic Geography, Vol. 40.

ANNEX B

ANNOTATED BIBLIOGRAPHY OF KEY SOURCES

ANNEX B

ANNOTATED BIBLIOGRAPHY OF KEY SOURCES

Congress of the United States Office of Technology Assessment, 1984. Technologies to Sustain Tropical Forest Resources. Washington, D.C.: Office of Technology Assessment.

Contents: Economic, social and environmental importance of tropical forest resources throughout the world; Status of tropical forests: deforestation, degradation and causes, and alternative techniques; Technology assessments for undisturbed forests; Assessments for disturbed forests: management of secondary forests and reforestation of degraded lands; Reduction of overcutting esp. industrial wood and fuelwood; Support of tropical agriculture: agroforestry, watershed management, site-specific resource development planning, education and research (esp. as needed to determine interactions between social and biophysical factors of tropical forest systems, technology transfer); Issues and options for congressional consideration: development assistance, resource development planning, protection of biological diversity, improvement of tropical forest research and market development; U.S. tropical forests: addresses resources of U.S. insular territories in Caribbean and West Pacific.

Dasmann, Raymond F., Peter H. Freeman, and John P. Milton, 1973. Ecological Principles for Economic Development. London: Unwin Brothers Ltd.

Partial contents: Ch.1, Introduction--goals of development and their attainment; conservation and economic development should be directed toward a common goal which is the rational use of resources to achieve a higher quality of life; Ch.2, General ecological considerations, includes overview of the biosphere and its functioning, factors influencing population growth, ecosystems and their functions, biotic succession and land rehabilitation, carrying capacity, diversity vs. simplicity, ecological balances and survival thresholds; Ch.3, Development of humid tropical lands, describes characteristics, biotic succession, diversity, stability and resilience, limitations for development, alternative schemes for development; Ch.5, Development of tourism, includes regional planning considerations, development of national parks, ecological aspects of coastal zone tourism, aspects in island environments; Ch.6, Agricultural development projects, examines agriculture in the tropical environment, soil productivity and management considerations, ecological impact of agricultural production technology such as implication of disease and pest control,

subsistence farming; Ch.7, River basin development projects, considers manmade lakes and river basin ecology, irrigation projects.

Special emphasis on ecosystems subject to heavy developmental pressure, e.g. tropical humid forests, high mountains and coastal areas.

Eckholm, Eric P., 1976. Losing Ground: Environmental Stress and World Food Prospects. Published for Worldwatch Institute. New York: W.W. Norton & Co.

Contents: 1, The undermining of food-production systems; 2, A history of deforestation; 3, Two costly lessons: the dust bowl and the virgin lands; 4, Encroaching deserts; 5, Refugees from Shangri-La: deterioration of mountain environments; 6, The other energy crisis: firewood; 7, The salting and silting of irrigation systems; 8, Myth and reality in the humid tropics; 9, Dual threat to world fisheries; 10, The politics of soil conservation; 11, Environmental stress, food, and the human prospect.

This book is the classic popularized account of the problem of erosion and environmental degradation in the developing world and sounds a call to action on a variety of fronts. Analyzes ways in which balanced food systems are being ecologically undermined, and the urgency of international cooperation and strong response from governments; examples of deterioration through deforestation, silting of irriga tion systems, and changes in the frequency and severity of flooding; deterioration compounded by population pressure and careless land practices; argues that the ecological view can be used to explain the success or failure of efforts to overcome social and political inadequacies but can also cause these problems.

Farnworth, Edward A., and Frank B. Golley, eds. 1974. Fragile Ecosystems: Evaluation of Research and Applecations in the Neo-tropics. A Report of the Institute of Ecology (TIE). New York: Springer-Verlage New York, Inc.

Partial Contents: 1, Tropical population ecology; 2, Tropical ecosystem structure and function; 3, Recovery of tropical ecosystems; 5, Interaction of man and tropical environments; 6, Impacts of regional changes on climates and aquatic systems; 7, Mechanisms to support and encourage research and education in tropical ecology.

Catalogue of important research topics for the neo-tropics; stresses fundamental theory or patcerns characteristic of neotropical population, communities and landscapes, and how man interacts with ecological units; gaps in knowledge and research questions identified in each area.

Specific recommendations for a sustained yield of products without degradation of productivity or long-term stability; argues that ecological research must be conducted in context of needs and realities of society; raises research questions in determination of optimal rates at which ecosystems operate, and tolerable levels of stress without losing recovery capacity; recommends establishment of permanent centers to study secondary succession over long time periods.

Analysis of man's impacts concerns maintenance of a given system, inputs and outputs, and linkages to other man-dominated or natural ecosystems; research recommendations include development of a sound economic base for tropical forest management.

Goodland, Robert, Catharine Watson, and George edec, 1983. Environmental Management in Tropical Agriculture. Boulder, Colorado: Westview Press.

A valuable primer on sustainable tropical agriculture in an environmental context. The first 16 chapters consider the environmental aspects of the principal tropical crops, including rice, maize and other large grains, legumes, cassava and other root crops, coffee, cocoa, sugar cane, tobacco, cotton, oil palm, rubber, timber and other forest products, large livestock, small livestock, and freshwater and marine fisheries. The book then examines nine production factors as they affect the sustainability of tropical agriculture, including biocides, integrated pest management, tsetse fly control, irrigation, energy use in agriculture, weed control, water weeds, conserving biological and genetic diversity, and soil erosion.

Hammond, Kenneth, George Macinko, and Wilma B. Fairchild, eds. 1978. Sourcebook on the Environment: A Guide to the Literature. Chicago: The University of Chicago Press.

Contents: 1, Environmental perspectives and prospects (includes environment and quality of life, resource scarcity, limits to growth controversy); 2, Environmental modification, (uses case studies to examine impact of human activity on wildlife, agricultural activities, environmental stress, impact of mining; 3, Major elements of the environment (describes land forms and soils, vegetation, human population and the environment, coastal zones); 4, Research aids (reviews selected periodicals of environmental interest, and provides list of selected environmental organizations).

Divided essentially into three parts: introduction to environmental philisophies and perspectives, which considers reaction to some problems and previews future; closer look at environment through case studies; references.

Contributors also act as bibliographers for the reader with distinct interpretations in areas such as quality of life, rates of resource consumption under scarcity, and limits to growth.

Hecht, Susanna B., and G.A. Nores, eds. 1982. Amazonia: Agriculture and Land Use Research. Cali, Colombia: Centro Internacional de Agricultura Tropical (CIAT).

Country Reports: Evaluation of the agricultural protential of the Bolivian Amazon; General evaluation of development policies and research in the Brazilian Amazon; Development policies and plans for Ecuador's and Peru's Amazon region; Considerations on the Colombian Amazon region; A Peruvian experience for the development of Amazonia; Agricultural development in Venezuala's Amazon region.

Technical Reports: Ecosystem research, looks at natural resources for land use in the Amazon region; Agricultural research, e.g., production of annual food crops in Amazon, appraisal of perennial crops in Basin.

Forestry and Agroforestry in Amazon Basin: Practice, theory and limits in Colombia; Humid tropics in each of the Andean nations; Forestry and agroforestry research in Colombia.

Overview of national policies concerning agricultural development; reviews current state of knowledge on alternative agriculture and land use options; presents priority research topics and future research needs, e.g., quantitative information on basic ecological processes, further study of farming or forestry methods practiced by indigenous people. Particularly valuable for treatment of livestock systems.

Luchok, J., J.D. Cawthon, and M.J. Breslin, eds. 1976. Hill Lands: Proceedings of an International Symposium. West Virginia: West Virginia University Books.

This volume of proceedings is particularly interesting because it brings together descriptions of experience from practitioners in developed and developing countries and from both temperate and tropical regions. Articles include broad reviews of experience and specific technical discussions of technologies or sites.

Partial contents: Hill land agriculture in the humid tropics, by D.J. Plucknett; Intensive crop and animal production systems in the tropical hill lands of Puerto Rico, by Jose Vicente-Chandler; Andean culture and agriculture: perspectives on development, by Stephen B. Brush; Social adaptation to the mountain environment of an Andean village, by William P. Mitchell; The tragedy of the commons revisited: land use and environmental quality in high-altitude Andean grasslands, by Benjamin S. Orlove; Economic experience, by L.B. Rankine; Crop diversfication in lowland Bolivian hills, by J.A. Duke; Some general problems of soil erosion of disturbed lands in the Caribbean, by L.A. Wilson; Grazing systems for hill lands, by T.B. Trew; Dairy beef production in the Guatemalan highlands, by M.T. Cabezas and R. Bressani.

National Research Council, 1982. Ecological Aspects of Development in the Humid Tropics. Prepared by the Committee on Selected Biological Problems in the Humid Tropics. Washington, D.C.: National Academy Press.

Contents: 1, "Development" of the humid tropics; 2, Humid tropical ecosystems; 3, Evaluation of renewable natural resources; 4, Germplasm and conservation of genetic resources; 5, Agriculture in the humid tropics; 6, Ecological and management considerations for forested lands; 7, Soil management considerations; 8, Surface water resources in the humid tropics.

Part of comprehensive effort to review existing technical information on environmental protection and natural resource management; organized for use by AID missions and other development agencies for use in project planning and execution.

Identifies three major approaches to utilization of humid tropic resources in the short-term: 1) retain parts of humid tropic ecosystems to serve as parks and reserves, scientific repositories with restrictions on human use, limited short-term economic yield but good long-term environmental protection; 2) utilize parts of natural ecosystems to produce lumber, pulpwood, plywood and fuel, emphasize management practices such as selective cutting, underplanting, limited clear-cutting and human assisted regeneration and reforestation; 3) convert extensive areas already deforested and selectively deforest others to increase food production through applications of new agriculture technology, human impact substantial with maximum modification to produce short-term yields.

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_____. 1980. Research Priorities in Tropical Biology. Washington, D.C.: National Academy Press.

Contents: 1, Summary and recommendations; 2, The problem--conversion rates of tropical moist forest (includes land use, population growth, food production, preservation of forests); 3, Inventory of tropical organisms; 4, Studies of selected tropical ecosystems--goals and guidelines (considers selection of research sites, recommends subprojects); 5, Tropical aquatic systems.

Concentrates on kinds of basic scientific studies essential for theoretical and practical reasons, e.g. biological inventory, investigation of natural and experimentally manipulated ecosystems with emphasis on solutioins, concludes that donors should initiate or expand studies of major tropical areas in Latin America, fund national monitoring and international reporting of rates of conversion of tropical vegetation types esp. moist forest.

Recommends multidisciplinary efforts on two levels: 1) investigation of socioeconomic "dysfunctions," often produced by transplanted models of development; 2) investigaion of dysfunctions in perspective of national and international linkages, such as knowledge of 'systemic' characteristic of forest conversion demands, research on ways in which aboriginal, peasant and urban-industrial societies perceive and relate to tropical environment and regulate its use.

Nelson, Michael. 1973. The Development of Tropical Lands: Policy Issues in Latin America. Published for Resources for the Future, Inc. by the John Hopkins University Press, Baltimore.

Contents: 1, The role of tropical lands in development (analyzes land capability for agriculture and forestry, development policies, tropical land development and increased crop production, structure of agriculture, sociopolitical and institutional factors); 2, Two theories of land development in the humid tropics, i.e. the case for and against development; 3, The development of new lands (studies current practice and problems, direct government programs, colonization, public and quasi-public enterprise, regional development authorities, private initiative and government promotion policies); 4, Project evaluation (defines goals and performance criteria, benefit-cost analysis, welfare aspects); 5, A survey of 24 development projects (outlines colonization schemes i.e. directed, semidirected, spontaneous, foreign, livestick development programs); 6, The conservation and use of natural resources (depletion and waste, underutilization, high grading, need for technology breakthroughs, forestry administration, yield decline, erosion, and downstream effects, fertilizers); 7,

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Factors affecting development policy (i.e. area selection, beneficiaries, and infrastructure); 8, Factors affecting development policy, economic, technical, administrative (i.e. settlement organization, credit, extension, marketing, cooperatives, land tenure, level and distribution of income and farm size, public administration).

Examines economic base underlying investment and policy for development of new lands for agriculture and forestry in humid tropical lowlands, uplands, and semi-arid Chaco; addresses potential consequences of further expansion toward interior tropical forest regions or converting native pasture to crops; also how to increase efficiency of lands already exploited.

Novoa B., Andres R., and Joshua L. Posner. 1981. Agricultura de Ladera en America Tropical. Memoria del Seminario Internacional sobre Produccion Agropecuaria y Forestal en Zonas de Ladera de America Tropical. Turrialba, Costa Rica: Centro Agronomico Tropical de Investigaciones y Ensenanza (CATIE). (Spanish)

A collection of papers from a regional seminar on experiences with hillside agricultural development in Latin America. Particularly valuable for the discussion of specific project experiences, including both regional development and research projects. Specific activities analyzed include Plan Zacapoaxtla in Mexico, Oriente Antioqueno in Colombia, Ordenacion Integrada de Cuencas Hidrograficas in Honduras, Plan Sierra in the Dominican Republic, among others. Discusses socio-economic, institutional, and technical aspects of hillside development. Includes English versions of the three summary sections (including conclusions and recommendations for future action).

Organization of American States. Department of Regional Development. 1984. Integrated Regional Development Planning: Guidelines and Case Studies from OAS Experience. Washington, D.C.: OAS.

The result of a cooperative study sponsored by U.S. National Park Service and U.S. Agency for International Development.

Contents: 1, Introduction (defines integrated regional development planning as practiced by DRD); 2, Guidelines (draws on DRD experience in regional development planning and project formulation, designing the study, executing the study, and implementing recommendations based on actions taken before, during and after study; includes bibliography); 3, Case studies (describes six Latin American projects organized to focus on the six steps identified in the guidelines section; projects are examples of integrated planning methods and deal with major development problems,

represent work done in various ecosystems, and use a variety of spatial planning units e.g. development regions, river basins and frontier zones; successes and failures identified to help practitioners; bibliography); 4, Looking ahead (identifies major challenges to regional development and discusses how planning methodology may have to gradually evolve to respond to changing Latin American conditions).

Ruthenberg, Hans. 1980. Farming Systems in the Tropics. 3rd ed. New York: Oxford University Press.

Contents: 1, Introduction (farm systems and farming systems, with classification of systems); 2, Some general characteristics of farming in a tropical environment (the natural environment, critical aspects of tropical farming); 3, Shifting cultivation systems (types and geographical distribution, general characteristics, problems, development paths); 4, Fallow systems; 5, Ley systems; 6, Systems with pernament upland cultivation; 7, Systems with irrigation; 8, Systems with perennial crops; 9, Grazing systems; 10, General tendencies in development of tropical farm systems.

Restricted to cultivation and grazing systems; main chapters organized according to type and intensity of land use; farm system expressed as goal-orientated system i.e., crop and livestock production for economic gain; relations of farm system with environment described in economic terms.

Sanchez, Pedro A. 1976. Properties and Management of Soils in the Tropics. New York: John Wiley & Sons.

Contents: Ch..1-2, defines tropical environment in physical and human terms, geographical distribution and classification of soils in tropics; Ch.3-9, specific soil-plant relationships related to physical and chemical soil properties, organic matter, plant nutrients, and methods of soil fertility evaluation; Ch.10-13, integrates above in terms of four principal soil management systems, i.e. shifting, rice culture, multiple cropping and pasture production.

A basic reference on tropical soil management. See esp. Ch.10, Soil Management in Shifting Cultivation Areas, includes changes in soil physical properties, e.g. runoff and erosion, evidence from Guatemala and Peru to show crop yield decline under shifting cultivation; Ch.12, Soil Management in Multiple Cropping Systems, examines what is known about managing soil in various multiple crop systems, relationship to small farming operations; various systems are considered in detail from a soils perspective.

Applies principles of soil science to tropical conditions; emphasis on how to increase food production in developing countries; emphasizes need for site-specific applicaton of universal principles discussed.

Wilkenson, Richard. 1973. Povery and Progress: An Ecological Perspective on Economic Development. New York: Praeger Publishers, Inc.

Criticizes "mechanical" development models of conventional economics; concerned with laying out a new foundation of empirical theories for an interdisciplinary approach to development; model set in ecological framework of cultural evolution, and defines adaptive tasks that cultural system performs; sees "contest" historically taking place between environmental problems and innovation; innovations no longer serving as an effective response to succession of new ecological problems or offer long-term improvements in our circumstances as demonstrated by the threat of resource shortages now and in the future; analysis of changing ecological circumstances is focused on the relationship between population and resources, and argues that societies are now forced to exploit the environment in new ways; development is primarily the result of attempts to increase output from the environment, not to produce a given output more efficiently; ecological equilibrium or the conditions for maintaining stability is reinforced by resource management and cultural practices; success of this strategy in primitive societies; discusses how change is initiated where ecological equilibrium existed before; population control breakdown, emergence of subsistence problems leading to initiation of change process.

ANNEX C

ADDITIONAL BIBLIOGRAPHIC SOURCES

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Andrew, Chris O., and Peter E. Hildebrand. 1982. Planning and Conducting Applied Agricultural Research. Boulder, Colorado: Westview Press.

Arledge, Jerome. 1980. Guatemalan Small Farmer; Soil Conservation Regions I and V; Project 520-T-026. Guatemala: USDA Soil Conservation Service.

Bauer, J., and J. Calix. 1981. Guia de reforestacion en communidades rurales. Proyecto HON/77/006. Documento de trabajo No. 5. Tegucigalpa.

Beller, William, ed. 1979. Transactions at the Conference on Environmental Management and Economic Growth in the Smaller Caribbean Islands. Washington, DC: Department of State.

Blaikie, Piers. 1981. Class, Land-Use and Soil Erosion. ODI Review, No. 2, Vol. 1981.

Blake, Robert, et al. 1980. Aiding the Environment: A Study of the Environmental Policies, Procedures, and Performance of the U.S. Agency for International Development. Washington DC: Natural Resources Defense Council.

Brinkman, W.L., and J.C. Nascimento. 1972. The effect of slash and burn agriculture on plant nutrients in the tertiary region of central Amazonia. Turrialba, (23)3: 284-290.

Brush, S.B. 1976. Man's Use of an Andean Ecosystem. Human Ecology, 4: 147-66.

_____. 1983. Traditional Hillside Farming Systems. Culture and Agriculture (18): 9-16.

_____, H.J. Carney, and Z. Huaman. 1981. Dynamics of Andean Potato Agriculture. Economic Botany, 35: 70-88.

Budowski, Gerardo. 1956. Tropical Savannas: A Sequence of Forest Felling and Repeated Burnings. Turrialba, (6)1-2: 23-33.

Chijcke, E.O. 11980. Impact on soils of fast-growing species in lowland humid tropics. FAO Forsetry Paper 21. Rome: FAO.

Child, George I., Richard G. Clements, Michael J. Duever, Frank B. Golley, and John T. McGinnis. 1975. Mineral Cycling in a Tropical Moist Forest Ecosystem. Athens, Georgia: University of Georgia Press.

Cochrane, Thomas T. 1973. El potencial agricola del uso de la tierra en Bolivia: Un mapa de sistemas de tierras. Mision Britanica en Agricultura Tropical. Bolivia: Ministerio de Agricultura.

Congress of the United States. 1982. Joint Hearing on Deforestation: Environmental Impact and Research Needs. House Committee on Science and Technology. Washington, DC.

Cornick, Tully R., Patricio Gallegos, and Roger Kirkby. September 1981. On-farm Research Methods: A Comparative Approach. Experiences of the Qimiag-Penipe Project, Ecuador. Cornell Intenational Agriculture Mimeograph 91. Ithaca, New York: Cornell University.

_____ and Roger A. Kirkby. August 1981. Interactions of Crops and Livestock Production in the Generation of Technology in Sloped Areas. Cornell International Agriculture Mimeograph 90. Ithaca, New York: Cornell University.

Cummings, R.W., Jr., and S. Wortman. 1978. To Feed This World; the Challenge and the Strategy. Baltimore: The Johns Hopkins University Press.

Denevan, William M. May 1973. Development and the imminent demise of the Amazon Rain Forest. Professional Geographer (25)2: 130-135.

Dickinson, Joshua. 1972. Alternatives to Monoculture. The Professional Geographer, (24)3: 217-222.

_____. 1982. Development Planning at the Interface of Mountain and Plain: a Venezuelan Case Study. Mountain Research and Development, (2) 3.

Dongelmans. L. 1980. Analasis financiero de reforestacion para lena y cultivos en terrazas. Proyecto HON/77/006. Documento de Trabajo No. 6. Tegucigalpa.

Dorner, Peter, and Bonnie Saliba. 1981. Interventions in Land Markets to Benefit the Rural Poor. Land Tenure Center Research Paper No. 74. Madison, Wis.: University of Wisconsin.

Eckholm, Erik P. July 1978. Disappearing Species: The Social Challenge. Worldwatch Institute Paper 22. Washington DC.

_____. 1979. Planting for the Future: Forestry for Human Needs. Worldwatch Institute Paper 26. Washington DC.

_____ and Lester R. Brown. 1979. Spreading Deserts--The Hand of Man. Worldwatch Paper 26. Washington, D.C.: Worldwatch Institute.

114

Food and Agriculture Organization. 1965. Soil Erosion by Water: Some Measures for its Control on Cultivated Lands. FAO Land and Water Development Series No. 7, FAO Agriculture Development Paper No. 81. Rome: FAO.

Fundacion Natura. March 1982. Evidencias del Deterio Ambiental en el Ecuador. Quito: Gangotena & Ruiz Escitores S.A.

_____. Problemas ambientales en el Ecuador. 1981. Proyecto EDUNAT 1. Quito: Laboratorios Life.

Gentry, K., and J. Lopez-Parodi. 1980. Deforestation and Increased Flooding of the Upper Amazon. Science 210: 1354-1356.

Golley, F.B., ed. 1983. Tropical Rain Forest Ecosystems: Structure and Function. New York: Elsevier Scientific Publishing Co.

Goodland, R., and Howard S. Irwin. 1975. Amazon Jungle: Green Hell to Red Desert?. New York: Elsevier Scientific Publishing Co.

_____, H. Irwin, and G. Tillman. 1978. Ecological Development for Amazonia. Ciencia y Cultura (3013): 275-290.

Harwood, R.R. 1979. Small Farm Development: Understanding and Improving Farming Systems in the Humid Tropics. Boulder, Colorado: Westview Press.

Hawes, Robert A., and Lawrence S. Hamilton. May 1980. A Method of Watershed Classification and Assessment for the Tropics: A Case Study of Rio Guanare, Venezuela. Cornell International Agriculture Mimeograph 77. Ithaca, New York: Cornell University.

Hecht, Susanna. 1983. Cattle Ranching in the Eastern Amazonia: Environmental and Social Implications, pp. 155-189. In Emilio F. Moran, ed. The Dilemma of Amazonian Development. Boulder, Colorado: Westview Special Studies on Latin America and the Caribbean.

Herrera, Rafael, Carl Jordan, Ernesto Medina, and Hans Klinge. 1981. How Human Activities Disturb the Nutrient cycles of a Tropical Rainforest in Amazonia. Ambio, (10):2-3.

Hildebrand, P.E., and R.E McDowell. January 1980. Integrated Crop and Animal Production: Making the Most of Resources Available to the Small Farmer in Developing Countries. New York: Rockefeller Foundation.

Holdridge, L.R. 1967. Life Zone Ecology. San Jose, Costa Rica: Tropical Science Center.

115

Hollander, Seth. 1982. Annotated Bibliography on Population, Resources, and Environment Relationships. Environmental Policy Analysis Department report no. 19. New York: National Audobon Society.

Hopfen, H.J. 1969. Farm Implements for Arid and Tropical Regions. FAO Agriculture Development Paper No. 91. Rome: FAO.

Johnson, Dennis V. 1983. Agriculture on Slopelands of Tropical America: Problems and Prospects. Culture and Agriculture (18): 1-8.

Katzman, Martin. July 1976. Paradoxes of Amazonia Development in a "Resource Starved" World. Journal of Developing Areas (10)4: 445-450.

Kirkby, J.M. 1978. Colombia land-use change and the settlement of the Orient. Pacific Viewpoint, (19)1: 1-25.

Lanly, J.P. 1983. Present situation and evaluation of tropical forest resources. Mazingira (7)4: 2-15.

LeBaron, A., and L.K. Bond. 1979. An Explanation of the Bolivian highlands grazing-erosion syndrome. Journal of Range Management, (32)3: 201-208.

Leigh, Egbert G. Jr., A. Stanley Rand, and Donald M. Windsor, eds. 1982. The Ecology of a Tropical Forest: Seasonal Rhythms and Long-term Changes. Washington, D.C.: Smithsonian Institution Press.

Mayer, Enrique. 1981. Uso de la tierra en los Andes: Ecologia y agricultura en el Valle del Mantaro del Peru con referencia especial a la papa. Lima: Centro Internacional de la Papa (CIP): Departamento de Ciencias Sociales.

Momsen, Richard P. Jr., ed. 1975. Geographical Analysis for Development in Latin America and the Caribbean. Proceedings of the Conference of Latin Americanist Geographers (CLAG), Vol. 4. North Carolina: CLAG Publications, Inc.

Nicholaides, J.J. 1977. Education and extension requirements for conservation and management of Latin American soils. In P. Arens, ed. Lima: FAO Workshop on Soil conservation and Management in Latin America.

Nye, P.H., and D.J. Greenland. 1960. The Soil Under Shifting Cultivation. Commonwealth Bureau of Soils. Technical Communication No. 51. Farnham Royal: Commonwealth Agriculture Bureaux.

Pinchayat, A.M., and J. Soria, and R. Bazan. 1976. Multiple Cropping in Tropical America. Multiple Cropping, ASA Special Publication No. 27. Madison, Wisconsin: American Society of Agronomy, Crop Science Society of America and Soil Science Society of America.

Posner, Joshua and Malcolm McPherson. May 1982. Agriculture on the Steep Slpoes of Tropical America: Current Situation and Prospects for the Year 2000. In World Development (10)5: 341-352.

Rhoades, R.E., and S.I. Thompson. 1975. Adaptive Strategies in Alpine Environments: Beyond ecological particularism. American Ethnologist (2): 535-51.

Sanchez, P.A. 1979. Soil fertility and conservation considerations for agroforestry systems in the humid tropics of Latin America, pp. 79-124. In H.O. Mongi, and P.A. Huxley, eds. Soils Research in Agroforestry. Nairobi, Kenya: ICRAF.

_____ and S.W. Buol. 1975. Soils of the Tropics and World Food Crisis. Science 88:4188.

Sarmiento, K. 1983. The Savannas of Tropical America, pp. 245-288. In Francois Bourliere, ed. Tropical Savannas. New York: Elsevier Scientific Publishing Co.

Shane, Douglas R. 1978. A Latin American Dilemma: Current Efforts to Develop the Tropical Forest Areas of 13 Latin American Nations. Presented at the U.S. Strategy Conference on Tropical Deforestation. Washington D.C.

Sheng, T.C., and T. Michaelson. 1973. Run off and soil loss studies in yellow yams: Forestry development and watershed management in upland regions. Jamaica: UNDP/FAO.

Stanfield, David. 1984. Puerto Gande: a case study of the infrastructure approach to marginal lands development. Madison: University of Wisconsin Land Tenure Center (draft).

Stewart, N., J. Beloti, and L. Beloti. 1976. Transhumance in the central Andes. Annals of the Association of American Geographers (66)3: 377-397.

Talbot, James J. 1983. Ecological aspects of development in the humid tropics. Mazingira (7)4: 44-55.

Thorne, D. Wynne, and Marlowe D. Thorne. 1979. Soil, Water and Crop Production. Westprot, Conn.: AVI Publishing Co., Inc. 353 p. Examination of present farming systems, and evaluation of available and potential technology systems to find an effective way of solving problems.

Tosi, J.A., and R.F. Voertman. 1964. Some environmental factors in the economic development of the tropics. Economic Geography (40): 189-205.

United States Agency for International Development. 1979. Environment and Natural Resource Management in Developing Countries: A Report to Congress. Volume I: Report. Washington, D.C.:

Watters, R.F. 1971. Shifting Cultivation in Latin America. FAO Forestry Development Paper 17. Rome: FAO.

Wischmeier, W.H., and D.D. Smith. 1978. Predicting rainfall erosion losses--a guide to conservation planning. U.S. Department of Agriculture. Handbook No. 537.

World's Tropical Forests: A Policy, Strategy, and Program for the United States. 1980. Report to the President by a U.S. Interagency Task Force on Tropical Forests. Washington, DC: US Department of State.

ANNEX D

LATIN AMERICAN INSTITUTIONS WITH EXPERTISE IN FRAGILE LAND ISSUES

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LATIN AMERICAN INSTITUTIONS WITH EXPERTISE IN FRAGILE LAND ISSUES

The following is a partial listing of organizations active in environmental management in Latin America. Organizations working only in a single country, including local ministries of natural resources or the environment, are not included in this listing.

Chile

CEPAL
Casilla 179-D
Santiago
TEL: 48-50-51

Colombia

Centro Internacional de Agricultura Tropical
John Nichol, Dir.
Cali

Costa Rica

Instituto Internacional de Ciencia Agricola

Tropical Science Center
Joseph Tosi/Gary Hartshorn
Apartado 8-3870
San Jose
TEL: 22-62-41

life zone mapping
consulting on agricultural planning, impact assessment, forestry

CATIE
Turrialba

graduate training in agriculture and forestry
agro-forestry and farming systems research

Universidad Nacional
Escuela de Ciencias Ambientales
Herredia
TEL: 37-41-51

Ecuador

Fundacion Natura
Jorge Juan 481 y Mariana de Jesus
Quito
Roque Sevilla, Pres.
Yolanda Kacabadse, Exec. Dir.
TEL: 239-177

Mexico

UN Environmental Program
Latin American Office
Jose Lizarraga, Dir.

Peru

Centro Internacional de la Papa
La Molina
Lima

Puerto Rico

Institute of Tropical Forestry
Box A2
Rio Piedras 00928
TEL: 809-753-4335 or 4336

US Virgin Islands

Island Resources Foundation
Red Hook Center
Box 33
St. Thomas 00802
TEL: 809-775-3225

Venezuela

Centro Interamericano de Desarrollo Integrado de Aguas y Tierras (CIDIAT)
Apartado 219
Merida 5101
074-522-011
Carlos J. Grassi, Dir.

provides training (degree and short-courses)

FUDENA (Fundacion de defensa de la naturaleza)
c/o Cecilia Blohm
Avenida los Cortijos 203-102
Campo Alegre, Caracas
23-94-510 or 23-94-721

conservation of habitats, but including soils, etc.
analysis of mangroves and coastal zones