Keynote: Environmental Protection verses Restoration: A Model for Policy Decisions

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ABSTRACT

Very substantial economic impacts of land degradation in developing countries have been documented, in terms of agricultural supply, economic growth, welfare of the rural poor, wealth, off-site effects, and environmental damage. However, this evidence alone is not sufficient to justify re-allocation of public resources to combat land degradation. Key considerations include not only the economic returns to land interventions relative to other public objectives, but also the policy relevance of the problem, future land quality requirements, the timing and reversibility of degradation, predicted farmer response to degradation, and opportunities to convert natural capital to scarcer man-made capital.

A three-part policy decision model is proposed, which asks: Is degradation of significant policy relevance? Is the best response through land husbandry interventions? Is the most appropriate strategy prevention or restoration? This model is illustrated by assessing the appropriate policy response to several types of land degradation in one micro-watershed in the hillsides of central Honduras. Rigorous identification and documentation of policy priorities, and rigorous assessment of policy options, are essential for mobilizing broad public support for land rehabilitation, as they lead to targeting of interventions where they will provide significant and visible payoffs.

INTRODUCTION

Agricultural expansion and intensification in the developing world over the past 50 years have been accompanied by widespread degradation of soil chemical, physical, and biological qualities (Bridges, et al. 2001). Alarmed by this evidence of a possibly permanent diminution of the capacity for agricultural production, land husbandry specialists from many fields have come together in forums such as the ISCO International Conference to lobby for greater public investment and legislation to protect soils from further degradation. A new global convention on soils is being developed to generate a global commitment to this end.

Motivating much of this political action is an underlying frustration at the lack of action by policymakers to address soil degradation at local and national levels. While clearly inaction is often simply due to the short planning horizon of many politicians, even many economists have questioned the wisdom of re-allocating substantial private or public resources to soil conservation. At the same time, there are few guidelines around to assist those who strongly support soil conservation to choose between competing problems and areas, between prevention and restoration, in focusing scarce human and material resources. Current methods to evaluate land husbandry interventions emphasize plot or farm-level analyses, or biophysical watershed-level effects, which cannot be easily scaled up to answer questions about aggregate impacts on key effects, which both recognizes economic realities and tradeoffs, and also reflects the real short and long-term socioeconomic and environmental costs of soil degradation.

This paper attempts to integrate various perspectives which concern policy-makers in making such decisions. It is premised on the assumption that by structuring the decision questions more systematically, it may be possible to generate political consensus for action, even where detailed quantitative evidence is not available. At the same time, the approach highlights critical information gaps for assessment and research efforts.

The section below summarizes the available evidence on the magnitude and nature of the socioeconomic and environmental impacts of soil degradation that appear to justify a significant public policy response. The third section presents a set of factors that should ideally inform the policy response to a given case of degradation, whether to emphasize prevention or restoration, or not address the problem at all. The next section synthesizes these factors into a qualitative decision model and illustrates its use with a case study from Honduras. The conclusion discusses actions needed to promote a more policy-relevant planning process for land resource protection and improvement.

IMPACTS OF LAND DEGRADATION

Humans use about 8.7 billion hectares of land worldwide. About 2 billion hectares are potentially arable, of which less than half is used to grow crops. The remaining 1.7 billion hectares of potentially arable land, along with most non-arable land, function as pasture, forest and woodland. There are many other direct and indirect uses of land, as well as the role of land in supporting bio-diversity and habitats for other species (Figure 1). Recent global studies estimate that soil quality on three-quarters of the world's agricultural land has been relatively stable since the middle of the twentieth century. On the rest, however, degradation is widespread and the overall pace of degradation has accelerated in the past 50 years, with highly visible "hot spots" identified throughout the developing world (Scherr and Yadav 1995). This degradation has policy-relevant impacts related to on-site agricultural

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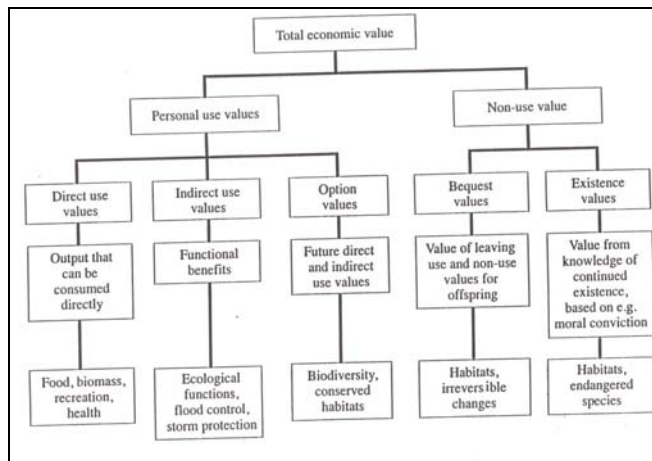productivity, off-site economic effects, and environmental quality (Scherr 1999). [1]

Figure 1. Categories of economic values attributed to environmental assets. Source: Munasinghe, 1992. [crooked]

Productivity-related impacts
Agricultural supply

The cumulative productivity loss for cropland from soil degradation over the past 50 years is estimated to be about 13 percent, and for pasturelands 4 percent (Olderman, 1998). In developing countries, agricultural productivity is estimated to have declined significantly on approximately 16 percent of agricultural land, with much higher rates on cropland in Africa and Central America, pastures in Africa, and forests in Central America. Almost 75 percent of Central America's agricultural land is seriously degraded, as is 20 percent of Africa's and 11 percent of Asia's (Oldeman 1994). Crop yield losses in Africa from 1970 to 1990 due to water erosion alone are estimated to be 8 percent (Lal 1996). Dub-regional studies have documented large aggregate declines in crop yields due to degradation in many parts of Africa, China, South Asia, and Central America (Scherr 1999). A global agricultural model suggests a slight increase in degradation relative to baseline trends could result in 17 to 30 percent higher world prices for key food commodities in 2020, and increase child malnutrition (Agcaoli, et al 1995).

Economic Growth

Besides affecting aggregate food supply, soil degradation also diminishes agricultural income and economic growth. In South and Southeast Asia, estimates for total annual economic loss from degradation range from under 1 to 7 percent of agricultural gross domestic product (Young

1993). Given that more than half of all land in this region is not affected by degradation, the economic effects in the degrading areas would appear to be quite serious. Estimates for eight African countries show annual economic losses ranging from under 1 percent of AGDP in Madagascar to 9 percent in Zimbabwe (Bojo, 1996). Effects of erosion in different regions of Mexico vary from 2.7 to 13.3% of AGDP (McIntire, 1994). Country models simulating the effects of soil degradation in Ghana and Nicaragua find annual economic growth to be reduced by nearly a percentage point (Alfsen, et al., 1996).

Welfare of the poor

The poor are particularly dependent on agriculture, on annual crops (which generally degrade soils more that perennial crops), and on common property lands (which generally suffer greater degradation than privately managed land), and often lack the capacity to make land-improving investments. Thus the poor tend to suffer more than the non-poor from soil degradation. In West Africa, for example, the proportion of children who died before the age of five was the highest in areas with high soil degradation.

Wealth

The potential impact of degradation on national and global wealth in land resources- that is, on "natural capital"[2] in the form of land—is also a major concern. Estimates of land loss due to degradation vary from 5 to 12 million hectares every year (0.3-1.0% of the world's arable land). Assuming that land loss continues at current rates, an additional 150 to 360 million hectares would go out of production by 2020. But because much of this is lower-quality land, the greater concern may be a serious decline in the quality of soils that remain in production. Countries with large areas of high-quality agricultural land-Brazil, China, India, Indonesia, and Nigeria-may need to worry less about long-term loss in soil wealth than the more immediate economic effects of degradation. But for the 57 developing countries with high population pressure on the land and only 1 to 10 million hectares of arable land and the 38 countries with less than 1 million hectares, long-term soil quality maintenance is likely to be a significant food security concern (Scherr, 1999).

Off-site economic impacts

Off-site economic impacts are additional concerns. In developed countries, the key issue is non-point water pollution, which affects water supplies for residential and industrial purposes, results in water nutrient enrichment, and reduces the recreational and amenity values of water resources. In developing countries, the main impacts of erosion are the sedimentation of hydroelectric, flood control and irrigation facilities (Enters 1998).[3] Extensive soil compaction and de-vegetation may reduce the quality and reliability of downstream water supplies for domestic, agricultural and industrial use. Good economic analyses of

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[1]No attempt has yet been made to calculate, through natural resource accounting approaches, the aggregate economic value of soil products and services at national, regional or global scales. Efforts are underway to develop a suitable approach allowing economists and environmentalists to monitor changes over time in natural soil capital (NRC 1994).

[2]"Natural capital" is defined as the stocks of resources generated by natural bio-geochemical processes and solar energy that yield flows of useful services and amenities into the future (Daly 1994), cited in Izac (1998).

[3]Enters and others warn, however, that new studies show the importance of non-agricultural sources of sediment, such as infrastructure, construction of new settlements, and mining.

off-site damages are difficult to do because of the lack of data and unclear understanding of agriculture-environment interactions. However, many analysts consider the magnitude of off-site economic impacts to be even higher than the on-site effects.

Environmental impacts

Land degradation may also result in significant local, regional or global environmental changes that affect indirect use values, such as environmental services and ecological functions provided by land, and habitats for other species. Terrestrial ecosystems are an important carbon sink and there is growing evidence that degradation (in particular changes in soil carbon) may result in increased greenhouse gas emissions and reduce the land's capacity to serve as a carbon sink. Land degradation may affect bio-diversity in several ways, directly affecting above and belowground bio-diversity in agricultural regions through habitat changes, and indirectly by forcing farmers to clear more natural areas for cultivation. Sedimentation, pollution, and flooding problems caused by degradation in upstream watersheds may affect water quality and habitats in lowlands, estuaries and coral reefs downstream (Pagiola 1999). Most of these effects have not been translated into economic terms, but further strengthen the justification for policy initiatives to combat degradation.

POLICY RESPONSE TO DEGRADATION: KEY FACTORS TO CONSIDER

But despite the magnitude of these impacts, they may not always be sufficient to justify a significant re-allocation of public resources to combat land degradation. Even in cases where degradation is a clear policy concern, it may sometimes be desirable to delay action—to choose restoration later, rather than prevention now.

Key factors to consider in making such policy decisions include not only the familiar criteria of economic returns, but also five factors commonly missing from soil conservation studies. These are:

− Problem assessment from a policy perspective
− Consideration of future land quality requirements
− Evaluation of land damage and recovery functions
− Expectations about farmer responses to degradation and
− Opportunities to convert natural capital to man-made capital.

Standard investment (cost-benefit) analysis

Economists consider the decision to invest resources in soil-improving or protecting investment in terms of maximizing the discounted flow of net benefits. Standards and method for such analyses are fairly well defined within evaluation economics, whether from the perspective of private farmers, watershed protection or broader public policy (Table 1). Cost-benefit analysis ideally (but less often in practice) reflects the full opportunity costs of any

resources used for soil protection or restoration, identifies which groups will pay the costs of conservation and which groups will receive the benefits, and distinguishes private and social returns. The analysis should ideally value costs and benefits at their real values, as they would be without policy or market distortions or institutional constraints (Anderson and Thampapillai 1990; Enters 1998; Gittinger1982; Gregersen and Contreras 1979; Pagiola 1996).

Public investment analysis usually "discounts" the future stream of costs and benefits to reflect the real cost of capital borrowed for investment and the fact that people commonly value income and services in the near future more than those in the distant future. The practice of discounting can be problematic for natural resources, where inter-generational equity demands that future users' concerns also be recognized in making policy choices.

Table 1. The main steps of cost-benefit analysis. Source: adaped from Angelsen and Sumaila, 1995, cited in Enters, 1998.

Define the alternatives

Identify economic and environmental effects (cost and benefits)

Select key externalities for consideration

Quantify in physical terms the economic and environmental effects

Value the economic and environmental effects

Weigh the costs and benefits

     - between different groups of people (by income, location)

     - in time (discounting)

Sensitivity analysis

Relative returns to prevention versus rehabilitation

All things being equal, the decision to prevent degradation or restore land after degradation will depend crucially upon the relative costs of the two approaches. In the rainforest, for example, the cost of maintaining soil fertility for annual crop production is much higher than the cost of fallowing when land is abundant and cheap. The economic feasibility and farmer adoption of soil erosion control is much higher when low-cost vegetative systems are used than with high-cost structures. The feasibility and cost of soil rehabilitation depend in part on the severity of degradation.

Opportunity costs of soil investment

Farmers, communities, and societies always have multiple objectives to balance in determining the use of their limited investment resources. Preserving soil quality in the short and long-term competes with other important objectives, such as improved health and education, economic development, improved housing, better roads, etc. These represent the "opportunity cost" of soil-protecting or improving investments. Thus, even when strategies of soil quality protection may be highly efficient and effective,

policymakers may give priority to other investments. Prevention, which avoids future costs rather than raising current benefits, is often not competitive with other investments that have clear and immediate payoffs.

Thus, land quality improvement projects are often economically more attractive than are "prevention" projects. For this reason, it is usually desirable to promote soil conservation activities that simultaneously have a significant impact on short-term production or environmental goals. This strategy widens the scope of land management programs, since in many cases (especially areas undergoing agricultural intensification) the land quality challenge is not so much degradation from a previously more productive condition, as how to increase productivity on soils that have inherent constraints to sustainable, continuous production.

Cost-benefit analyses may be based on simple calculations of the expected trajectories of costs and benefits at farm scale (with results for different groups extrapolated to more aggregate scales to evaluate the impact on policy objectives), or more complex, decision-based feedback models of watershed dynamics. In any case, to do CBA *well* requires careful selection and definition of the externalities, and quantification of those effects and their value. These costs and benefits are then weighed for different groups of farmers (e.g., by income group or region) and over time. Sensitivity analyses are also essential to test the sensitivity of the results to key assumptions such as prices or the coefficients of degradation-impact effects (Table 1). Explicit attention to the factors below will help to produce more rigorous and policy-relevant cost-benefit analyses.

Problem assessment from a policy perspective

Those concerned with land quality problems often jump directly from the documentation of physical land degradation to proposals for direct intervention. But not all land degradation problems are equally important, particularly from a public policy perspective. The key question for policymakers is the extent to which degradation seriously compromises major policy objectives, such as agricultural supply, economic growth, welfare of the poor, long-term soil wealth, off-site economic effects, or environmental quality. Also, to design effective interventions requires a clear definition of the specific policy objectives to be addressed, the specific groups of farmers or communities responsible and why, and the specific geographic areas where policy-critical degradation is taking place.

Policy action in the form of direct land husbandry interventions may not even be the best solution to degradation-related problems. In some cases, land degradation is being encouraged by unfavorable input or output price policies, by land market distortions, by ill-considered regulations, or population changes. It may be more effective and less expensive to reform those policies than to fight an uphill battle encouraging farmers to invest in land quality when the economic environment discourages such action.

It may also be possible, and more cost-effective, to offset supply, income, welfare, or ecological effects by finding substitutes for the goods and services provided by the degrading area. For example, production losses may be compensated for by producing more intensively on other fields in the same farm, or farms in the neighboring area, or by purchasing cheap imports. It may prove cheaper to invest in water filtration systems downstream than in erosion control upstream.

In general, substitutability increases with the scale of the analysis; there are more options for nation-states than for individual farmers or communities. A substitution strategy needs to be considered from the perspective of different users or consumers. An import strategy may pose non-negligible costs. Additional risks of supply interruption, cost variability, etc. need to be assessed when considering the viability of a substitution strategy.

Future land quality requirements

While some land degradation may be socially and environmentally acceptable, policymakers must ensure that adequate resources are available to meet expected future direct and indirect use values (what economists call "option values"), to conserve resources for future generations ("bequest values"), or to preserve species or habitats based on moral, religious or aesthetic grounds ("existence values"). Thus, economic analysis of public land husbandry investments should ideally specify a minimum quality or value of soil resources, which would remain at the end of the period of analysis (called "terminal value" by economists). If policymakers deem it important to bequeath a large area of high quality soils to the next generation--either as a base for agricultural production or to preserve valued environmental resources—this must be built into the analysis of policy options. Such an assessment would not necessarily specify that all soils must maintain a certain standard (i.e., that no degradation may take place), but that some area be maintained at current quality, or some smaller area at higher quality.

Thus, policymakers may wish to act aggressively to preserve irrigated land quality in the Indian Punjab--ideally the breadbasket for all of South Asia for many generations yet to come—while tolerating high levels of degradation in low-quality drylands experiencing high levels of out-migration. Similarly, a high soil erosion rate on farms along the head-stream above a rare river ecosystem presents a more serious off-site problem than similar rates near abundant habitats.

It is unlikely that all of the world's soils currently under cultivation will constitute important resources for agricultural production 50-100 years in the future. While global population is predicted to increase 35 percent by 2020, reaching 7.7 billion people, growth rates are subsequently expected to slow down considerably and eventually stabilize by the end of the this century at 10-11 billion. While per capita agricultural land in developing countries is expected to decline from 0.3 hectare in 1990 to 0.1-0.2 hectare in 2050, spatial shifts in supply are certain to occur. Structural changes in global and national economies, trading patterns, infrastructure development, and settlement patterns may make some resources much more important than others. Technological breakthroughs may make some "problem" soils much more productive in the future, while

unforeseen events may contaminate soils that are most productive at present (Scherr, 1999). Evaluation of the future threat of degradation thus requires that we assess likely future trends in the broader economy and their implications for land management.

Land damage and recovery functions

The urgency of preventing degradation depends greatly upon the physical process of degradation (what economists call the "damage function") and potential reversibility of degraded attributes (the "recovery" function). Poor land husbandry can have quite different long-term effects on different types of soils, and costs of land returns to soil improvement can vary substantially, depending upon soil resilience and sensitivity. Tengberg and Stocking (1997) have undertaken some of the few empirical studies comparing rates of degradation on different types of soils under different management (examples in Figure 2). These graphs illustrate that the urgency to implement preventative measures for degradation will be much greater for Ferralsols under poor vegetative cover than for Luvisols under similar conditions.

Where soil degradation is reversible at low-to-moderate economic cost (relative to agricultural product prices and land values), even significant degradation may result in little long-term economic cost. If, however, degradation results in permanent reduction of the soil's productive potential, allowing degradation to continue is less likely to be economically justifiable.

What constitutes "irreversibility" is a matter of some debate. Only nutrient depletion and imbalance and surface sealing and crusting can be rapidly and relatively cheaply reversed. Many soil problems can be reversed over 5-10 years through soil-building processes and field or farm-scale investments and management changes. Some types of physical and chemical degradation, such as terrain deformation and salinization, are extremely difficult or costly to reverse[4] (Table 2). For many soil types, little is known about the thresholds for soil quality below which future investment in restoration is uneconomic.

Farmer response to degradation

Historical evidence suggests that linear extrapolations of current soil degradation trends are likely to be a poor guide to future soil quality. Farmers depend upon the land for their livelihood. It is uncommon for them to be unaware of serious soil degradation unless they are recent immigrants to a new agroecological zone, the process of degradation has not yet affected yields, or its cause is invisible (acidification, for example). We should therefore expect farmers themselves to respond to degradation with new land management or investment, as land scarcity or attractive economic opportunities raise the relative value of land. Trajectory 1 in Figure 3 reflects such a process of innovation, in which increasing pressure on soil resources
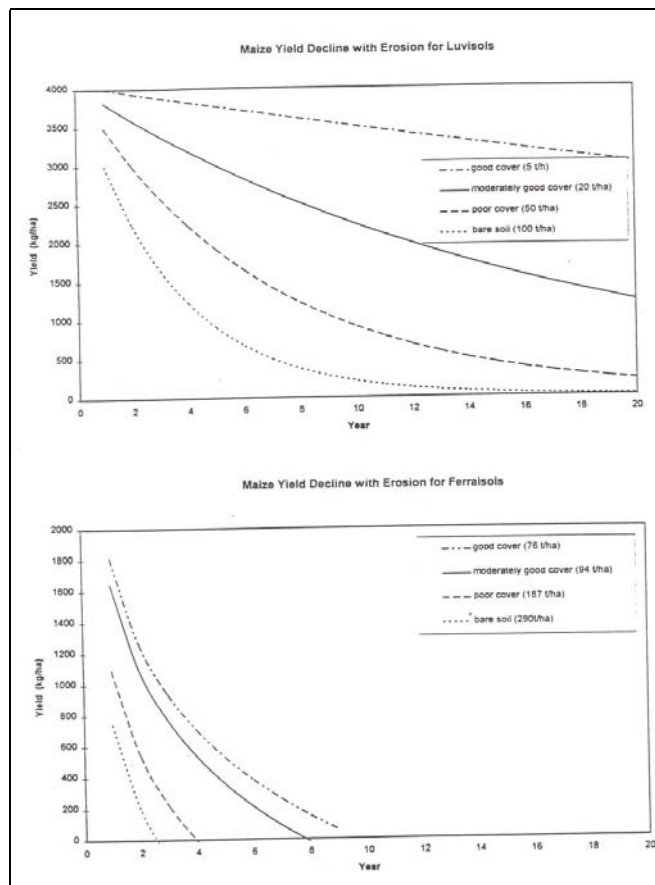
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[4]Of course, there is potential for recovery over very long time periods, even after severe degradation, although this is usually associated with significant habitat change, species mix, and productivity potential for agriculture.

Figure 2. Relationship between soil degradation and yields. Source: Tengberg and Stocking, 1998.

Table 2. Relative reversibility of soil degradation processes. Source: Scherr, 1999.

Type of Degradation	Degradation Process	Largely reversible, at low cost	Reversible, significant cost	Largely irreversible/ very hi cost
Physical	Clay pans, compaction zone		X	
	Surface sealing and crusting	X		
	Subsidence			X
	Topsoil loss through wind or water erosion		X (if active deposition)	X
	Terrain deformation (gully erosion, mass movement)			X
Water-Holding	Reduced infiltration/ impeded drainage		X	
	Reduced waterholding cap.		X	
	Waterlogging		X (farm)	X (landscape)
	Aridification		X	
Chemical	Organic matter loss		X	
	Nutrient depletion/leaching	X		
	Nutrient imbalance	X		
	Nutrient binding		X	
	Acidification		X (w/lime)	X
	Alkalinization/Salinization			X
	Dystrification			X
	Eutrophication		X	
Biological	Soil disturbance, over-work		X	
	From agrochemicals		X	
Pollution	Contamination		X	
	Pollution (accumulation of toxic substances)			

over time initially leads to soil degradation, but farmers eventually respond by improving soil management practices and making investments to restore, maintain, or even ultimately improve the soils' productive potential.

Of course, farmers may fail to take action (Trajectory 2) or delay taking action until significant, irreversible degradation has taken place (Trajectory 3). They may lack knowledge about effective means for soil improvement; or lack access to the farm resources, such as capital, labor, or inputs needed to make improvements. They may believe the economic contribution of the plot to their livelihood is marginal; expect low economic returns from available options for soil improvement[5]; or are uncertain about reaping the longer-term benefits of soil improvement due to tenure insecurity or price or climate risks. Under these conditions, targeted policy action is needed to slow or reverse soil degradation. Policy intervention may also be desirable to accelerate farmer response in situations where social benefits are greater than farmers' private benefits (Trajectory 4).

The trajectories of soil degradation and improvement vary considerably with differences in the soil resource base, demographic patterns, market integration, local institutions, and policy actions. Judicious use of public investment resources requires that we be able to predict when and how farmers will respond to degradation and intervention.
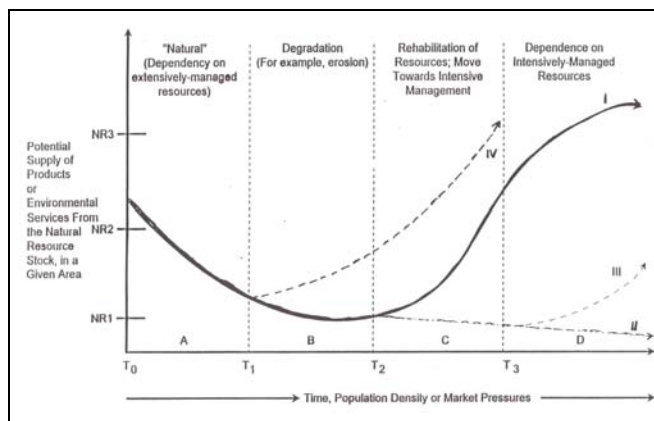

Figure 3. Innovation is soil resoureve management under population or market pressure. Source: Scherr et al., 1996.

Opportunities for capital conservation

The long-term decline in "natural capital" resulting from land degradation poses problems of intergenerational equity. Daly (1994) has proposed that the optimal way of liquidating inventories of nonrenewable natural capital is for the net gains of liquidation to be used to finance investments in a partial substitute, renewable natural capital stocks. Izac (1998) extends this analysis to consider non-renewable stocks of soil phosphorus and renewable stocks of soil nitrogen, and concludes that public cost-sharing plans to promote investment in soil organic matter and phosphorus enrichment are widely justified, particularly in Africa.

However, preventing degradation will not be, in all cases, the most desirable strategy for managing land resources. Farmers may "mine" the land (natural capital) over a period of time in order to accumulate alternative forms of more economically valuable capital (e.g., education, farm machinery), and in a later period re-invest the new forms of capital to rebuild soil resources (Figure 4). Land abandonment after prolonged soil degradation could serve to keep the land fallow long enough for it to recover key long-term productive attributes. Or the greater wealth may provide resources for land improvements or conservation not feasible with few assets.

This intentional reduction of "natural capital" in land over time and subsequent restoration, can be explained as an attempt by farmers to diversify their "capital portfolio". As development of technology, infrastructure, or markets (and, under some circumstances, population growth) increase, the relative return to investment in man-made capital over natural capital, resource depletion will occur as man-made capital is substituted for lower-return natural capital.[6] Once returns are equalized, both man-made and natural capital are accumulated. If labor and these forms of capital are complementary, the output effects outweigh the substitution effects in the long run, leading to net accumulation of natural as well as man-made capital as a result of technological or market development (Pender 1998). This strategy of resource degradation may be especially attractive to farmers without access to credit, or remunerative off-farm employment for the self-financing of investments, as these provide alternative mechanisms for accumulating man-made capital. When resources are renewable or easily substituted, this strategy may make sense from both private and public perspectives.

TOWARDS A POLICY DECISION MODEL

Keeping in mind the above considerations, I propose a relatively simple three-part model for policy decisions about combating land degradation. The first decision that needs to be made is whether or not the soil degradation problem is in fact significant from a policy perspective. If the answer is "Yes", the second decision regards the most appropriate way to address the problem, whether through land husbandry interventions or other strategies. If land husbandry intervention is the chosen strategy, the third decision is to choose the most appropriate approaches and timing to achieve specific policy objectives. Depending upon data availability, the decision model may be implemented as a simple checklist using qualitative data and analysis, a more complex process using quantitative data and qualitative rankings, or a quantitative bio-economic simulation model. Involvement of key stakeholders and decision-makers is essential in establishing the objectives and parameters of the analysis, regardless of the type of methodology used.

To illustrate the model, I will use the example of a micro-watershed in the sub-humid central hillsides of

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[5]For example, farmers who cease to undertake soil-protecting investments during prolonged periods of food prices may resume those practices when prices rise.

[6]Izac (1997) emphasizes that manufactured capital can never be a full substitute for natural capital.
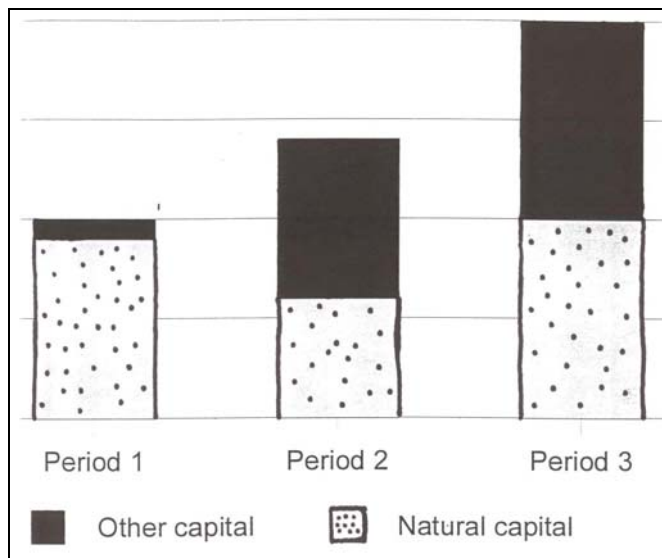
Figure 4. Conversion of natural capital (land(to other types of capital. Assumptions: 1) natural capital is diminished to finance an increase in manufactured capital, 2) degration of natural capital is at least partially reversible.

Honduras. Conditions in this micro-watershed reflect common hillside land degradation issues. Only 10% of land has less than 10% slope, 45% has 10-30% slope, and 45% is over 30% slope. Moderate and steep slopes are commonly used for cropping and grazing.

Research was undertaken in La Lima to document and explain patterns of change in land and resource management between 1975 and 1995. The research was designed to integrate socioeconomic and biophysical data, and track changes over time. Methods included: plot, farm, household and key informant surveys; geographic analysis of aerial photograph change over time, participatory mapping with local people, economic analysis of determinants and outcomes of change at various scales, enterprise budgets for different land management practices, and a linear programming model of the micro-watershed change 1975-95 integrating economic and ecological variables (Scherr, et al. 1999; Bergeron, et al. 1999). Available data permit semi-quantitative analysis of policy objectives and options in La Lima, but there are no data on program costs.

Decision 1: Is degradation of significant relevance?

The left half of Figure 5 illustrates the sequence of questions for Decision 1. This first involves assessment of the actual physical extent and severity of soil quality changes. To have meaning in a policy context, these assessments need to be linked to identifiable areas of land, producer groups, and/or habitats. This linkage permits evaluation of the relative threat of degradation to food security, market supply and prices, economic growth, and environmental quality. By pinpointing the nature of the policy problem, strategic objectives and targets for interventions can be defined. A complementary analysis is need to identify farming areas which are strategically important in the long run, for their option, bequest or existence values.
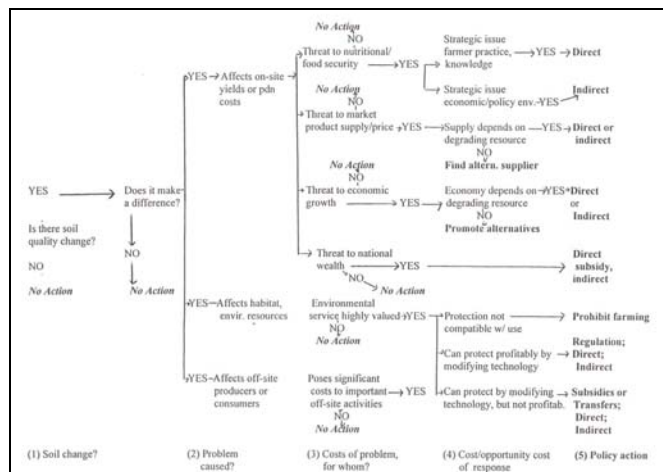

Figure 5. Decision model for policy response to soil degradation.

La Lima

Over the study period, farming in La Lima evolved from a semi-subsistence, mixed crop-livestock system using no external inputs, to a significant regional source of non-perishable and perishable vegetables, using improved varieties, external inputs, and sometimes sprinkler irrigation in improved, permanently cultivated plots called "labranzas". Fallow-based production of basic grains declined, as did livestock numbers and pasture management. While there was considerable deforestation and afforestation, and significant population increase, aggregate forest cover remained fairly stable.

In 1995, of all land in the micro-watershed, 3% was used for irrigated labranzas, 11% for non-irrigated labranzas, 18% for medium or long-cycle fallow agriculture, 1% for coffee, orchards and home gardens, 29% for pasture, and 37% was under forest. In 1995, perishable vegetable production accounted for a third of farm income. Most maize is grown in non-irrigated plots and half is sold, mostly to other households within La Lima. Average maize yields are a third higher than the national average, and on the more fertile plots with good inputs, yields are double. Maize yields range from 1000 to 2500 kg/ha; potatoes 10,500 to 23,300 kg/ha, and onions 2300 to 7600 kg/ha, a function of varieties used, inputs used and soil quality.

Farmers and researchers identified four principal types of land degradation:

1. Nutrient depletion was documented in labranza plots, resulting from very intensive cultivation (2-3 harvests/year), low organic nutrient applications (only 15% of farmers incorporate crop residues and 8% organic manure), and rising fertilizer prices leading to reduced fertilizer use. Problems were more common in maize, whose price did not justify as much fertilizer purchase, although average fertilizer applications in 1995 on non-irrigated labranzas was 80 kg of nitrogen. Over half of all households in the micro-watershed have access to some irrigated labranza, through ownership or sharecropping, and poor farmers, who can afford less fertilizer, are especially concerned. Also, the 5% landless and 35% near-landless households depend upon labranzas both as producers (sharecroppers), consumers

(through local purchases) and for employment in vegetable plots. Farmers reported that from 1975-95, and especially since the late 1980's, soil fertility had declined significantly on a quarter of non-irrigated labranzas surveyed.

2. Mass movements (landslides) are affecting labranzas along stream banks and steeper upland slopes.[7] Stream bank collapses are due to de-vegetation, abandonment of streamside tree planting practiced earlier, and more intensive, irrigated cultivation. While in 1975 70% of the length of the streams in the micro-watershed had forest cover, this proportion had dropped to only about 30% in 1995. Over half is in fallow or scrub vegetation, with moderate to poor vegetative cover, and 10% is in intensively managed annual crops or coffee. The collapses represent the loss of land with high productivity potential, and contribute to sedimentation.

Landslides on upper slopes are a longstanding problem, but they increasingly affect lands in use as labranzas as a result of more intensive cultivation, irrigation, and inappropriate siting of new plots. While half of the vulnerable plots of the upper slopes are kept in forest, and a quarter in pasture, a quarter are used as labranzas. About 17% of plots surveyed experienced landslides fairly regularly since 1975; this increased to 21% by 1993, but in 1995 (after a major rainfall event) landslides have caused farmers to abandon previously practiced ditch irrigation there. Sedimentation has also affected several small lakes valued for fishing, and habitats along the river and marshland.

3. Erosion from fallow lands and pastures on the upper slopes results from poor vegetative cover and lack of conservation measures. Although erosion rates are not high, nearly half of the land in the micro-watershed is at risk. Farmers concentrate their labor and resources on management of their intensive plots and in general do not manage these areas carefully.

4. Erosion also occurs on irrigated and non-irrigated labranzas, due to intensive cultivation with few conservation measures. Only 13% of plots had stonewalls, 5% tree or live barriers, and 11% used contour plowing. However, farmers reported rill erosion or serious gullying on only 7% of plots. This seems due to the mosaic arrangement of the landscape, and the interspersed presence of trees, forest, and grass.

Table 3 summarizes key indicators of economic and environmental impact used to assess the relative policy importance of these different types of land degradation. The two types of erosion would be considered of low policy priority. Although erosion on fallow lands and pastures was widespread, and there were food security impacts for poorer households who continue to practice some fallow-based cropping, it had minimal overall effects on agricultural

supply, household income, or long-term wealth in soil resources (unlike many other parts of Central Honduras). While these fields made a moderate contribution to sedimentation downstream, other sources of sedimentation—in particular the mass movements and the dense network of footpaths—were more important contributors. Erosion in labranzas was minimal, despite lack of intentional conservation measures, as soil and water flow were effectively controlled as a result of small plot size, use of vegetative barriers between plots, a mosaic landscape, and good vegetative cover by crops.

Mass movement was most important from a policy perspective, primarily because so much high quality

Table 3. La Lima: Is there significant and policy-relevant degradation? (Decision 1)

INDICATOR OF POLICY IMPORTANCE	Nutrient Depletion in Labranzas	Mass Movements on River Banks and Steep Slopes	Erosion in Fallowed Land & Unmanaged Pastures	Erosion in Labranzas
SCALE & SCOPE OF PROBLEM				
% total area in microwatershed affected	Low	Low	Moderate	Low
% of each land type affected	Moderate	High	Moderate	Low
% supply of basic grains from degrading lands	High	Moderate	Low	Moderate
% supply of vegetables from degrading lands	High	Moderate	Low	Moderate
% yield loss in basic grains on degraded plots	Moderate	High	Moderate	Low
% yield loss in vegetables on degraded plots	Moderate	High	Low	Low
% local income from degraded lands	High	Moderate	Low	High
% farm households affected	High	Low	Moderate	Moderate
% poor households affected	Moderate	Low	Moderate	Moderate
% best lands in micro-watershed affected	High	Moderate	Low	Low
% total sedimentation in microwatershed	--	Moderate	Moderate	Low
% riverbank and marsh habitat affected	--	High	Low	Low
IMPACT OF DEGRADATION ON:				
Vegetable supply	Moderate	Moderate	--	Moderate
Basic grains supply	Moderate	Moderate	Low	Moderate
Income/economic growth	Moderate	Moderate	Low	Low
Welfare of the poor	Moderate	Low	Moderate	Low
Long-term wealth	Low	Moderate	Low	Low
Environmental quality	Low	High	Moderate	Low
RISK OF IRREVERSIBLE DEGR.	Low	High	Low	Moderate
POLICY PRIORITY	Moderate	High	Low	Low

land is being affected, as well as important environmental resources, and the changes were irreversible. Nutrient depletion in labranzas is a moderate priority, as it affects a quarter of labranzas, and incomes and food security of many households including the poor. Although yield loss from degradation is moderate, and degradation is largely reversible, these fields account for a high proportion of basic grains and vegetable production in the micro-watershed.

Thus, the specific priority policy challenges—in relation to which all further assessments will be evaluated—are (a) to increase smallholder incomes and the supply of basic grains and vegetables, and; (b) to protect river habitats by reducing sedimentation from mass movements of labranzas.

Decision 2: Is the best policy response through land husbandry interventions?

Once priority land degradation problems have been

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[7] A third type of mass movement is found in one section of the micro-watershed, which local people call "the snake". Underlying geological formations have gaps, which are regularly settling, causing a slow but steady movement of the overlying soil down the slope (1/2-1 m/yr). This can be measured in the movement of fence posts from year to year.

identified, policymakers can consider a range of options to address those problems, which may not always be through direct land husbandry programs. For example, if the main policy-significant impact of degradation is chronic malnutrition among the poor, it may sometimes be cheaper and more effective to start a community-feeding program rather than a land rehabilitation program. Thus, the first option to assess is the feasibility and cost of finding substitutes for products and services from the degrading resource, which might offset the need for interventions in the degrading areas.

If substitution appears difficult or costly, the second group of options to consider are indirect policies which would influence the incentives and capacity of farmers to undertake land husbandry improvements on their own, without direct intervention by the state at farm or community level. Examples of these are taxes or subsidies of agricultural inputs or outputs, taxation of off-site damages, or market improvements to improve financial returns from agriculture. This approach is particularly attractive if the economic environment is such that farmers would be discouraged from participating in land husbandry programs.

The third option to consider is direct land husbandry interventions, such as land retirement programs; land use restrictions or regulations; credit, subsidies or cost-share for soil conservation technology; technical assistance; or education and research programs (Sanders, et al. 1995).

La Lima

Having decided that nutrient depletion in labranzas and mass movements in La Lima do result in policy-relevant problems, the next step is to assess possible policy approaches. A review of possible substitutes for the yield and income losses and environmental resources resulting from these types of degradation suggested few viable alternatives. A limited reversion from labranza to fallow-based cultivation is feasible. The 4% richest households have holdings over 30 hectares which could be rented, but over 60% of households have less than 3.5 hectares. This strategy would likely result in additional deforestation and acceleration of erosion concerns. A feasible substitute for cultivating along riverbanks and landslide-prone uplands might be to establish labranzas in other parts of the micro-watershed, although this is a fairly high-cost strategy, land is limited, and such action alone will not resolve riverbank degradation.

A limited number of indirect policy actions could be considered, mainly to reduce fertilizer prices, to improve the functioning of product and input markets in order to reduce input-output price ratios. These would make it more remunerative to farmers to use additional organic and inorganic nutrients. In the case of mass movement areas, however, improved income-earning opportunities without accompanying land husbandry interventions would likely exacerbate degradation problems, as farmers further intensify in these niches. Econometric analysis indicates that over the past 20 years, degradation has been associated with higher maize and onion prices.

The most promising strategy would be direct action in land husbandry for both problems, while improving organic nutrient markets in central Honduras hillsides. Feasible options for addressing nutrient depletion are: support for land-improving investments, development and dissemination of lower-cost, integrated nutrient management systems for basic grains and vegetables, and community organization for cooperative purchases of nutrient inputs. Options for controlling mass movements include: local adaptation and enforcement or rules regarding riverbank cultivation, siting of labranzas to avoid landslide-prone areas, establishing perennial vegetation to slow water movement and stabilize land to reduce landslide risk (ideally through cooperative and coordinated community efforts), and research to assess the sustainability of production in these niches.

Table 4. La Lima: Is the best response through land husbandry intervention? (Decision 2)

Policy Approaches	Nutrient depletion in labranzas	Mass movements
SUBSTITUTES FOR LOST OUTPUTS OR SERVICES?		
Alternative sources for basic grain supply	__% of farmers have enough land to fallow; Expand area under cultivation	---
Alternative sources for vegetable supply	No substitute	Other labranzas
Alternative income sources	Urban employment	Intensify cultivation at higher altitudes; Urban employment
Alternative ways to reduce sedimentation	---	Address problems of pathways, fallow erosion instead
Alternative sources of soil wealth	None	None
Alternative habitats, wetlands	--	None
INDIRECT POLICY OPTIONS?		
Modify farmer incentives	Reduce price ratio of fertilizers: crops (make nutrients affordable) Improve functioning of organic nutrient markets Improve fertilizer access	Increase input: output price ratios (make production uneconomic) None None
DIRECT LAND HUSBANDRY INTERVENTION		
Land use regulation	None (unrealistic)	Adapt and enforce prohibition of riverbank cultivation
Support land-improving investment	Organic nutrient build-up, phosphorus addition	Buffer strips, drainage, perennial vegetation
New technology, technical assistance	Lower-cost, integrated nutrient management	Research to assess sustainability of use
Community organization	Cooperative purchase or production of nutrients	Cooperative stabilization of riverbanks
MOST PROMISING STRATEGY	DIRECT ACTION (+ market development)	DIRECT ACTION

Decision 3: Is the most appropriate strategy prevention or restoration?

The right half of figure 5 presents the broad questions for Decision 3. The advantages of prevention (immediate action) relative to those of restoration (delayed action) are compared in relation to five key factors described below:

- Determination of the minimal extent of high quality land that needs to be maintained to meet the needs of future populations;
- The implications of the specific damage and recovery functions of each type of degradation for the decision to act or to wait;
- The likelihood of farmers resolving the degradation problems on their own before significant irreversible degradation occurs (in part a function of likely changes in the value of land);
- The potential benefits of accumulating man-made capital by converting (degrading) natural capital in land, and (finally);

- The relative discounted returns for different types of interventions and for each specific intervention implemented immediately or at a later point in time.[8]

La Lima

Land suitable for permanent cultivation of annual crops is limited in the micro-watershed by slope, soil depth, access to water, and soil depth and quality. Only 10% is currently being cropped. Population in the micro-watershed is not likely to decline, even with continued urbanization, as it is located along the peri-urban fringe of Honduras' capital city Tegucigalpa. The population may come to rely increasingly on non-agricultural income in the future, but this would likely be associated with consolidation of cropland by those who remain farmers and continued access to urban markets, and labranza land will still be valued. Thus, it is important to maintain at least a minimal nutrient content and nutrient-holding capacity for a majority of these plots. Given already advanced degradation of bottomlands and the scarcity of good agricultural land, policymakers should seek to protect most of the stream banks from mass movement, but only the most fertile parts of the upper slopes.

The expected increase in value of labranza and river bottom land over the next few decades, if vegetable markets and urban demand for land continue to grow, will itself stimulate farmers' interest and financial capacity to invest in nutrient management. Because of the short-term responses of soil to nutrient amendments, immediate action is economically justified in relation to organic nutrient market development, technical assistance, and local adaptation of integrated nutrient management systems, and further investment in labranzas in the form of organic matter improvement. Benefits from community organization are predicted to be relatively low, and market interventions to increase farm-gate prices will stimulate additional inorganic fertilizer purchase, but without technological improvements, organic nutrient management will be inadequate.

However, the current lack of community cooperation is likely to constrain effective planning by farmers to address mass movement problems. Early returns are likely to be positive for technical assistance, technology development, and community organization interventions. Returns to enforcing use restrictions will be lower, due to the loss of production income and the costs of enforcement. Investment in land improvements requires pre-existing technology and local organization to be effective, and should thus be delayed until those are in place.

To summarize, a responsible policy for La Lima at this time would be: to ignore the erosion in labranzas, which is minimal; to ignore the erosion problem in fallowed lands and unmanaged pastures, as having relatively low impact on policy objectives; but to address the high-impact problems of nutrient depletion and mass movements in riverbank and upland labranzas. The priority strategies for soil fertility improvement would be to promote integrated nutrient management technology through extension and investment in organic matter, and to begin to improve the function organic nutrient markets. The priority strategies to address mass movement would be to stimulate and technically support community organization for cooperative management of the problem.

Table 4. La Lima: Is the most appropriate strategy prevention or restoration? (Decision 3)

FACTORS IN TIMING OF INTERVENTION	Nutrient depletion in labranzas	Mass movements
(1) Future land quality requirements? (to establish terminal value for CBA)	At least half of land is needed [low % higher quality land, but also potential to re-build]	Most land needed
(2) Implications of damage & recovery functions for timing?	Okay to wait a few years	Not okay to wait a few years
(3) Likelihood of farmers resolving problem on their own before serious degradation?	Moderate	Low
(4) Potential benefits from conversion of natural capital to other forms of capital?	Minimal (capital accumulation much greater without degradation)	None (conversion not taking place)
(5) Cost-benefit analysis (preliminary, qualitative)?		
* Reduce fertilizer costs	Wait	--
* Organize organic nutrient markets	Begin now	--
* Technology adaptation	Begin now	Begin now
* Technical assistance	Begin now	Wait
* Community organization	Wait	Begin now
* Land improvements	Begin now	Wait
* Enforce use restrictions	--	Wait
* Market interventions to increase farmgate prices	Wait	Wait

CONCLUSIONS

The decision model described above may be applied at various scales and lends itself to consultative and participatory decision-making. For application at sub-regional, watershed or community scales, a decision-making or advisory group could be expected to provide a reasonably good quantitative grasp of the directions and magnitudes of the degradation threat, the viability of potential responses, and reasonable assessments of tradeoffs over time. The approach could be utilized in national or international decision-making about relative priorities (Decision 1), but probably not to guide program design, which requires assessment at a lower scale.

The quality of decision-making will depend on the quality of the underlying information base. Assessing policy impacts of land degradation poses a major challenge for our institutions of agriculture and resource monitoring (e.g., design of agriculture censuses and remote sensing). Degradation and its physical effects need to be measured using sampling frames and geographic units that can be linked directly with farmer characteristics, while estimating the contribution made by those units to total agricultural supply, income and environmental quality. International initiatives such as the Land Quality Indicator program and the Millenium Assessment of global ecosystems—which seek to overlay data on production, ecology, demography and degradation—are taking significant steps in this direction. The geo-referencing of national agricultural

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[8] This calculation would ideally incorporate the defined "terminal value" of land, reflect the damage and recovery functions in estimating each year's costs and benefits, and reflect farmers' incentives to "mine" land for capital accumulation by including this in the objective function. Use of a bioeconomic model would make it possible to incorporate changing incentives to farmers over time which result from changing land values or product prices (see Barbier and Bergeron 1998).

census data will also contribute essential information for policy-relevant impact assessments.

Other information essential for local and national decision-makers include damage and recovery functions for various types of degradation on key soil types. Greater investment in research is needed to understand the processes of soil quality change, how those changes translate into larger-scale economic and environmental impacts, and the likely response of farmers to proposed interventions. More reliable estimates of the costs and benefits of different types of land husbandry and indirect policy interventions are needed.

Implicit in the above discussion is the recognition that policy decisions related to land quality are not, and cannot be, completely "objective". The benefits and costs of preventive action will usually accrue to different actors than those of restoration. Weighting the stream of costs and benefits, discounting them over time, and valuing environmental benefits are all subjective decisions and thus quite rightly fall into the realm of the political process, rather than expert decision. Land management experts can play pivotal roles in this process by motivating and implementing data collection, analysis and education to accurately inform stakeholders and decision-makers about likely tradeoffs, and supporting an inclusive and participatory decision process.

In this paper, I have noted a number of circumstances under which I believe it is difficult to justify public investment in land improvement. My intention, however, has certainly not been to discourage public action to conserve our valuable land resources. On the contrary, I consider such action to be indispensable and of the highest priority for sustainable development, particularly in the tropics. Rather, I believe that rigorous identification and documentation of policy priorities, and rigorous assessment of policy options, are essential for mobilizing broad public support for land rehabilitation, as they result in targeting interventions where they will clearly provide significant and visible payoffs.

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