# Economics and Soil Conservation on Sloping Lands: Nine Hypotheses for MSEC Project Implementation and Research

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## Abstract

*While the basic physical processes behind land degradation are reasonably well understood and technologies for their arrest have been developed, the area of severely degraded land continues to expand. Part of the explanation for this unfortunate outcome may lie in the fact that the socio-economic factors which drive farmers' conservation decisions are often overlooked when degradation control measures are developed and implemented at the farm level. This paper attempts to highlight the role of socio-economic systems and institutions in producing and controlling land degradation. In the discussion, the concept of economically "optimal" degradation levels is introduced and a simple model of the farm level economics of land conservation is provided. The model is then utilized to develop nine hypotheses relating socio-economic conditions to farmers' decisions to adopt various land conservation strategies. These hypotheses are intended to serve as a departure point for the Management of Soil Erosion Consortium (MSEC) in its efforts to broaden the use of socio-economic analysis in its soil conservation research and implementation agenda.*

## Introduction

Land degradation has been defined as "the substantial decrease in either or both of an area's biological productivity or usefulness due to human interference" (Johnson and Lewis 1995, 2). While there is uncertainty as to the exact magnitude of the land degradation phenomena at the global scale (Swallow *et al.*, 2002), it is clear that degradation affects a significant portion of the earth's surface and that its costs can be substantial both to individual farmers and whole societies (Eswaran *et al.*, 2001). Furthermore, there is evidence that the social dimension of these costs may be especially high in certain tropical developing countries (Stocking, 1984; Lal, 1990; Barbier and Bishop, 1995; Bojö, 1996; Enters, 2000). While the basic physical processes behind land degradation are reasonably well understood and technologies for their arrest have been developed, the area of severely degraded land continues to expand (Oldeman *et al.*, 1990). Part of the explanation for this unfortunate outcome may lie in the fact that the socio-economic factors behind which individual farmers make land conservation decisions are often overlooked when land conservation measures are developed and implemented at the farm level.

The Management of Soil Erosion Consortium (MSEC) of the Consultative Group on International Agricultural Research has as a primary objective the development of community-

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based land management practices to arrest soil degradation. The consortium consists of six member countries including Indonesia, Laos, Malaysia, the Philippines, Thailand, and Vietnam. The first phases of MSEC work focused on the development of land conservation strategies for a variety of environmental and economic settings, but especially to areas with steep elevation. The next stage of the work will focus on the dissemination and uptake of the accumulated knowledge and understanding. Recognizing that socio-economic factors will play a significant role in this endeavor, MSEC is incorporating economic research into its work plan and strategies. This paper provides some concepts for using socio-economic theory and data to assist MSEC in its endeavor.

To do this, the paper first uses economic theory to provide insights into the costs and benefits of land conservation and presents the concept of "optimal" degradation. It then argues that current land conservation investment, whether from the perspective of individual farmers or society as a whole, is likely to be sub-optimal, in particular on the marginal lands of poor farmers in developing countries, the areas of most interest to MSEC members. A simple model of farmer investment in land conservation is then provided and employed to develop hypotheses which MSEC and others can use to create and target farm-scale land remediation strategies and which can serve as a basis for future research.

## The Political Economy of Land Degradation

The term land degradation is typically considered to consist of soil erosion, the "physical loss of topsoil, reduction in rooting depth, removal of plant nutrients, and loss of water" (Lal 1990, 9), and loss of soil fertility. Soil erosion is the more easily quantifiable, and therefore more often studied, component of land degradation, but fertility decline may be as important, at least in developing countries (Drechsel and Gyiele, 1999; Eswaran *et al.*, 2000). At its most fundamental level, land degradation is caused when natural physical factors such as wind, rain, and gravity combine with human management practices to remove soil or its nutrients from a given site. While land degradation could be considered "natural" in some senses, it is human involvement which typically results in rates of decline of social concern at human time scales and drives the working definition given in the opening paragraph. Of the range of human actions associated with land degradation, the most important have been listed as deforestation and removal of natural vegetation, overgrazing, and poor agricultural practices (Oldeman *et al.*, 1991). The fundamental human role in land degradation is now relatively well understood, at least conceptually, and there is probably also near consensus that research to remedy land degradation must include a social component. This idea was exemplified by Miller who stated, "...curtailing soil and land degradation rests as much, if not more, in the realm of social sciences as in the natural or physical sciences" (1998, 15).

Unfortunately, an understanding of the interconnection between land degradation and land use practices has not always meant that social science has been effectively used to improve land conservation. Instead, many land conservation programs, especially in the developing world, have tended to emphasize technical solutions, such as terracing or ditch construction (Barbier, 1990; Lutz *et al.*, 1994; World Bank, 1994; Current *et al.*, 1995; Barbier 1999), rather than the economic factors, such as profitability, which drive farmers' decisions to employ degradation-reducing technologies and strategies. Even less emphasis has been put on the more fundamental factors such as poverty, legal institutions, and the national policy environment which can be seen, in some senses, as the ultimate causes of land degradation.

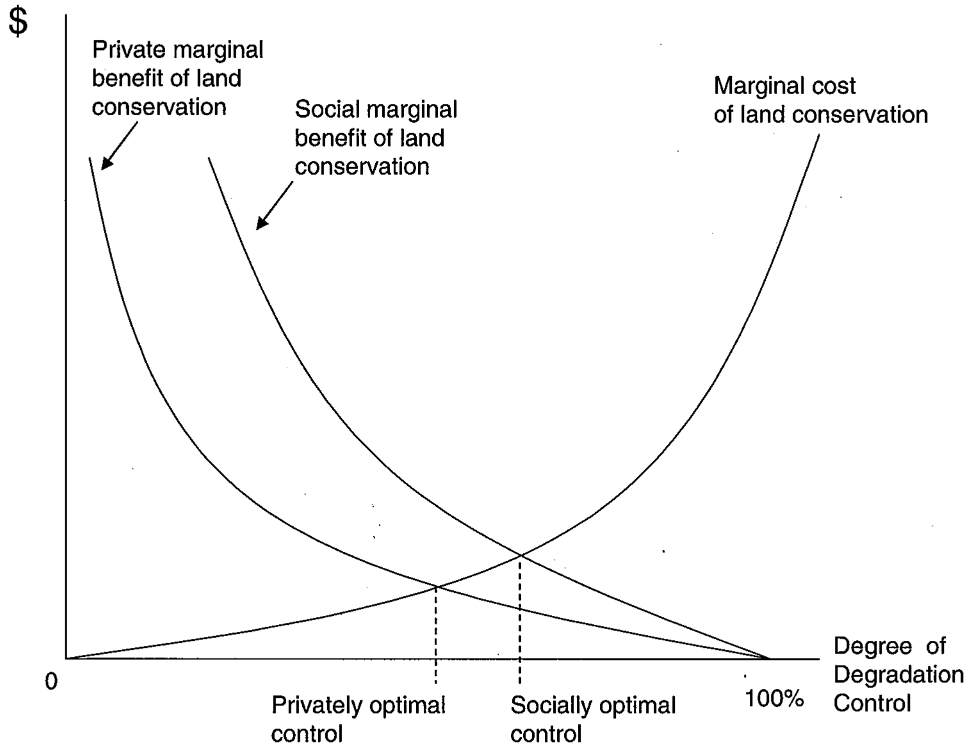
It is an understanding of these ultimate factors combined with the economics of farm level decision making, which together might be considered as "the political economy of land degradation," that is critical if the technical degradation control work of natural and physical scientists is to be successfully implemented in a manner which is sustainable in the long-term.

## Economics, the Costs of Land Degradation, and "Optimal" Degradation Levels

Economics can add to an understanding of land degradation in part because it addresses costs. As highlighted above, land degradation can impose substantial costs on individuals and societies. These costs occur at two levels, typically referred to as on and off site. The on-site, or farm level costs of degradation are primarily related to reductions in future agricultural productivity but can also include increased risk, a factor disproportionately affecting marginal farmers (Barbier, 1996). Additional on-site costs may occur in terms of decreased forest cover and degraded water supplies which increase household labor requirements (e.g. in terms of fuelwood gathering) and contribute to lower health levels. The off-site impacts of land degradation can take myriad forms and may include reduced water quality, decreased reservoir storage, loss of navigational efficiency, disrupted irrigation supplies, and degraded fisheries. More broadly, off-site costs can include changed climatic conditions, decreased carbon sequestration, and reductions in perceived environmental amenities.

While any of these costs may be substantial, from an economic perspective, the question is not how land degradation and its damaging impacts can be stopped, but rather what the optimal rate of degradation is and how a society may move towards it. The concept of "optimal" land degradation can be perplexing to non-economists but is critical to grasp in formulating land conservation strategies with the highest chance of successful farmers' adoption. The idea of optimal degradation levels stems from the fact that degradation control generally requires the utilization of resources. Resources are by definition scarce (i.e. they have a cost and are not free), and so the use of a resource for one purpose, such as erosion control, generally means that the same resource, or the money equivalent used to purchase the resource, cannot be used for another purpose. With respect to land conservation, the problem then becomes one of determining the quantity of resources which should be devoted to avoidance of land degradation rather than some other investment or consumption option. From the farmer's perspective, the optimal level is that at which the benefit, in terms of on-farm productivity and other gains, from applying an additional unit of resources for land conservation is equal to the cost of applying that unit. In other words, a farmer should invest in land conservation until her/his marginal benefit from that investment is equal to her/his marginal cost (see Figure 1, "privately optimal control"). So long as there are positive costs to land conservation, the optimal investment level is likely to be one resulting in continued degradation.

From this analysis, we can see that in a perfectly functioning economy, land degradation would still exist. However, there would not be a land degradation "problem," because farmers, in attempting to maximize their own welfare, would reduce degradation to the optimal level given relative resource scarcity and existing technologies. Unfortunately, an "optimal" degradation level is unlikely to be achieved, especially in the case of poor farmers on marginal lands, for at least four reasons.




*In general, we expect that farmers will devote resources to land conservation until the marginal costs of conservation equal the marginal benefits. However, the existence of externalities-the off-site costs of erosion- suggests that the private marginal benefits of conservation for the farmer are less than those for society as a whole, resulting in underinvestment in conservation from a societal perspective. Whether from the point of view of the individual farm or society, it is important to note that the "optimal" conservation is unlikely to be equated with no degradation.*

***Figure 1.*** "Optimal" land degradation and the marginal costs and benefits of land conservation

First, as stated, when farmers take measures to reduce degradation on their plots, benefits accrue both on and off site. However, the costs of controlling degradation, for example in terms of investment and possible removal of land from production, will generally fall entirely on site, i.e. to the farmer. This asymmetry in the benefits and costs of action causes what is known as an externality problem and will tend to result in an underinvestment in erosion control measures. Put another way, the marginal benefit to society of reduced degradation is greater than the marginal benefit to the farmer and, as shown in Figure 1, the farmer's investment in land conservation, from a societal point of view, is sub-optimal.

Second, property rights' regimes are frequently ill-defined in the marginal lands of developing countries, and land markets are likely to be imperfect or non-existent. When property rights are poorly defined, a farmer's expected return to erosion control is lower than would otherwise be the case, because she or he is not assured of reaping the long-term returns from her or his action in terms of increased crop output (Feder and Onchan, 1988). Even with well-defined property rights, land tenure arrangements may also influence the adoption of land conservation strategies. For example, there is evidence from the United

States that cash-renters are less likely to use conservation tillage than share-renters or owner-operators (Soule *et al.*, 2000), and in India land tenure laws discourage long-term leasing and, with it, incentives to invest in erosion control (Kerr, 1998). Similarly, if land cannot be sold (an illiquidity problem) or improvements in land are not fully capitalized in land values, farmers will be unable to recoup their investments through sale or legacy, again tending to result in underinvestment.

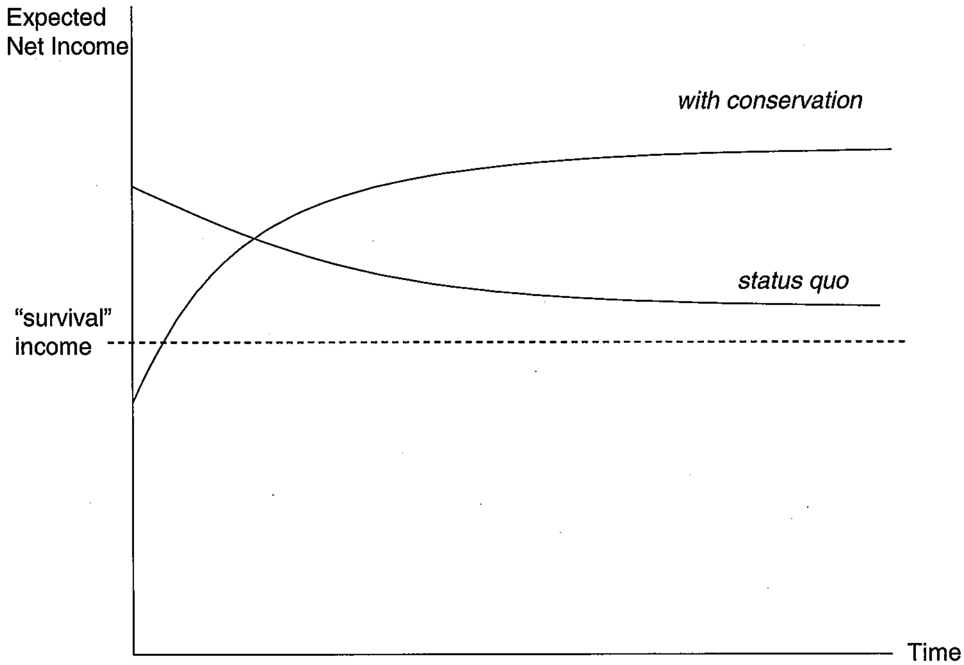
Third, capital markets are likely to be highly distorted in rural areas in developing countries and credit especially expensive for poor farmers. In part, this is related to the fact that many poor farmers, especially in marginal areas, do not have collateral in the form of land, a problem exacerbated by the property rights' problems just mentioned. As a result, farmers are unable to access formal credit channels and instead must borrow at high rates from local creditors, increasing the cost, and hence decreasing the quantity of investment in degradation control. In fact, Feder and Onchan (1988) showed that one of the principal reasons that land ownership in Thailand was correlated with conservation was that title to land allowed access to institutional credit. Furthermore, there is evidence that, even if rural credit markets did function properly, the discount rate that individual farmers apply to investment decisions may be lower than that which society applies, again resulting in sub-optimal investment (Barbier, 1996). This problem may also be worsened when property rights are not secure (Bishop, 1992).

Finally, there may be overarching national policies that encourage underinvestment in erosion control. For example, Barbier (1990) found that subsidies encouraged Javan farmers to purchase fertilizers to enhance yields rather than invest in more environmentally sound soil conservation practices. Nelson (1990) came to a similar conclusion regarding the subsidization of tractors in Tanzania (cited in Kerr, 1998). Other policies which may impact farmers' willingness to invest in soil conservation include exchange rate distortions, agricultural price interventions (Barbier and Burgess, 1992 cited in Barbier, 1996), and tax policy, though the direction of these impacts on erosion control is dependent on circumstance.

## A Conceptual Model of Farm Level Investment in Land Conservation

There are thus many factors which tend to cause farmers, especially poor farmers on marginal lands, to choose land conservation levels which are socially, and even privately, sub-optimal. In addition, each of the factors just cited was socio-economic, rather than physical, in nature. As a result, there is no reason to believe, *a priori*, that further dissemination of technology-based erosion control strategies will be, in and of themselves, likely to solve erosion problems. Rather than focusing predominately on technical solutions, researchers and extension agents should instead try to understand both the socio-economic and the physical environments in which farming decisions are made and which lead to sub-optimal erosion control and then tailor extension services to meet those specific circumstances. Only through such an approach are the many promising technical and engineering solutions to erosion control likely to be successful in the long term.

To help in understanding how land conservation investments are determined in a given physical and social environment, we can use the simple model, shown in Figure 2, of the farmer's decision-making process.[2] Most farmers appear to be aware that land degradation typically carries with it costs in terms of reduced soil productivity (Kerr, 1998). Thus, farmers anticipate that a continuation of status quo practices will result in a decline in net income from a given piece of land over time as degradation reduces soil productivity. In contrast, farmers expect that soil productivity will increase, or fall less rapidly, if productive investments in conservation are made. However, such investments involve initial costs as well as continued upkeep and so expected net income in early investment periods may actually be less than under the status quo scenario.




*Land use practices which cause degradation tend to reduce expected net income over time as productivity decreases. Investment in conservation can reverse the fall but typically requires up-front and on-going costs. How farmers perceive the status quo degradation path, the costs of conservation and the rate at which the investment will provide returns all influence whether or not a particular conservation measure will be undertaken. However, particular socio-economic factors and constraints will also influence the adoption rates of particular farmers in particular places. For example, if an initial investment in a conservation strategy puts a farmer below "survival" income levels, the strategy is unlikely to be adopted even if it "pays" in the long term.*

***Figure 2.*** The farm-level economics of investment in land conservation

We would expect the farmer to engage in erosion control investment as long as the expected net income with conservation was more over the relevant time horizon of the investment than if no investment were made. Given a range of land conservation options, the farmer would be expected to invest in the technology resulting in the highest expected net income. However, as already discussed, there are many reasons that investment in land conservation will be less than optimal even as individual farmers attempt to maximize their own welfare. The

[2] This model is based on Barbier (1998). In Barbier's original work, present value is measured on the vertical axis. Since present value measures the value of an income stream at a point in time, it cannot be used to measure income across time. This is a minor mistake in the original work.

question for researchers and extension agents then is, given the socio-economic conditions in which farming takes place and a farmer's decision-making process, which technologies and bundles of extension services can be provided that have the highest possibility of being adopted over the long term and which will provide on-farm benefits and/or reduce off-site land degradation costs?

## Implications for Extension and Further Research: Nine Hypotheses

With a better understanding of the role of socio-economics in land management decision making, insights can be developed to help address various aspects of the question just posed. For example, we can quickly see from Figure 2 that an investment in land conservation is unlikely to be made if that investment does not raise expected net income above the status quo levels. From insights such as this, working hypotheses can be developed to help extension agents and researchers target particular land conservation strategies that are consistent with the broader socio-economic environment in which they are working. Nine such hypotheses for targeting land conservation strategies are presented here.

**Hypothesis 1: When property rights are insecure or land tenure has only a short-term guarantee, land conservation strategies with low initial costs are more likely to be adopted.** As shown in Figure 2, an investment in erosion control causes an immediate decline in expected farm income. The larger the initial costs of that investment, the longer the time period which is required for the farmer to recoup her or his funds. Insecure land rights, short-term tenure arrangements, and certain rental arrangements, as discussed above, reduce the probability of farmers reaping the full benefit from the future productivity gains. Under such circumstances, land conservation strategies with low initial investments are more likely to be profitable from the farmer's perspective and are therefore more likely to be adopted. To a lesser degree, the same result holds for cases in which land markets are imperfect and investments in soil conservation are not capitalized in land values. As an addendum, we should remember that "property rights" does not necessarily imply private property, and that many communal rights' systems may also be effective in guaranteeing a farmer's investment in soil productivity. Furthermore, there may be strategic reasons that farmers without property rights or tenure may invest in conservation under certain circumstances (Neef and Sangkapitux, 1999)

***Hypothesis 2: When property rights are insecure or land tenure has only a short-term guarantee, land conservation strategies with short pay off periods are more likely to* be adopted.** As described in Hypothesis 1, farmers are unlikely to invest in land conservation strategies with high up-front costs. However, there are two factors which influence the break-even time for an investment in land improvement, the initial costs already described as well as the waiting time before the investment produces increased yields (or decreased declines in yield). Land conservation strategies which have high "waiting costs," for example agro-forestry schemes which may take many years before any returns are realized, are also less likely to be adopted when property rights or land tenure is insecure.

***Hypothesis 3: When farmers are extremely poor, land conservation strategies with low initial costs and short pay off periods are more likely to be adopted.*** Even if land tenure is secure, poor farmers, in particular those with no off-farm income and small plots needed for subsistence, will be unlikely to invest in land conservation strategies with high up-front costs and/or long pay-off periods because of short-term survival concerns. Consider a farmer with an income at the "survival" level as depicted in Figure 2. If the land conservation strategy shown in the figure were implemented, income in year zero would fall below the level needed for mere survival. Unfortunately, it is not possible to invest for long-term gain when short-term survival is in question. Poor farmers may also be reluctant to make erosion control investments, even if such investments do not put them below the survival level, if the investments require a switch from subsistence to cash crops because of the added risk (see Hypothesis 7).

***Hypothesis 4: Farmers who do not perceive a direct land degradation problem are least likely to adopt land conservation strategies.*** Educational level and perception of erosion as a problem have been shown to be related to willingness to invest in erosion control (Ervin and Ervin, 1982). While, as stated above, there is evidence that farmers in general understand that degradation can have direct, on-farm costs, this is not necessarily the case. Furthermore, the actual costs of degradation are likely to be as difficult for farmers as for researchers to grasp. For example Eswaran (2001) noted that even establishing cause-and-effect relationships between land degradation and productivity is difficult. In addition, the existence of particular land management problems, for example high levels of erosion, does not necessarily translate into reduced farm income (Barbier, 1990). If the farmer's perception of land degradation is underestimated or degradation does not result in direct income losses, but rather imposes costs only off site, the fall in expected income depicted in the status quo scenario of Figure 2 will be less than true levels, in turn reducing both the perceived gains from land conservation and the likelihood of conservation investment.

***Hypothesis 5: New commodity technologies are more likely to be adopted in areas where access to markets is secure, improved natural resource practices are more likely to be adopted in areas where this is not the case.*** New commodity technologies generally require more purchased inputs than improved natural resource practices (Crosson and Anderson, 2002). In areas where institutions and policies give farmers reliable and easy access to inputs on favorable price and credit terms, for example where markets and governments function well, commodity technologies will be relatively more attractive to farmers than improved natural resource management practices. Where markets and governments are less likely to function, natural resource management practices are likely to be relatively more attractive. In terms of Figure 2, this implies that, for a given technology, the shape and slope of the *with conservation* expected income curve will vary based on the location of the farmer. Thus understanding the institutional and policy environment, *at the location of the farmer*, is important in understanding the land conservation strategies most likely to be profitable at the farm level. It should be noted, however, that even when market access is poor, it is still important to consider relative prices and demand. In India, for example, straw and manure, which could provide soil nutrients, have high value for feed and fuel and so are unlikely to be employed in soil fertility schemes whether or not farmers are integrated into the cash economy (Kerr, 1998).

***Hypothesis 6: Land conservation strategies which use crops that are consistent with the overall policy environment are most likely to be adopted.*** The introduction of new erosion control practices often requires a change in cropping patterns. New practices which encourage plantings of policy disadvantaged crops, that is crops which face higher taxation or lower subsidization than other viable crop options, will be less likely to succeed in the long term. Conversely, practices which favor policy advantaged crops, when farmers perceive that the advantage will be sustained, are more likely to succeed. The impact of the policy environment on the relative attractiveness of land conservation schemes which require changes in cropping patterns can also be much deeper than relative pricing levels. For example, McMillan and Masters (2000) showed that, all *else* being equal, farmers in many tropical countries have a disincentive to investment in crops with high-fixed costs or long gestation periods, aside from the issues brought up under hypotheses 1 and 2, because farmers expect confiscatory tax rates to reduce returns after investments are made.[3] In terms of Figure 2, the income effects of changes in cropping patterns are reflected by changes in the slope and level of the *with investment* income stream.

***Hypothesis 7: Land conservation strategies which take into account the risks of erosion control, farmers' risk perceptions, and farmers' risk tolerance are more likely to be*** **adopted.** The adoption of land conservation measures, either in terms of new cropping patterns or new procedures, involves risk. For example, a change from subsistence to cash cropping adds risk in terms of exposure to unfamiliar price patterns as well as unfamiliar responses to climatic and other natural variability. Increases in risk are typically reflected in a perceived decrease in future benefits (reflected by a drop in the *with investment* income stream of Figure 2) and should not be underestimated as a disincentive to change. Furthermore, this disincentive to change may vary markedly across farmers and locations. For example, subsistence farmers with little or no savings, small plots, and no off-farm income may have a much lower tolerance for the price risk associated with a shift to commercial cropping, even if they are guaranteed higher average income over time, than a farmer in a better economic condition.

***Hypothesis 8. The expected benefit from conservation can change over time, even holding output prices and technology constant.*** The relative benefits from investing in land conservation can change over time as society-scale transitions take place. For example, Kerr (1998) and Southgate (2001) have provided conceptual models to demonstrate the mechanism through which changes in population densities or the land/labor price ratio can cause farmers to shift from non-degrading practices, to degradation and finally back to conservation. Tiffen *et al.* (1994) described how such an outcome actually occurred in Kenya while Critchley *et al.* (2001) discussed the relationship for the specific case of terracing. This finding implies that the exact nature of the curves shown in Figure 2 will vary over time for a given farmer in a given location as the broader economic and demographic landscapes change. Thus a conservation practice deemed "good" at one time might become unadoptable later and vice versa.

***Hypothesis 9: Second "best" is sometimes better than best.*** Because farmers do not take into account the off-site benefits of erosion control, erosion control strategies with the highest on-site benefits are most likely to be adopted. This suggests that it may be best to advocate "second best" strategies which, though they are not optimal at the catchment or broader scales, may be better than no action in that they have an improved likelihood of adoption. To highlight this point, consider two erosion control strategies. The first has a high yield-increasing component, contributing to farmers' willingness to adopt, as well as minor off-site benefits in terms of reduced sedimentation. A second technique provides no yield increase to the farmer but substantially reduces downstream sedimentation. In general, it may be better to advocate the first strategy, even if it is sub-optimal from a technical or societal point of view, because of higher likelihood of actual adoption out of farmers' self-interest. Kerr (1998) points out that the second best strategy may also be appropriate when, as is likely

[3] The study was actually designed to explain how production technologies may influence tax rates, R&D expenditures, and growth rates in tropical countries. However, the study results have clear implications for willingness to change cropping patterns as explained in the text.

to be the typical case, land conservation decisions are influenced by other social, economic, and environmental objectives and constraints. For example, he notes that on some Indian lands, technically superior contour-based erosion control measures are unlikely to be adopted over boundary-based measures because of the need to demarcate ownership boundaries.

In summary these hypotheses and the ideas behind them highlight the role of property rights, income, resource policies, and markets, along with perceptions of the costs and benefits of land degradation, in farmers' decisions to change land management practices. The use of economic analysis to develop such insights into the "political economy of land degradation" can serve to broaden our understanding of the causes of, and likely solutions to, land degradation within the socio-economic settings of particular farmers in particular places. In addition, such insights can serve to suggest the policy interventions which might be used to encourage adoption of particular land conservation technologies. For example, in extremely poor areas, credit subsidies may be necessary to entice the adoption of conservation strategies with high start up costs (Hypothesis 3) whereas changes in national agricultural policy may be required in other circumstances (Hypothesis 6).

## Conclusion

As stated by Barbier, "Far from being a purely technical problem of soil science or plant breeding, the core of the land degradation problem is economic" (1997, 891). While physical scientists may differ with the exact wording of this statement, it is clear that economics and land degradation are integrally intertwined. This paper attempted to highlight the interconnection by applying the tools of economics to the analysis of land degradation and the adoption of conservation strategies. To do this, the concept of "optimal" land degradation was introduced, and it was suggested that current land conservation investment, especially for poor farmers in marginal lands, is likely to be sub-optimal. A model of farmers' behavior with respect to land conservation investment was then presented and used to generate hypotheses related to the adoption of land conservation strategies under various socio-economic circumstances. These hypotheses have four main functions. First, they can serve as a basis for targeting conservation intervention and suggest the data which should be collected to effectively carry out that targeting. Second, they suggest the policy interventions which might best be used to encourage the adoption of particular land conservation technologies in order to overcome externality or other market failures. Third, they can be taken as refutable statements to provide a basis for future research and empirical study to further improve our understanding of the factors which drive farmers' adoption of land conservation. Finally, and perhaps most importantly, they highlight the vital importance of economic, political, and geographic circumstances – the "Political Economy of Land Degradation" – in understanding why degradation takes place and how programs such as MSEC can best integrate their physical and social science work to lessen its negative impacts.

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