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SUSTAINABLE AGRICULTURAL DEVELOPMENT STRATEGIES IN FRAGILE LANDS

Sara J. Scherr and Peter B. R. Hazell

Environment and Production Technology Division

International Food Policy Research Institute
1200 Seventeenth Street, N.W.
Washington, D.C. 20036-3006 U.S.A.

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ABSTRACT

Current trends in demography, agricultural production and rural environment in the developing countries suggest that so-called "marginal lands" must play a larger and probably growing role in food supply and economic development for the foreseeable future. To fulfill this critical role, public policy towards these lands needs to be revised. A key policy focus should be to strengthen incentives for local land users to not only maintain, but to improve the natural resource base for food and fiber supply. Such "land-improving investments" are needed to reduce production and subsistence risks and permit more intensive use without degradation.

Under population and market pressure, one can expect an endogenous process of intensification, through land improvements, tenurial and institutional changes and "re-ordering" of the landscape. But this process is not automatic. Factors influencing the pace and scale of land transformation include: farmer knowledge of degradation of the degrading resource; incentives for long-term investment; capacity to mobilize resources for land investment; level of economic returns to such investment; and factors affecting the formation and function of local groups to help mobilize resources and coordinate landscape-level change. Current policies often work to constrain, rather than support, this process. New research is needed to support policy change for "marginal" lands.

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SUSTAINABLE AGRICULTURAL DEVELOPMENT STRATEGIES IN FRAGILE LANDS[*]

Sara J. Scherr[**] and Peter B. R. Hazell[***]

1. RE-VISITING THE DEVELOPMENT CHALLENGE FOR "MARGINAL LANDS"

The past 50 years saw dramatic increases in agricultural production in the tropics, to accommodate rising urban food and export demand and the consumption and livelihood needs of growing rural populations. This unprecedented growth in production has resulted from four phenomena: expansion of the agricultural frontier; declining use of fallow within settled agricultural systems; use of industrial farm inputs (chemical fertilizers, pesticides, tools and machinery), and improved plant seeds suitable for their use; and land-improving investments, particularly irrigation and drainage.

Most public policy and investment were oriented to better endowed agroecological areas with high agricultural potential. Policymakers and donor agencies at the national and international levels were attracted to these areas by their higher marginal returns to

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[**] Research Fellow, Environment and Production Technology Division, International Food Policy Research Institute.

[***] Director, Environment and Production Technology Division, International Food Policy Research Institute.

investments, by their relatively well-endowed infrastructure that facilitated the flow of modern inputs and the capacity of these areas to supply food to growing urban areas, and by the greater political clout (in terms of money, numbers, and organization) of farmers in these areas. (See Eicher and Staatz 1984 for a history of the evolution of development thinking.)

Despite the massive evidence of new settlement, the long-term development strategy for so-called "marginal lands" -- lands unsuitable for continuous tillage or lands where there were major constraints to economic use of industrial inputs -- was seen to be de-population through migration to economic growth centers in urban and high potential areas. In the short- and medium-term, "equity" concerns prompted a minimal level of investment in infrastructure, market development, and social services, and extension, but rarely at levels sufficient to generate sustainable growth in rural livelihoods.

This strategy can no longer be considered viable. Many of the high potential areas are now suffering from various forms of environmental stress (for example, waterlogging and salinization of irrigated land, fertilizer and pesticide contamination of water, increasing pest resistance and resurgence, soil erosion, and habitat loss) which, together with tapering yield potential (perhaps even declining potential - see Pingali et al. 1990), casts serious doubt on the ability of these areas to continue to meet growing food needs on a sustainable basis. Short of major biotechnology breakthroughs, many of today's marginal lands will be required to play an increasing role in meeting national food needs. This will be especially true in Sub-Saharan Africa, where the shares of high-potential and irrigated lands are much lower to begin with.

Population growth and poverty in many marginal lands has also reached the point where serious resource degradation is occurring. Until quite recently, natural resources were generally abundant in these areas, and damaged resources had time to recover (for example, the long fallows in shifting cultivation). Moreover, many of the more fragile lands were not even farmed in the past, or were only farmed extensively. Today, they must support moderate to high population densities, providing not only increasing amounts of basic foods, but also fuelwood, water, housing, etc. The resilience of these ecosystems is also suffering, particularly their ability to recover after stress events like droughts.

In the long term, migration and economic diversification will be needed to provide a better balance between people and natural resources in marginal areas, but current growth trends in population and non-farm employment are such that the absolute number of agriculturally dependent people will continue to grow in many of these regions for some decades yet. For all these reasons there is, therefore, an urgent need to increase the productivity of marginal lands, and to diversify the sources of rural livelihood of local populations.

We have learned many valuable policy lessons from promoting agricultural development in high potential areas. But there are likely to be significant differences in policy strategies, investment priorities and institutional arrangements in the fragile lands. In this paper we present a conceptual framework for considering sustainable agricultural development in fragile lands, focusing on incentives for maintenance and investment in the natural resource base (cropland soils, pastures, trees, local water systems).

The following section presents some empirical results from recent research which documents sustainable intensification processes in marginal lands. Section 3 discusses the key incentives which must be present for farmers to make investments in their resource base, and the common distortions of policies on those incentives. The concluding section highlights some of the major research questions for agricultural and natural resource economics.

2. GROWTH-ENVIRONMENT-LIVELIHOOD LINKAGES FOR SUSTAINABLE DEVELOPMENT IN FRAGILE LANDS: SOME EMPIRICAL EVIDENCE

The current debate about natural resource policy in agriculture has been triggered by widespread reports of land degradation, for example, rangeland degradation in Africa associated with the demise of tribal councils; soil erosion on sloping lands in Southeast Asia; and the extensive deforestation of agricultural landscapes in formerly forested parts of south Asia and Ethiopia. In many cases, public concerns have been raised mainly when the effects of degradation are felt in urban areas or regions of irrigated agriculture (for example, population movements or siltation of dams). Some forms of degradation, such as avalanches on steep slopes of the Himalayas or desertification in some of the African drylands, have been found through recent research to be due to unavoidable natural phenomena or climatic cycles, rather than induced by human action, yet still require some response.

THINKING ABOUT RESOURCE DEGRADATION

While we believe that large-scale land degradation is a very real phenomenon, its short- and long-term economic implications are less clear. Most of the resources used by the inhabitants of fragile, rainfed areas are renewable, and their degradation is not an inevitable consequence of agricultural development. Degradation typically occurs when people find it more profitable to manage resources in unsustainable than sustainable ways.

Not all resource degradation is bad. Conversion of forest to agriculture may be essential for achieving sustainable livelihoods for growing populations. If appropriately farmed, deforested land need not be degraded. Some forms of degradation are also reversible (for example, soil nutrient depletion), and it may sometimes be rational to "mine" resources for limited periods of time and then to reinvest in them at a later date. Some resources also have substitutes, so their degradation is not essential for sustainable development (for example, agroforestry can replace forests or communal woodlands as a source of fuelwood).

From an economic perspective, degradation must therefore be defined relative to the optimal use of a resource from a social or communal point of view, and it is bad only if it is excessive relative to that optimum. That is, we generally need to be concerned about socially "inappropriate" degradation, not with degradation per se. In some cases, "inappropriate" resource use may mean that insufficient new investment is occurring (for example, in planting new trees) compared to the socially desired levels.

From an ecological perspective, we also need to be concerned about the degradation of habitat for wild flora and fauna, as well as for human populations. It is possible for highly sustainable systems, from the perspective of human livelihoods, to be characterized by ecological conditions which radically alter habitats. Where habitat conversion is occurring over large areas, such as to threaten species viability, protection of biologically viable areas for habitat may be justified. In other cases, minor modifications in resource management (for example, the maintenance of patches of natural vegetation as a corridor for wildlife movement) can be integrated into land use systems to improve wildlife habitat

or other ecological features. In theory, if the "existence value" of species associated with threatened habitats is fully recognized and factored into the decisions of resource users, then socially "inappropriate" degradation will not occur. But this kind of full pricing rarely occurs, and some form of public regulation is generally needed to protect endangered species.

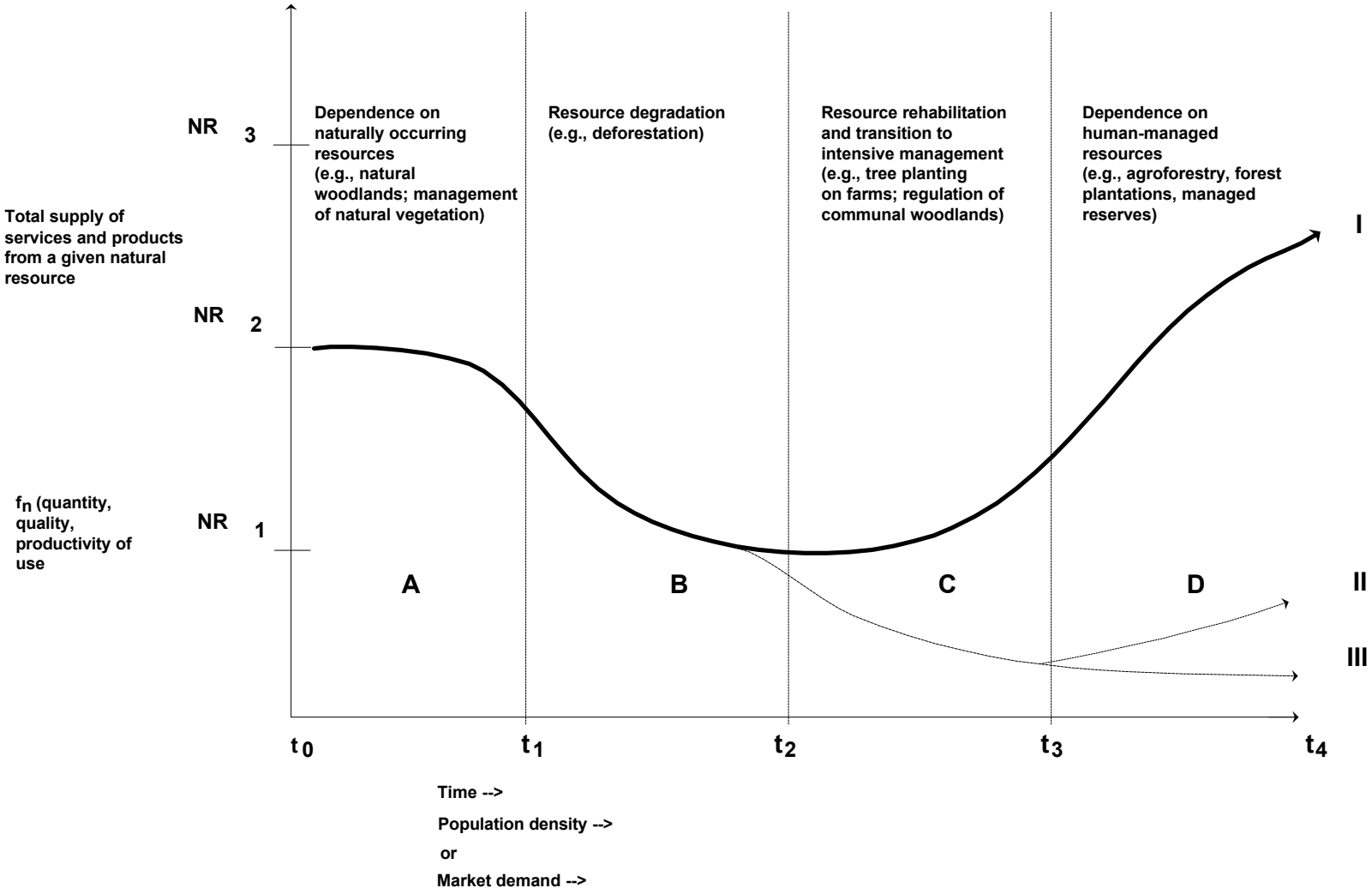
ENDOGENOUS PATTERNS OF TECHNICAL AND INSTITUTIONAL INNOVATION

Induced innovation theory (Boserup 1965; Ruttan and Hayami 1984) suggests that degradation may be self-correcting, as resource scarcity or rising private and/or social costs from degradation induce the development and use of new agricultural and resource management practices. Ruthenberg's (1980) classic study of "Farming Systems in the Tropics" summarizes a large literature documenting the agricultural innovations historically associated with increasing population density and increasing market integration in different agroecological zones. This evidence is particularly compelling in that most innovation was endogenous, or the process of informal borrowing and adaptation of technology between trading zones. Ruthenberg associates many of the technical changes in crop management, crops and landscape management explicitly with crises in soil management. Other work in induced innovation has documented similar evolution of farming systems in the areas of mechanization (Pingali, Bigot, and Binswanger 1987) and livestock management (McIntire, Bourzat, and Pingali 1992).

This literature is rather weaker in explaining the mechanisms by which these innovations developed, largely due to lack of documentation. Recent empirical research, however, has identified and described similar processes of largely endogenous intensification, and has attempted to identify the role played by different technical, institutional and policy factors. These suggest that rural land users are involved in dynamic adjustments to changing scarcity or degradation of natural resources, although the adjustment process takes some time, and may not begin on a large scale until degradation has reached an economically important level.

Figure 1 illustrates the nature of such changes. With increasing population or market pressure on a given natural resource, degradation begins to occur, reaching notable levels after t_1. Trajectory I represents the results predicted by induced innovation theory. As the value of the resource (or costs associated with its degradation) increases, returns to technical, institutional and other investments in the resource base begin to increase. After t_2, the benefits of resource investment become greater than the costs and resource rehabilitation begins to occur during period C. With continuing increases in productivity and other changes in resource utilization and investment patterns in period D, the population comes

Figure 1--Induced innovation in natural resource management



to depend primarily on resources which have been substantially modified by human management. The level of resource supply for human use (NR3) achieved after the period of innovation is higher than the initial level (NR2), though all the ecological services provided by the original resource configuration may not be maintained.

This model suggests that there may be a range of possible interpretations of resource degradation. If observations are made while the resource cycle is in period A, degradation is likely to be not yet economically important. In period B, significant economic costs are occurring, but the benefits to resource users of taking action for rehabilitation are not yet evident. During period C, there is still evidence of a degraded resource, but the benefits of rehabilitation have become attractive and innovation and investment are actively taking place to raise the total supply of products and services provided by the resource.

This expected pattern of resource degradation and rehabilitation will not always occur. A wide range of conditions may inhibit the innovative responses of periods C and D, resulting in the delay of rehabilitation efforts (trajectory II) or continued degradation (trajectory III). Such "inappropriate" degradation may occur where individuals cannot or do not optimize returns to their resources (for example, due to inadequate information) and/or because there is a divergence between private and social interests (for example, externalities or inappropriate public policies). Policy action to resolve these incentive problems can be a key to accelerating endogenous processes of transition into periods C and D. These factors will be further discussed in section 3.

Endogenous Agricultural Intensification in Machakos, Kenya

An example of this sequence can be seen in a recent case study in the semi-arid highlands of Kenya. This documented, through aerial photography and secondary data, the transformation of Machakos District since the 1930s (Mortimore and Tiffen 1993). The area had a high prevalence of soil erosion, pasture degradation and deforestation with very low agricultural productivity and income, and was considered at the time to be populated well above its carrying capacity. By 1990, however, population had increased five-fold, and the resource base had not only been rehabilitated, but the value of agricultural output per head (at constant prices) is estimated to be three times larger than it was then. This is despite considerable population movement into more marginal agricultural zones. There was widespread tree-growing; most agricultural land has been terraced; many new agricultural technologies were in use; and average income had gone up. The process of agricultural innovation was associated with innovations in local institutions and educational opportunities.

The authors attribute this largely endogenous transformation principally to local land use innovations, local institutional development, good roads, opportunities to grow high-value products for the nearby Nairobi market, and access to capital for land-related investments (terracing, tree-growing, live fencing, water harvesting, etc.) from off-farm income. The study emphasizes that land resource management was intimately tied to overall development processes.

Agroforestry Intensification in Western Kenya

Another case in Kenya illustrates historical changes in tree cover. The study was undertaken in two districts near Lake Victoria, a mid-altitude region where the climate was sub-humid, with poor soils. It traced the history of Luo farmers' use and management of tree resources since their early migration to Kenya, using archival materials, anthropological accounts, aerial photography, oral history, and household surveys (Scherr 1993). The author found that contrary to the perception by outsiders, that the Districts were suffering from extensive deforestation, in fact the tree cover in agricultural areas in the 1990s was significantly greater than earlier in this century.

The area in natural woodlands and woody fallows has been much reduced, due to land-clearing for settlement and agriculture. Farmers' tree-growing strategies have evolved together with the broader land use system. When practicing shifting cultivation and livestock herding in the 1600s and 1700s, farmers depended upon gathered tree products. The development of settled, fallow-based agriculture in the 1800s brought new uses for trees in crafts, fencing and land demarcation, and the domestication of valued indigenous fruit and timber species.

As farms were brought under permanent cultivation in the 1900s, and fallow areas began to disappear, tree protection and transplanting of wildlings became common. New commercial fruit and timber species were introduced, although these were planted in very low densities. With agricultural commercialization and intensification, and rapidly increasing population densities after the 1940s, tree product scarcity increased further and farmer treeplanting was widespread, especially for construction materials.

By the 1970s and 1980s, degradation of land resources in general had led to reduced crop yields and subsistence scarcities. Agroforestry strategies have been oriented to intensification, with most new trees being established in or around cropland, and the use of new species appropriate to intensive intercropping. With the rise of local and regional commercial markets for tree products, tree-growing has become a cash strategy for many farmers as well as a strategy for obtaining key subsistence products. The importance of trees in enhancing food security has grown, with the use of windbreaks, green manure, fruit production and mulch. At the same time, trees have offered a low-cost means of improving human habitat, through privacy hedges, shade and aesthetic plantings around homesteads.

Endogenous Change in Property Rights in Africa

A third recent study undertaken in ten agricultural regions of Ghana, Rwanda and Kenya documented the dynamic evolution of property rights over cropland with increasing population density and market integration (Migot-Adholla, et al. 1991; Place and Hazell 1993). As in much of Sub-Saharan Africa, full ownership rights over land traditionally reside with the community in the study regions, and individuals have a more restricted set of rights to use the land, exclude others from it, or transfer rights to it. A key issue is whether these restrictions on land rights limit farmers' incentives to make land-improving investments, including conservation measures, that only pay off in the longer term. The lack of full ownership rights, and hence the ability to mortgage land, may also constrain the availability of credit for land-improving investments.

Based on detailed farm surveys, land rights were found to vary widely from one location to another, and even across parcels operated by the same farmer. However, many

parcels (nearly two-thirds of the parcels at one site) were fully privatized, including the right to sell without permission from kin or village elders, indicating an important departure from the traditional tenure system. Privatized parcels were concentrated in areas with higher population density or greater commercialization of agriculture, or both, supporting the hypotheses that land rights evolve toward greater privatization in response to increased land scarcity (see also Cohen 1980; Boserup 1981; Noronha 1985; and Bruce 1988).

After controlling for differences in land quality and household characteristics, Place and Hazell found few significant relationships between land rights (including, in Kenya, the possession of a current land title) and the incidence of land-improving investments, the use of yield-enhancing inputs, or access to formal credit. Nor was the productivity of land found to be significantly affected by land rights. It would appear that, because land rights do evolve in response to increasing land scarcity, then there are other more binding constraints on agricultural productivity, such as lack of improved technology or inadequate access to credit.

The study provides little support for ambitious land registration and titling programs in the kinds of regions that were studied, at least not until other more binding constraints on agricultural development have been overcome. But there are circumstances when titling might be worthwhile: for example,

- When the indigenous tenure systems are absent or very weak. This is frequently the case in land settlement areas, but it can also arise elsewhere following periods of major economic or political upheaval, particularly if traditional lines of authority have been severed.

- In areas where the incidence of land disputes is high. This may occur in areas where large numbers of migrants or strangers have settled and established rival claims to land owned by indigenous peoples.
- Where major project interventions are planned that either require full privatization of land rights for their success, or are likely to weaken the land rights of some vulnerable groups. Some irrigation and tree crop projects provide good examples.

OPPORTUNITIES FOR DEVELOPMENT IN MARGINAL LANDS

These cases counter still widely-held development models which place the principal impetus for rural economic and institutional change in external interventions. They attest to a high degree of adaptability in farming communities, which have generated radical land use changes over a time scale of only a few generations. They also illustrate a capacity for land and natural resource rehabilitation in degraded areas, even with increased populations. The resulting landscapes, ecology and biological species mix do differ markedly from earlier periods.

What role did public policies play in these "success" stories of intensification? In Machakos and western Kenya, outside agents introduced new crop and tree species, acting mainly to accelerate already on-going processes of land use intensification. Economic growth outside the region, together with improvements in communications, created opportunities for rural households in these "marginal areas" to accumulate capital for land investment through off-farm employment or sale of higher-value products. Local farmers' groups were instrumental in mobilizing capital and labor for small-scale farm investment, marketing and land rehabilitation. NGOs and some government agencies were able to work with these groups to enhance their effectiveness. Income diversification strategies

were actively pursued for both agricultural and non-agricultural income, and in the evolution of property rights which provided access to a range of land types.

It also appears that the policy context contributed to effective adaptation. In Machakos, this took the form of infrastructure investment, economic linkages of urban development, and various programs which supported local capital accumulation. In western Kenya, better access to selected tree germplasm and technical information, encouraged agroforestry, particularly under conditions of weak agricultural prices and limited income diversification opportunities. In the case of land tenure change, the principal contribution of government seems to have been one of limited intervention. Where governments did intervene, they did so in ways that threatened to undermine the indigenous tenure systems (for example, by nationalizing land in Ghana and Rwanda). Fortunately, although laws were enacted, they were not enforced in rural areas.

LIVELIHOOD STRATEGIES ADAPTED TO FRAGILE LANDS

This evidence and others like it (see, for example, Conroy and Livinoff 1988; Chambers et al. 1989) suggest that there are real potentials for growth, resource conservation and enrichment, and rural livelihood security in what are now considered "marginal lands." This should not be taken to mean that the problem of marginal lands development will take care of itself. Numerous economic conditions and policies can create disincentives for farmer investment in marginal lands. It remains an open question even in the cases cited above, whether the necessary innovation and investment can continue to take place without significant declines in average household consumption.

The evidence suggests some common strategies, which differ in important ways from the agricultural development strategies which have found success in high potential

areas. From a technical perspective, intensive monocultures of annual crops are not likely to be viable in the long-term. Rather, more diverse cropping systems appear to be more stable. Key elements will be the integration of perennial plants which provide continuous ground cover (grasses or creeping legumes), canopy cover (tree crops, agroforestry mixtures), or live barriers (contour hedgerows) to protect fragile soils. Other strategies will be more efficient and reliable under harvesting and integration of livestock and green manures into farming systems to maintain soil fertility. (See, for example, Altieri 1989 and Gliessman 1990 for reviews of the scientific foundations of regenerative agriculture; useful reviews and syntheses for applied work my be found in the ILEIA Newsletter series 1985 to present.)

High within- and between-field diversity in biophysical conditions calls for more micro-site specific land and water investments. Overall, land investments to improve response to more intensive inputs are a critical element. The chronic lack of capital calls for more divisible types of investments and incremental approaches to land improvements. Reliable non-agricultural sources of income will be a critical component of stable livelihood systems for most farmers. However, because agricultural growth is the prime driving force behind the rural non-farm economy (Haggblade, Hammer, and Hazell 1991), interregional migration and remittances are likely to provide the most important sources of non-farm income for many marginal areas, at least during the initial stages of regional economic development.

From an institutional perspective, development strategies are constrained by the almost definitional marginality of the zones. The institutional presence of many national agencies is likely to remain limited relative to high-potential areas, so that development efforts must rely more heavily on local and regional action. Because of this, national

agencies may need to modify their agenda, so that their more limited resources are used more strategically, rather than simply to provide an inadequate level of conventional services. At the same time, more effective political integration of fragile lands populations is essential to command a more reasonable share of national investment resources, and possibly more importantly, to orient policies for urban and high-potential areas in ways that provide the most effective development linkages for fragile lands.

3. INCENTIVES FOR FARMER INVESTMENT IN NATURAL RESOURCES

As indicated earlier, understanding and appropriately modifying household and community-level incentives to reduce the socially inappropriate degradation of resources will often be the key to achieving necessary investments in natural resources for sustainable agricultural development. Table 1 summarizes key types of incentives, along with the common disincentives which prevent or slow down the necessary adaptation to more sustainable farming systems, and some policy approaches which can be used to address them.

KNOWLEDGE

Some forms of resource degradation are easily observed (for example, deforestation), but some are only visible after long periods of time (for example, loss of soil fertility) or at sites removed from the source of damage (for example, river pollution or destruction of beneficial species).

Farmers and other users of natural resources may, therefore, be poorly informed about the damage that they cause, even when they have to bear the costs themselves. Lack of knowledge may be a particularly important constraint under conditions of recent settlement, where settlers are unfamiliar with the environment, or during periods of rapid land use change. In social systems with weak communications links and infrastructure, new information about effective resource

Table 1--Incentive structure for farmer investment in natural resources for production

	Necessary Incentives	Disincentives due to:	Intervention Approaches	
Knowledge	1) Farmer knowledge of investment needs or options to reverse resource degradation ○	Recent settlement in ecozone	Improve design of settlement programs	○
		Rapid pace of land use change	Research on new technology	●
		Poor information exchange	Improve inter-farmer communications	○
		Failure to perceive environmental externalities and effects	Extension re: options	○
			Environmental Education	
Economic Importance of Resource	2) Farming plays an economically important role in household livelihood	Off-farm business interests	Land taxes to encourage tenancy or sale	♣
		Small farm size leading to dependence on wage labor	Interventions in labor markets	♣
	3) Degraded resource plays an economically important role in farm production system	Allocation of resources to higher productivity, non-degrade plots	Land management requirements	♣
			Taxes on degraded lands	♣
Willingness to Invest Long-Term	4) Long-term horizons	Acute subsistence insecurity	Food aid, social security	♣/○
		Unusual short-term profit opportunities from resource mining	Price stabilization	♣
	5) Security of future investment return	Limited land or water rights	Property rights reform	♣
		Temporary settlement	Incentives for permanent settlement	♣
		High production risks	Technology to reduce risks	●
			Insurance for productions risk	○
Capacity and Mobilize Resources	6) Sufficient inputs for investment	Lack of labor	Incremental land use charges	●
		Lack of cash	Improve infrastructure to reduce input costs	♣/○
		Lumpiness of in investment		
		Lack of planting materials	Improve input and credit markets	♣
		Lack of equipment or tools	Economic linkages with urban and agricultural regions	♣
			Organization to mobilize local resources	○

(continued)

Table 1 (continued)

	Necessary Incentives	Disincentives due to:	Intervention Approaches	
	7) Flexibility in resource management	Land use restrictions or requirements	Regulatory reform	♣
			Reduce costs of compliance and transactions	♣
Economic Incentives	8) Attractive returns to resource investments	Low productivity technology	Technology improvement	○
		Artificially low product prices	Maintain competitive agricultural prices	♣
		Low financial value of natural vegetation	Substitute perennials with marketable products	●
		Subsidized alternatives for resources (for example, water, chemicals, national forest timber)	Reduce subsidies	♣
			Improve infrastructure and institutional support for markets	♣
Institutional Support	9) Group action to invest or benefit from investment or organize land use to attain environmental aims (for example, local credit coops, taxing authorities)	High transaction costs	External inputs to reduce transaction costs (for example, NGOs)	○
		Regulatory obstacles on local organizations	Loosen controls on local organization	○
		Weak institutional development	Catalyze and support local institutions	○
		Unequal effects of externalities or costs of group action		
		Inadequate information on activities and environmental effects or options	Support local and regional resource planning and conflict resolution	○

● Technical interventions
○ Institutional interventions
♣ Policy interventions

management strategies (whether originating on farms, research centers, or elsewhere) may be slow in diffusing to other areas.

Where knowledge is a critical constraint to farmer investment, policy interventions may include research, improvement of communication networks, information transfer or environmental education.

ECONOMIC IMPORTANCE OF THE RESOURCE

Farmers' incentives to invest in maintenance or improvement of the natural resource base will be critically affected by the economic importance of that resource to their livelihood. Degradation of resources considered of marginal economic importance is not likely to be a concern, much less a priority. If, due to externalities, the degradation is important to other groups, use of subsidies or other external incentives may be needed to encourage investment. Regulations may also be used, but without a supportive incentive structure, may be difficult or costly to enforce.

Importance of Farming

Farmers will invest in the resource underpinning agriculture only if farming is a critical part of their livelihood strategy. Research in fragile agricultural areas consistently shows the importance of non-farm and off-farm income sources to livelihood security. In Niger, for example, 60% of average farm household income in the Sudano-Sahelian and 51% in the Sudano-Guinean zones derived from non-farming activities (Hopkins 1993, pp. 105-111). An investment in tree-growing, soil improvement, water harvesting, etc.

would have to compete in terms of returns to household labor and/or cash with alternative artesanal, trade or wage activities. In Central America, largeholders may hold land for speculative or social purposes, while depending for income on urban activities; resource degradation would present little economic cost.

Importance of the Degraded Resource

Even where farmers are dependent for livelihoods primarily upon farmland, they may take a strategic approach to land investment. Higher quality or nearby plots may be selected for high investment in soil amendments, trees, terracing, etc., while a deliberate decision is made to allow (or even actively manage) resource degradation in other plots. Thus farmers have been reported to accelerate soil erosion in steep, difficult to work plots, to accumulate soil in flatter plots below. Organic residues may be collected from far plots for concentration in near plots, as in Nigerian homegardens.

Policy interventions to influence these trade-offs may be tricky, involving difficult-to-implement instruments such as land taxes, land management requirements and interventions in labor markets.

WILLINGNESS TO INVEST FOR THE LONG-TERM

Investments are by definition long-term activities. Farmers will only make those investments where they have a long-term perspective and feel confident they will receive expected benefits.

Subsistence Security

There is evidence that much rural resource degradation is associated with conditions of acute livelihood insecurity. Famine, war or economic crises, which disrupt normal food and income sources, may force farmers to adopt very short-term strategies, intensively harvesting food, fodder or saleable products from natural fauna or flora in a manner which depletes or seriously erodes the resource (for example, felling of trees for charcoal, accelerated soil erosion due to removal of vegetative cover from cropfields by over-grazing). The very poor and landless may depend upon such strategies for their livelihood even in good agricultural years. Development strategies are needed which offer some 'insurance' against disaster, and strengthen alternative income sources to supplement or replace agriculture (for example, public employment programs).

Certainty of Future Returns

Farmers may have a long-term planning horizon, yet face high uncertainty as to whether long-term benefits will actually materialize. Where unusual short-term profit opportunities, involving resource depletion, arise (for example, sharp and temporary increases in prices of agricultural or gathered products), farmers may decide that current

opportunities are not worth sacrificing for future production which may receive much lower prices.

Farmers may also be influenced by the high risk agricultural environment prevalent in most fragile lands. Even where investments in the natural resource base raise the long-term average income, they may not reduce high variability in income unless accompanied by other complementary investments. The risk of facing several bad agricultural years immediately following a major investment, may (with discounting) result in negative expected returns, even if returns in later years are very attractive. This highlights the importance of land improvements to reduce risk and variability.

Secure Property Rights

If farmers do not have assured and long-term access to the resources they use, they may not bear the full cost of resource degradation, nor are they confident of receiving the benefits associated with investment in sustainable resource management. Under these circumstances, they are more likely to pursue unsustainable practices. This may result from lack of clear allocation of rights over resources (whether to individuals or groups), rental or other arrangements which reduce long-term interest in resource condition, or from migration patterns which result in only temporary settlement in a particular site. In extreme cases, for example, open access areas, a "mining" mentality can arise. Resolution of these problems may require the reform or regularization of property rights, including land tenure, access to communal resources, and resolution of land use conflicts.

CAPACITY TO MOBILIZE RESOURCES

Farmers may have knowledge, the resource may be important and they may be willing to invest over the long-term, but they may still be constrained by management factors and the capacity to mobilize resources for investment.

Sufficient Inputs for Investment

Most important, farmers need access to the inputs required for investment, namely labor, cash, planting materials, tools, etc. Land and water investments require mobilization of resources and are often "lumpy." Credit markets are typically very weak in fragile land areas, and the higher risks associated with crop production further limit the willingness of creditors to lend for long-term investment. Inadequate property rights may also constrain the supply of credit.

Several different policy interventions have been used to address this issue. Types of land use changes may be promoted which are easily divisible and can be encouraged incrementally. (for example, tree-planting). Improved infrastructure and markets may reduce input prices, transaction costs, etc. Strengthening non-agricultural sources of income and improving access to temporary labor migration may permit accumulation of investment resources, as may local innovations to mobilize resources, such as rotating credit.

Flexibility in Resource Management

Because of the complexity of livelihood strategies and high variability, it is essential that farmers have a great deal of flexibility in farm management. Considerable research indicates the high farm costs associated with inflexible management rules and regulations for soil conservation, tree management, etc. While some regulation may be necessary, as part of natural resource management policy, these should be designed flexibly, be focused on outcomes (for example, in terms of soil loss or ground cover) rather than activities (for example, so much land terraced), and with low transaction costs.

ECONOMIC INCENTIVES

An obviously critical incentive for farmers to invest in long-term land improvement in fragile lands is that returns from those investments must be economically attractive. Much current resource degradation can be attributed to poor economic returns associated with land conservation investments. In some cases, this reflects real long-term opportunity costs, but in many others it reflects short-term technological constraints, externalities and other market failures, or policy distortions.

Appropriate Technology

Poorly designed, or inappropriately used agricultural, livestock and forestry technologies can lead farmers to increase production in ways that degrade natural resources. Better technologies and management practices may be available, but may be more costly, lower yielding or knowledge demanding, and hence less likely to be adopted by farmers. There is considerable scope for developing more appropriate technologies

(i.e., those which are lower-cost and higher-return for small-scale managers as well as environmentally friendly) and for policy interventions and farmer training programs that promote greater complementarity in technology use between agricultural productivity and sustainable resource management. External interventions should be designed to catalyze and support, rather than replace, local technical innovation.

Supportive Economic Policy

Government pricing and investment policies have significant effects on the incentives and opportunities available to farmers in making choices about technology and land use patterns. Government interventions can be environmentally destructive, for example, subsidies which encourage excessive use of agrochemicals or scarce water or timber resources. Chronically suppressed crop, livestock and forest product prices can create conditions in which farmers have little incentive to invest in the natural resource base for agriculture. Alternatively, policies can be used to create or reinforce positive incentives for sustainable natural resource management, for example, subsidies for integrated pest management and erosion control programs or infrastructure which reduces costs of interregional economic linkages.

LOCAL INSTITUTIONAL SUPPORT

Because of the bulkiness and indivisibility of some natural resource investments, or the need for coordination among producers in undertaking investments, access by farmers to organizational support beyond the household can often be critical to farmer investment

capacity. Institutions may include local organizations, such as self-help groups or community credit cooperatives; local government which can mobilize resources for community-scale investments (for example, through taxes) or regulate resource conservation and use; or local offices of state or national public or private organizations (for example, NGOs or farmer cooperatives) which can respond to local needs.

Developed Institutional Support

Weak institutional development may, in some cases, explain farmers' failure to undertake key natural resource-conserving or improving investments, even where these would be attractive to the farmers. Constraints include high transaction costs where communication is poor or population densities are low. Government regulations may restrict the formation of local groups, for political reasons, or burden fledgling organizations with complex reporting or budget rules. In areas of recent settlement, high in-migration or active labor migration, it may be difficult to form cohesive groups for action.

Also important are improvements in basic government institutions and services, which have the advantage of relative permanence. A critical feature of institutional strengthening, however, is to orient public institutions to provide services to local institutions and encourage local initiative, rather than attempt to substitute for them in activities for which local organization is more efficient.

Internalizing Externalities

Constraints to group action often arise when the costs of environmental degradation are borne off-farm (for example, pollution of rivers and groundwater, soil runoff, destruction of beneficial species), or when benefits of resource investment are freely enjoyed by non-investors (for example, protection from a community shelterbelt). These "externality" problems can undermine incentives to use more sustainable technologies and management practices, even when available.

Use of taxes, subsidies or government-imposed regulations to correct for market failures is unlikely to be practical. To overcome these constraints may require improved organization of farmers and rural communities--sometimes by strengthening indigenous or formal institutions, sometimes by promoting new institutions. Policies can be devised to enhance the functioning of local organizations, by reducing transaction costs, loosening controls, training and other support for young organizations, and technical support for local and regional resource planning and conflict resolution (Savenije and Huijsman 1991).

4. RESEARCH ISSUES FOR FRAGILE LAND DEVELOPMENT POLICY

It is not likely that a "magic formula" will emerge for sustainable development in fragile lands. This is a long-term investment challenge, one which must also be complemented by supportive demographic policies. Solutions will also have to be site-specific given the diverse agroecological and social conditions found across fragile lands. As the discussion above makes clear, however, current policies frequently contribute to problems of degradation, and pose constraints even to farmers and other resource users who are willing to work for resource conservation and enrichment. The first order of business is to identify those conditions, and explore practical policy alternatives.

Some key topics call for research attention (for a more extensive treatment of research needs, see Winpenny 1990, and Vosti et al. 1991). In most fragile areas, policymakers need a clearer identification of who the principal resource users are, and what their actual (as opposed to theoretical) incentives are for investment and disinvestment in important natural resources. There is still relatively little known about farmers' and community perceptions of resource degradation, their understanding of the ecological processes involved when production systems change, or their strategies of adapting to degradation. Policymakers also need empirical evidence of the costs of resource degradation at the farm, community and regional levels, and realistic estimates of the costs and benefits of resource rehabilitation, for different actors.

Current debates about the efficacy of "low external input agriculture" would benefit greatly from economic studies indicating the market, geographic and productivity conditions under which low external input systems are the most realistic and promising options, either in the short or long term.

Research is needed to understand endogenous processes of technical and institutional innovation, in the face of rising resource degradation, population, and market pressures. A key objective of such research would be to identify policies which would strengthen or accelerate these endogenous processes.

There is a need to understand the economics of institutional formation and operation in the area of natural resource management, from group-managed woodlands, to group-managed investments. Action research could usefully be pursued in the area of institutional development for new types of responsibilities or functions (for example, improved systems of insurance for high-risk areas (Hazell 1992). Of particular interest are viable institutional arrangements to support decentralized technology development.

We need to know much more about inter-sectoral, inter-regional and macro-level effects on processes of development in fragile and marginal lands. It is time to re-examine our understanding of critical growth linkages, now from the perspective of fragile lands development, and with a realistic assessment of the effects of risk and livelihood insecurity, and farmers' strategies for dealing with them. Such analysis should help policymakers from those regions make better decisions about allocating available public investment resources within the region. We also need to understand more clearly how different types of investments made in urban or high-potential agricultural areas affect

natural resource management in the fragile lands, and consider policy options which will have more positive effects on livelihoods and resources in those lands.

Finally, we need to know much more about the political economy of control and decisionmaking of natural resources in fragile lands. Issues of resource access remain critical to the livelihoods of the poor and a primary area for policy action.

To answer these questions, policy researchers will find it useful to draw upon the insights and empirical findings not only of economics, but also of other disciplines which have examined resource management and intensification, such as agricultural history, geography, anthropology, and human ecology.

Fragile lands development in the tropics -- for sustainable livelihoods, without ecological disaster--will be one of the prime challenges of the next century. The agricultural economics profession should be able to contribute significantly to this objective, through a major empirical research effort on patterns of resource degradation and enrichment, through documentation and analysis of the "success" stories, through rigorous analysis of incentive issues at the farm and community levels, and by reiterating the value of policies which facilitate and support dynamic adaptation at the local level, rather than impose external solutions by fiat.

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