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Adoption of soil conservation: the case of the Philippine uplands

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Abstract

Soil degradation in the sloping uplands of Asia is a serious problem that threatens the sustainability of agriculture. Although several soil conservation technologies have been developed and promoted, their adoption has not been widespread. A micro-economic analysis of adoption of contour hedgerows by upland farmers in the Philippines is conducted to identify the factors that determine adoption. The empirical results show that adoption depends on several farm and farmer characteristics and the relative importance of these factors differs across sites. The high cost of establishment, maintenance and the loss of land to hedgerows are considered to be the major constraints to adoption by non-adopters. The economics of the contour hedgerow system is found to improve substantially if crop intensification or cash cropping is possible. In addition to the need to develop a range of cost-effective technologies, the study indicates that in the more marginal environments, on-site benefits alone may not be sufficient to justify investment in soil conservation.

Keywords: Soil conservation; Uplands; Contour hedgerow technology

1. Introduction

One of the major factors leading to the unsustainability of agriculture in the sloping uplands is soil erosion (Blaikie and Brookfield, 1987). Although the extent of anthropomorphic soil erosion is debatable (Oldeman et al., 1991), activities such as deforestation and intensified land use in the uplands undoubtedly have led to increased soil erosion. In the humid tropics of Asia, farmers grow a range of subsistence crops in sloping and marginal uplands using practices which are often highly erosive (Garrity et al., 1993). In addition to reducing the in-situ productivity and sustainability, these practices also reduce the sustainability of lowland agriculture through siltation and damage of irrigation infrastructure (Francisco, 1994).

What are the conditions under which farmers will adopt practices which conserve soil and enhance the long-term sustainability of agricultural production systems in these sloping uplands? Experiences from a large number of projects implemented in these uplands indicate that the problem is often not the lack of technology per se but rather the incompatibility of the technology promoted with the socio-economic conditions under which farming is carried out (Fujisaka, 1989; Anderson and Thampapillai, 1990; Baum et al., 1993; Lutz et al., 1994). Engineering solutions such as rock walls, check dams, and terraces have had very little success in generating a wider impact due to their high costs. Other less costly technologies such as contour hedgerows, contour plowing, and cover management have also been adopted but sporadically. Overall, technological research and promotional work done so far seem to have had a limited impact in increasing the adoption of conservation technologies.

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The limited success of these efforts highlights the need to develop a better understanding of conditions which encourage the adoption of conservation practices. Such factors could be farmer-specific, farm-specific, or technology-specific. Farmer-specific factors include the goals of the farmer and the resource base. At a broader level, the socio-economic milieu under which production takes place determines the resource base by allowing resource augmentation through market participation. Farm-specific factors are related to the biophysical characteristics of the production systems such as soil characteristics and climate, as well as the broader characteristics of the production system. Technology-specific factors are features of the technology available to the farmers and which are designed to alter the farmers' production systems. This paper focuses on the microeconomic factors conditioning the adoption decision of upland farmers in the Philippines. The paper starts with a discussion of the broader policy and institutional conditions essential for ensuring that soil conservation practices are potentially profitable to farmers. This conceptual discussion is followed by the presentation of results based on an analysis of adoption of contour hedgerows in the Philippine uplands.

2. The nature of production systems and incentives for soil conservation

As soil conservation is an investment to enhance the future productive capacity of the soil, a microeconomic model of investment analysis can be utilized to study adoption behavior. Several specifications of such models are available in the literature (McConnell, 1983; Clarke, 1992; LaFrance, 1992). These models indicate that the factors determining both the potential benefits and costs of soil conservation depend critically on the nature of the production systems. The characteristics of the production system at any point in time is the result of the interplay between the farmers' attempts to change it in a particular way to meet their goals and the environmental factors which determine what is feasible. The three major determinants of the nature of the production system are population density, market access, and the agroclimatic conditions (Boserup, 1965, 1981; Pandey, 1996). A simplified construct based on population density and market access is presented in Fig. 1. When the population density is low and no outside market demand exists, returns to labor are maximized by adopting an extensive land use strategy, such as shifting cultivation based on long fallow periods (Type I). The farmers' primary objective in this land surplus situation is to allocate labor to expand the area and not necessarily to improve the yield. As a result of lack of investment, land quality suffers over time until the field is finally rested/fallowed and the farmer moves to a new plot. During the long fallow period, the natural regeneration may restore soil productivity sufficiently to allow re-cultivation of the field. Incentives to soil conservation under this situation will be minimal.

When the land frontier is closed, further increases in population provide incentives for intensification of agricultural production so that sedentary farming systems evolve (Type II). Farmers attempt to be self-sufficient by producing a range of agricultural output under a subsistence mode of production in the absence of markets. As the scope for increasing the area is limited, the only option available is to improve the yield per unit area by using more labor and other inputs for current production. Labor-intensive methods of soil conservation are likely to be more appropriate to Type II systems. Although investment in soil quality is also a way of improving productivity, whether or not farmers will actually do so will depend on several factors which determine economic incentives. Where such incentives are lacking, soil degradation will continue until migration reduces the population pressure or the area itself is abandoned.

When population density is low but market access is well-developed, plantation-type commercialized production systems are likely to emerge (Type III). Annual or perennial food/fiber or industrial crops predominate depending on market conditions. On the other hand, commercialized production systems are likely to develop when both population density and market access are high (Type IV). Such production systems may be diversified or specialized depending on a range of conditions. The opportunity to interact with the market in these systems can influence soil conservation decisions in two ways. First, to the extent that cash crops are more profitable per unit area than food crops, an increase in cash crop production would increase the marginal value product of soil and encourage the adoption of conservation practices.

		MARKET ACCESS	
		Low	High
POPULATION DENSITY	Low	* Traditional * Subsistence * Sustainable Type I	Perennial or food crop Sustainable? Type III
	High	* Intensified * Subsistence * Sustainable?? Type II	* Diversified * Food and cash crops * Sustainable?? Type IV

Fig. 1. Effect of market access and population pressure on land use and sustainability (Source: Pandey, 1996).

Income from cash crops will also help relax liquidity constraints that may restrict such investments. Second, market access will also increase the opportunity cost of labor used for conservation investment. This will make labor-intensive conservation practices more expensive, thus encouraging a preference for labor-saving methods. If such techniques are not available or limited security of tenure restricts the planning horizon, farmers may allow the land to degrade.

3. Intensification, property rights, and soil conservation

Extensification of land use as a means of enhancing sustainability is not an option in densely-populated areas of Asia. Land use needs to be intensified to feed the increasing population. What are the conditions under which land use intensification is compatible with conservation?

The effect of intensification on soil conservation depends on the structure of property rights, the level of development of land and capital markets, access to technology and information, and developments in the nonfarm sector. Security of tenure is a critical variable determining incentives to conserve land quality. If property rights to land are well-defined and enforceable, farmers will have incentives to conserve soil as future benefits from soil conservation will accrue to the farmer who makes the investment. Security of tenure will lengthen the planning horizon or lower the effective discount rate. On the other hand, if property rights are ill-defined or are unenforceable, a ‘mining’ strategy based on rapid exhaustion of soil fertility will be adopted. This kind of ‘mining’ strategy can be observed mainly in the forest margins, as well as in rapidly commercializing areas with ill-defined property rights (Fujisaka et al., 1986; Cruz and Repetto, 1992). For example, farmers who followed loggers in the uplands of the Philippines grew food crops in logged areas for a few years and abandoned the fields afterwards. As these fields did not belong to the farmers, they had no incentive to conserve the productive capacity of such fields.

The possession of a legal title to land is not, however, necessary for ensuring the security of land tenure (Bromley, 1992; Place and Hazell, 1993). Empirical evidence indicates that farmers who do not have legal titles have often invested in soil conservation while others with legal titles have not always done so. In many communities, the local land tenure system provides the security of tenure which a legal title does not necessarily provide. The local land tenure system can in fact assign rights to own, use, and transfer land in the same way that a legal title does, but often at a much lower cost due to community enforcement. In fact, attempts by governments to replace the community land tenure system by legal titles that are costly to enforce have often increased the insecurity of land tenure in many societies (Bromley, 1992).

How do the property rights to land evolve as land use is intensified? The theory of induced innovation indicates that when the land use intensity is low, the property rights to land tend to be non-specific and usufruct (Hayami and Ruttan, 1985; Binswanger and Pingali, 1987). As the land use intensity increases due to population pressure and/or expanded export opportunities, property rights become more specific with rights to own, use, and transfer. The natural evolution of property rights to land from general to specific rights breaks down if intensification occurs at a pace faster than the capacity of local institutions to adapt to the changes in property rights or if government policies hinder such a natural evolution. When intensification occurs in response to rapid migration to a newly opened area, the natural process of evolution of property rights tends to break down leading to adoption of agricultural practices that are not sustainable (Fujisaka et al., 1986). If such areas happen to be sloping uplands with highly erodible soils, land degradation in such societies can be a severe problem.

The existence of well-defined and enforceable property rights to land is a necessary but not a sufficient condition to adoption. The adoption of soil conservation practices is dependent on the existence of several additional conditions. A poorly-developed land market may fail to internalize land quality improvements in land values, thus discouraging the adoption of conservation practices. Similarly, a poorly-developed capital market may constrain adoption by limiting funds available for such investments. Soil conservation in the sloping uplands may be more effective if implemented at the watershed level. Without strong community level enforcement, such efforts could be stymied by the free-rider problem. The adoption of conservation practices in the uplands is also tied up with the macro and sectoral policies that determine incentives for different land use patterns (Cruz and Repetto, 1992; Coxhead and Jayasuriya, 1994). Some types of land use are soil eroding while others are soil conserving. For example, soil erosion under most perennial crops is minimal as such crops provide a continuous year-round ground cover. On the other hand, the production of annual food crops tends to cause more erosion unless remedial measures are undertaken. When faced with rising population, limited off-farm employment opportunities, and limited access to markets, upland farmers may have no alternative but to intensify the production of staple food using a subsistence mode of production even though the long-run sustainability is threatened. The history of upland development in the Philippines, Vietnam, and Thailand highlights the effect of macro and sectoral policies on the adoption of conservation practices very well. The migration of lowland population to the uplands in the Philippines in the 70s and 80s has been attributed mainly to the stagnant productivity of rice in the lowlands, a high rate of population growth and low absorptive capacity of the nonfarm sector. The migration, coupled with poorly defined property rights in the uplands, is considered to be a major factor causing soil erosion in the uplands. In addition, the overvalued exchange rate encouraged the production of food crops at the cost of perennial export crops. Similarly in Vietnam, the government policy of regional food self-sufficiency until the late 80s was a major factor for the expansion of area under shifting cultivation and the consequent soil erosion. On the other hand, improved market access through increased investment in infrastructure in the uplands helped diversify the upland production systems in Thailand (Shinawatra, 1985). The diversification and market integration not only relaxed the liquidity constraints to investment in conservation practices faced by upland farmers, but also improved their food security with the emergence of land use patterns based on comparative advantage. Additionally, the rapid growth in the nonfarm sector helped to siphon-off the excess population from these fragile upland areas and subsequently reduced the pressure for intensification.

With the right mix of policy and institutional interventions, there is no reason why intensification cannot be achieved sustainably. The Machakos experience in Kenya is a case in point. Despite a five-fold increase in population, Machakos residents were able to increase per capita agricultural output through a correct mix of institutional and technological innovations and improved linkage with the nonfarm economy

(English et al., 1994). Although the Machakos experience may not be replicable in many of the Asian uplands, it highlights the importance of various policy and institutional options in encouraging the adoption of sustainable practices.

4. Some microeconomic evidence from the Philippines

4.1. Study area and sampling design

Claveria and Cebu are the two major sites in the Philippines where the contour hedgerow technology was actively promoted in the early 80s. The World Neighbors, in collaboration with the Department of Environment and Natural Resources, promoted a range of soil conservation practices including contour hedgerows in Cebu in the early 80s. The soil conservation technology was a component of the overall technology to encourage a shift in production systems from subsistence to cash crops. Overall, the contour hedgerow technology has spread around the initial target area and the Cebu case is often cited as a successful example of adoption of soil conservation technology (Garcia and Gerrits, 1995).

In 1985, the International Rice Research Institute initiated a farming systems research program in the acid uplands of Claveria, Misamis Oriental in collaboration with the Department of Agriculture. A contour hedgerow-based farming system was promoted using the farmer-to-farmer extension approach based on the strategy of the World Neighbors in Cebu (Fujisaka and Garrity, 1988). Sixty-four out of 182 farmers trained had established contour hedgerows by the end of 1990 (Fujisaka, 1993). A subsequent study by Cenas and Pandey (1996) documented the status of the contour hedgerow systems of these farmers in 1995. While contour hedgerows were considered ineffective and subsequently abandoned by about 25% of the initial adopters, others modified and/or maintained their hedgerow structures.

This study focuses on the contour hedgerow technology as a soil conservation practice. A sample of 130 farmers consisting of 74 adopters and 56 non-adopters was selected from Cebu and Claveria. The city of Cebu provides a good market outlet for commercial production from the peri-urban sloping areas. On the other hand, the market for the products from Claveria which is located in the province of Misamis Oriental is somewhat limited to the smaller city of Cagayan de Oro. The population densities in the provinces of Cebu and Misamis Oriental are 574 persons per km^2 and 285 persons per km^2, respectively (NCSO, 1997). The study area in Cebu comes under Cebu City which has a population density of 2358 persons per km^2. Thus, in terms of Fig. 1, Cebu represents an area with good market access and high population density, whereas Claveria represents an area with a lower population density and somewhat limited market access.

The sampling design used to select farmers was stratified purposive. As the objective of the study is to carry out an in-depth analysis of adoption behavior, farmers were divided into two strata, namely adopters and non-adopters. Adopters were defined as farmers who have established contour hedgerows in at least one parcel of their farms, were cultivating and maintaining their contoured parcels, and had crop production during the year prior to the survey year. The sample consisted of 39 adopters and 21 non-adopters from nine villages in Claveria and 35 adopters and 35 non-adopters from six villages in Cebu. In order to reduce the effect of environmental variations, non-adopters were selected from the same villages and, where possible, were farmers with fields adjacent to the contour hedgerow fields of the adopters. Given the purposive nature of the sampling design, caution should be exercised in extrapolating the farm and farmer characteristics of the sample farmers to the overall population.

A structured questionnaire was used for the field interviews. Detailed information on production systems, input use, costs and returns, nature and extent of adoption of contour hedgerows, adoption of soil conservation practices other than contour hedgerows, and farmers' perceptions regarding advantages/disadvantages of contour hedgerows were collected. Interviews with key informants including government officials, non-government organizations, and other government agencies engaged in soil conservation were also conducted.

The farm level data on production systems collected during the survey pertains to the 1995 cropping season. The basic characteristics of the production systems in these two locations are summarized in Table 1. While

Table 1
General characteristics of the production systems in the study area

Features	Cebu	Claveria
Average area per household (ha)	1.7	3.0
Average parcel size (ha)	0.7	1.2
Cropping intensity (%)	150	190
Average slope (%)	32	24
Area under maize (%)	54	84
Area under cash crops (%)	14	5
Average yield of maize (kg ha^{-1})	902	1284
Average gross income ($ household^{-1})[a]	1616	1470

[a] US$1 = P25.

maize is the dominant crop in both locations, cash crops (mainly vegetables and flowers) are more extensively produced in Cebu compared to Claveria. The average farm size in Claveria (3.0 ha) is much larger than that in Cebu (1.7 ha). Due to the relatively larger share of cash crops, the gross farm income per household in Cebu is higher than that in Claveria.

4.2. Characteristics of adoption and adopters

The extent of adoption, as measured by the proportion of farm area with contour hedgerows of households who have adopted the technology and the proportion of farmers who have established contour hedgerows in the whole farm, is higher in Cebu than in Claveria (Table 2). Adoption started earlier in Cebu where almost a quarter of the sample farmers have adopted contour hedgerows for more than 10 years.

Adopters of contour hedgerows in both Cebu and Claveria have a larger proportion of farm area under cash crops than under subsistence crops (Table 3). The adoption of contour hedgerows may have encouraged a shift towards cash cropping [1]. The heads of households that have adopted contour hedgerows are younger and have more years of schooling. A larger proportion of households that have adopted contour hedgerows are members of *alayon*, a local labor-sharing group, and have received training in soil conservation for a slightly longer period compared to those of non-adopters. Likewise, a larger proportion of adopters own at least a parcel of the land they are operating. Households of adopters also live closer to the main road relative to those of non-adopters.

4.3. Characteristics of contour hedgerows

Based on the combined data for Cebu and Claveria, the average height of the riser [2] is estimated to be 0.8 m. It is found to be positively related to the number of years of adoption. The average annual increase in the height of the riser is estimated at 5 cm per year. The average width of the hedgerows is 1.3 m and the average length of hedgerows per hectare contoured is 1300 m.

Natural grasses are the predominant hedgerow species (Table 4). Napier grass is the second most commonly used species. A larger proportion of contoured parcels in Cebu are planted with Napier grass compared to those in Claveria. Due to the limited grazing area in Cebu, farmers consider Napier grass hedgerows to be valuable as fodder. Other hedgerow species used are gliricidia (*Gliricidia sepium*), setaria (*Setaria* sp.), and leucaena (*Leucaena leucocephala*).

There appears to be a movement towards natural grass-based hedgerows which is consistent with the results of a previous study done in Claveria by Cenas and Pandey (1996). While only about 8% of the fields started out with natural grass as hedgerow species and have remained that way, 35% of the fields have shifted from planted species to natural grasses as hedgerow species. Natural domination of grasses and high mortality of the planted species are the major reasons cited for a shift towards a natural grass-based system.

4.4. Farmer perceptions regarding contour hedgerows

More than half of the respondents considered the reduction of soil erosion to be the major benefit from contour hedgerows [3], while 16% of the respondents indicated that hedgerows improve soil fertility. Obviously, one would expect the reduction in soil erosion and improvement in soil fertility to ultimately help

[1] If the causality runs in this direction, the opportunity cost of not adopting contour hedgerows is the income from cash cropping forgone. Benefit-cost analysis of conservation practice based solely on the difference in yield of food crops with and without contour hedgerow will underestimate the economic value.

[2] A riser is the portion of the land that connects the upper terrace with the terrace immediately below it. For a given slope, flatter terraces have higher risers.

[3] Farmer perceptions were obtained using an open-ended interview format.

Table 2
Extent of adoption of contour hedgerows

	Cebu	Claveria	All
Percent share of contour hedgerow area to total area operated by adopters[a]	87(23)	69(33)	78(30)
Percentage of full adopters[b]	63	46	54
Partial adopters:			
≥ 50% but < 100%[c]	29	26	27
< 50%[d]	9	28	19

[a] Average share for all adopters. Figs. in parentheses are standard deviations.
[b] Adopters who have established contour hedgerows on 100% of their farm.
[c] Adopters who have established contour hedgerows on at least half but less than all area of their farm.
[d] Adopters who have established contour hedgerows on less than half of their farm.

Table 3
Characteristics of adopters and non-adopters of contour hedgerows

Characteristics	Adopters	Non-adopters
Mean age of the household head (years)	45	47
Mean years of schooling (years)	6	4
Farmers with membership in *alayon*[a] (%)	13	2
Mean duration of training on soil conservation obtained (weeks)	1.4	0.6
Average distance of house from road (km)	0.47	0.55
Farmers owning at least a parcel of land (%)	54	37
Area under cash crop (%)	12	5

[a] Alayon is a local organization of farmers with labor-exchange arrangements among members.

improve the yield. But yield increase ranked only third among the responses (11%). Although there may have been visible improvements in soil attributes with adoption, farmers probably did not observe a very clear yield gain. This indicates that yield gain is probably not very substantial and is confounded by other factors. If farmers do not in fact consider yield gain to be the major benefit, the extension message for promoting soil erosion is likely to be better received if couched in terms of other benefits that farmers can easily perceive. Other benefits cited by the respondents were the ease of land preparation as alleys become flatter (5%), hedgerow species serving as fodder (8%), and the avoidance of physical damage to crops due to gully formation and landslide (4%). These other benefits, however, tend to be somewhat location specific.

In terms of problems with the technology, 50% of the respondents indicated no problem with the technology while 35% considered the high cost of labor for establishment and maintenance to be the major problem. Other problems cited include the increased labor time for land preparation (3%), destruction of hedgerows by stray animals (4%), shading of crops by hedgerows (2%), and the persistence of soil erosion despite the presence of hedgerows (2%). A comparison of the characteristics of the farm, farmer, and hedgerows of farmers who have no problems with the technology with the characteristics of those having problems show no statistically significant differences (based on *t*-tests and chi-square tests) except for the membership in *alayon* which is higher (21%) among farmers reporting no problem than for farmers having problems (6%)[4]. An *alayon* is an informal group of farmers in which labor exchange among members is practiced under the principle of reciprocity. As *alayon* is a mechanism to help relax labor constraints, differences in perception may be related, at least in part,

Table 4
Percent shares of parcels by type of hedgerow species

Species	Cebu	Claveria	All
Natural grass	45	47	46
Napier grass	37	19	30
G. sepium	6	9	8
Setaria sp.	3	9	5
L. leucocephala	5	–	3
Others[a]	4	16	8

[a] Includes gmelina, guinea grass, bananas, mulberry, pineapple and ferns.

[4] Significant at the 10% level.

to the severity of labor constraints faced by different households.

Responses from non-adopters about the reasons for not adopting contour hedgerows indicate that the high labor requirements to establish and maintain the hedgerows is the most commonly cited major reason (38%). Lack of technical knowledge and loss of cultivable area are considered to be the major reasons for non-adoption by more than 10% of the respondents. Other reasons cited include the difficulties in land preparation in the presence of contour hedgerows (5%), non-ownership of the land (5%), lack of capital (2%), and the perception that soil erosion is not a problem (5%).

Among the factors that would encourage non-adopters to adopt contour hedgerows, the need for technical assistance and training on the technology and the need to have sufficient labor and capital are cited by almost one-third and one-fifth of the respondents, respectively. A wider choice of hedgerow species (11%), ownership of the land (5%), and clear evidence of loss of soil on their farms (5%) are the other major factors that would encourage non-adopters to adopt contour hedgerows. On the other hand, about 15% of the respondents feel that there is no need for them to adopt contour hedgerows as they do not perceive soil erosion to be a major problem on their farms.

The majority of non-adopters consider the destruction of crops and loss of seedlings and inputs to be the major erosion-related problems on their farms while about 16% of the farmers consider gully formation to be the major problem resulting from erosion. Judging from these responses, it appears that visible damage to the fields and physical losses of seedlings and crops loom large in the farmers' minds. No farmer mentioned the reduction of yield due to soil erosion as a major problem.

The majority of non-adopters have taken measures to reduce the soil erosion on their fields, of which 23% have constructed diversion/drainage canals, another 23% have practiced contour plowing, and about 16% have responded simply by using more fertilizer. Fallowing the land and placing other physical barriers are the other erosion-reducing measures practiced by 12% of the farmers. These responses indicate that farmers use other practices that may be more suitable to the specific conditions of their fields and/or cheaper to undertake than contour hedgerows. The implication is that promoters of soil conservation in the uplands must not view contour hedgerows as the universal solution for all farmers but only as one of the options. If a wider range of methods is promoted, farmers will have the flexibility to choose practices that they consider to be the most appropriate to their fields.

4.5. Factors determining adoption

The adoption data were analyzed using a probit model (Maddala, 1983; Greene, 1997) to identify the factors determining the adoption of contour hedgerows for soil conservation. A number of variables are hypothesized to determine the farmer's decision to adopt a soil conservation technology. These variables are classified into four categories, namely, personal factors, economic variables, institutional factors and the soil erosion potential of the field. Descriptive statistics of these variables and their anticipated effects are summarized in Table 5.

The effect of age of the farmer on adoption decision can be taken as a composite of the effects of farming experience and planning horizon. While longer farming experience as equated with older farmers is expected to have a positive effect on adoption, younger farmers, on the other hand, may have longer planning horizons and, hence, may be more likely to invest in conservation. The net effect on adoption, therefore, could not be determined a priori. Hoover and Wiitala (1980) found in their study of Nebraska farmers that age has a significant negative influence on adoption.

Higher education levels may be associated with greater information on conservation measures and the productivity consequences of erosion, and higher management expertise (Ervin and Ervin, 1982; Hoover and Wiitala, 1980; Feder et al., 1985). As a human capital variable, education is also found to positively affect the efficiency of adoption of conservation practices (Rahm and Huffman, 1984). Hence adoption is hypothesized to be positively correlated with the farmer's education level.

Membership in local labor exchange groups, called *alayon*, is posited to have a positive effect on adoption. The labor-exchange mechanism that is characteristic of these groups may help relax the labor constraint to adoption. Studies in other locations in the Philippines have found membership in *alayon* to be positively cor-

Table 5
Sample mean values of the independent variables used in the probit model and their expected effects on adoption

Variable	Cebu	Claveria	Effect
Age of household head	48.2 (13.5)[d]	46.5 (11.0)	+, −
Education (years)	4.4 (2.7)	7.1 (3.4)	+
Land/labor ratio	0.1 (0.1)	0.2 (0.2)	−, +
Slope (percent)	31.3 (11.5)	21.9 (13.3)	+
Distance from the road (km)	0.2 (0.4)	0.8 (1.0)	−
Nonfarm income[a]	48.8 (35.2)	35.3 (33.4)	+, −
Tenure[b]	30	52	+
Member[c]	12	3	+

[a] Percent share of nonfarm income to total household income.
[b] Percent share of owned parcels.
[c] Percent share of parcels cultivated by alayon members.
[d] Figs. in parentheses are standard deviations.

related with the adoption of soil conservation (Sajise and Ganapin, 1991; Gabunada and Barker, 1995)[5].

Tenure status affects investments in soil conservation by altering the planning horizon. As discussed earlier, security of tenure can be expected to be positively related to adoption. Our interview with farmers indicates, however, that ownership is not always a necessary condition for having security of tenure that would lead to investment in contour hedgerows in the Philippines. For example, in Cebu, almost 72% of the fields with contour hedgerows is rented while only 28% is owned. Moreover, most of the adopters of hedgerows in Cebu have revealed that their rented fields belong to a close relative. This suggests that the reciprocity involved in kinship ties may encourage the farmers to treat the rented field as their own. Recent evidence from the Philippines shows that the behavior of share-croppers with a kinship relation with their landlords is not affected by the disincentive effects of product and factor sharing (Sadoulet et al., 1997). Such kinship relations may also similarly influence investment decisions.

Land/labor ratio, measured as the ratio of the area operated to the number of family members engaged in farming on a full-time basis, is used as an indicator of the population pressure. Households with lower land/labor ratio may have incentives to invest in soil conservation for crop intensification. On the other hand, the potential loss of land to contour hedgerows may discourage adoption. It has been found that contour hedgerows occupy nearly 20% of the land (Cenas and Pandey, 1996) resulting in reduced cropping area. For households with more land per unit of labor, this potential loss of land and the subsequent reduction in cropping area may be less of a constraint relative to those with little land. Hence, households with higher land/labor ratio may be more likely to adopt contour hedgerows. The effect of land/labor ratio on adoption is, therefore, indeterminate a priori.

The distance of the homestead to the nearest road, as a proxy for market access, may capture the effect of several variables. Access to markets provides the farmer with opportunities for income-earning activities. Thus, there is more incentive for the farmer to ensure that farm productivity is improved or at least maintained in order to take advantage of market opportunities. Farmers who can potentially generate good returns from the production and sale of crops that are highly demanded in the market may therefore find soil conservation economically attractive (Clarke, 1992). Several farmers mentioned during the interviews that soil conservation is important for realizing high levels of profits from cash cropping. In addition to this effect, farmers who live closer to the road are more likely to be visited by extension agents than the ones who are situated far away. The cost of accessing technical knowledge and information will be lower for farmers

[5] *Alayon* groups may be strengthened and activated in the context of a specific project. To the extent that farmers acquire the *alayon* membership after deciding to adopt contour hedgerows, the causation may be reversed. Our survey data do not permit an assessment of the extent to which this may have happened in the study area. Nevertheless, studies in other sites in the Philippines (Sajise and Ganapin, 1991; Gabunada and Barker, 1995) show that *alayons* were pre-existing at the time of adoption of contour hedgerows.

Table 6
Estimated coefficients[a] of the probit model and the marginal probabilities of the independent variables

Variable	Cebu coefficient	Marginal probabilities (%)	Claveria coefficient	Marginal probabilities (%)
Constant	−1.78***		0.52	
Age of household head	0.007	0.3	−0.03**	−1.2
Education (years)	0.17***	6.7	−0.03	−1.2
Tenure (dummy)[b]	−0.31	−12.4	1.02***	40.2
Member (dummy)[c]	0.84**	33.5	0.34	13.4
Land/labor ratio	0.10	4.0	−0.94	−37.1
Slope (percent)	0.02**	0.8	0.05***	2.0
Nonfarm income	0.005	0.2	−0.005	−0.2
Distance from the road	−0.94**	−37.3	−0.10	−3.9
−2Log Likelihood ratio	192.54***		165.51***	
Probability of adoption	0.51		0.46	

[a] ***Significant at 1%; **Significant at 5%; *Significant at 10%.
[b] 1 for owner, 0 otherwise.
[c] 1 for *alayon* member, 0 otherwise.

living close to the road. The anticipated effect of this variable is, therefore, positive.

To the extent that liquidity is a constraint to adoption, nonfarm income will have a positive effect on adoption by relaxing this constraint. The level of nonfarm income, however, may not be exogenous but be affected by the profitability of the farming operation that in turn depends on conservation decisions. Thus, adoption of conservation practices and the level of nonfarm income may be determined simultaneously. The simultaneity arises due to the labor allocation decisions of the households into farm and nonfarm activities. The nonfarm income of the households surveyed is, however, mostly derived from remittances of family members working overseas, from nonfarm business activities, and from employment in the nonfarm sector. As skill requirements for these jobs are likely to be different from that for farming, the farm and nonfarm employment may be considered as non-competitive activities. In this situation, the level of non-farm income would be largely exogenous to the adoption decision.

Slope of the field is the only indicator used as a proxy for the erosion potential. Although the erosion potential depends on rainfall pattern, soil physical characteristics and slope in a complex way, the nature of the data collected does not permit the inclusion of factors other than slope. In addition, rainfall patterns and soil physical characteristics may not vary much from field to field within a location.

The results of the probit analysis are presented in Table 6. Two separate probit equations were estimated for each site after an F-test for the null hypothesis of no structural differences between the data from Cebu and Claveria turned out significant. A test of multicollinearity among the independent variables did not indicate collinear relationships among the variables to be a problem. The condition number (Belsley et al., 1980) was used to determine the presence of multicollinearity.

Adoption in Claveria is found to be significantly influenced by the age of the household head, ownership of the land, and slope. The results suggest that a farmer who is younger, owns the farm, and operates a field with steeper slope is more likely to adopt the contour hedgerow technology. The likelihood of adoption in Claveria is estimated at 46% on average. For Cebu, adoption is significantly influenced by the level of education, membership in *alayon*, slope, and market access. The effect of all these variables on adoption is positive. The likelihood of adoption in Cebu is estimated at 51% on average. If only the significant factors in these two sites are considered, they are age of the farmer, level of education, land ownership, membership in alayon, access to markets, and slope [6].

[6] Given the nature of the data collected, it is not possible to explain the reasons for the different sets of factors that significantly affect adoption in these two locations. A more in-depth study of the differences in the production systems in these two sites is needed to provide a satisfactory answer to this question.

Table 7
Average labor mandays per hectare for construction and maintenance of contour hedgerows, by type of hedgerows

	Natural vegetative	Planted species[a]	All
Construction	12.4 (13.9)[b]	55.1 (63.7)	48.9 (58.9)
A-frame construction	0.0	0.5	
Layouting	1.6	9.5	
Plowing	10.1	8.1	
Shoveling	0.7	22.5	
Hauling of planting materials	–	5.3	
Seeding/planting	–	9.2	
Maintenance	13.2 (13.9)	13.5 (13.8)	13.5 (13.7)
Fertilizer application	–	0.1	
Pruning and weeding	13.1	10.7	
Replanting	–	0.9	
Gully repair	0.1	1.8	

[a] Includes leguminous species, forage grasses and perennial species.
[b] Figures in parentheses are standard deviations.

The effect of land ownership turned out to be significant in Claveria but not in Cebu. The difference in the importance of ownership in determining adoption behavior in these two sites indicates that ownership is not a good proxy for security of tenure in the uplands of the Philippines. There are other factors such as the patron–client relationship between the tenant and landlord and kinship relations that may provide security of tenure even if the land is not owned. Obviously, these conditioning social factors vary from location to location. Similarly, the different sets of significant variables, except for the field slope, in these two locations also makes it difficult to generalize the results across locations. This can make the task of designing policy and institutional interventions much more difficult since a blanket approach would not be appropriate. A multi-site comparative study backed up by a detailed characterization of the production systems in each site may be needed to identify the intermediate conditioning factors that generate variability in responses.

4.6. Returns to adoption

Data problems beset a truly dynamic cost-benefit analysis of investment in contour hedgerows. Two major relationships are required. The first is the relationship between erosion (or soil depth) and productivity. The second is the relationship between conservation measure and soil erosion. The time path of land productivity with erosion control measure can be predicted by combining these two relationships. Considerable investments in research efforts have been made to understand the nature of these relationships, as well as to develop simulation models to predict the effect of soil conservation practices on productivity. Although several models with different degrees of sophistication are now available (Young and Muraya, 1990; McCown et al., 1995), the practitioner is constrained by the fact that the calibration and validation of these models often require considerable data and, sometimes, the reworking of some of the relationships.

Given the difficulties mentioned above, a somewhat simpler approach of relying on sensitivity analysis to highlight the major factors that determine the profitability of investment in soil erosion control is undertaken instead of conducting a full-fledged cost-benefit analysis. Temporal patterns of changes in yield from fields with and without contour hedgerows are ignored in this approach and, instead, yield is assumed to remain constant over time at their respective levels in both situations. The average cost of establishing contour hedgerows (49 mandays), the average annual cost of maintenance (14 mandays), and the proportionate area lost to hedgerows (20%) are obtained from the survey data (Table 7). The percentage increase in yield of maize required to recoup these costs at different discount rates are calculated assuming the life of contour hedgerows to be 10 years[7]. As adoption of contour

[7] Contour hedgerows assist in the formation of flatter alleys that could be maintained at a relatively low cost almost indefinitely. The assumed life of 10 years provides a somewhat conservative estimate of the benefits of contour hedgerows.

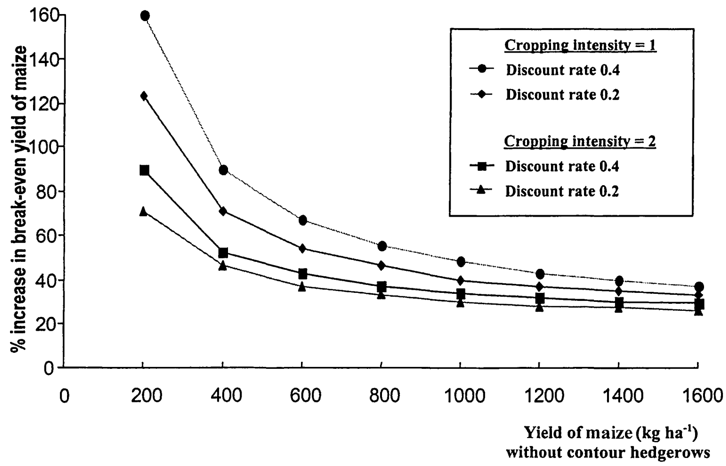

Fig. 2. Percentage increase in yield of maize needed for investment in contour hedgerows to break-even at different discount rates and cropping intensity.

hedgerows may encourage intensification of production, two levels of cropping intensity are also considered, namely, single cropping (cropping intensity = 1) and double cropping (cropping intensity = 2) [8].

The results presented in Fig. 2 indicate that the breakeven increase in percentage yield declines rapidly with the increase in base yield in the case of no conservation. In very poor environments where the maize yield is only 200 kg/ha, the breakeven increase in yield required is as high as 160% under a 40% discount rate and single cropping scenario. On the other hand, the required yield increase is only 26% under the most favorable scenario of maize yield of 1.6 t/ha, a 20% discount rate, and double cropping assumption. These results highlight a paradox. A much higher increase in productivity is needed to persuade farmers to adopt conservation practices in relatively low-yielding (or more degraded) environments where investment in soil conservation may be most needed to prevent further erosion. In contrast, yield gains required are much lower in relatively high-yielding (or less degraded) environments where the need to conserve soils may not be so apparent. These suggest that agricultural researchers face a much tougher challenge in making investment in soil conservation economically attractive to farmers in areas with low initial productivity. It may be difficult to justify soil conservation in these degraded marginal areas on the basis of on-site benefits alone. On the other hand, even if the on-site benefits are low, off-site effects may be large enough to justify a publicly-assisted conservation program in these low productivity environments. Further research on the off-site benefits from soil conservation is needed to address this issue which is beyond the scope of the present analysis.

The breakeven increase in yield is lower if the adoption of contour hedgerows subsequently encourages cropping intensification (or helps generate more income by encouraging farmers to switch to high-value crops). In areas with more favorable climatic conditions, an improvement in market access may, thus, promote adoption by facilitating crop intensification or a switch to cash cropping. Yield-increasing technologies may also similarly foster adoption.

Why do farmers need such a large increase in yield, especially in areas with lower initial productivity? Is investment in contour hedgerows too costly? Which of the three components of cost matters the most? To answer these questions, the above analyses are repeated for different scenarios of cost reduction. The base values assumed are maize yield of 400 kg/ha, a 20% discount rate, and single cropping. The analysis is done by changing one of the cost components at a time while keeping the other two fixed at their base

[8] Although we have assumed that contour hedgerows may lead to intensification through more frequent cropping, changes in farming practices (such as the use of more input) may be the source of additional profits while the cropping intensity remains constant. The outcome of the breakeven analysis is independent of the mechanism through which additional profits are generated.

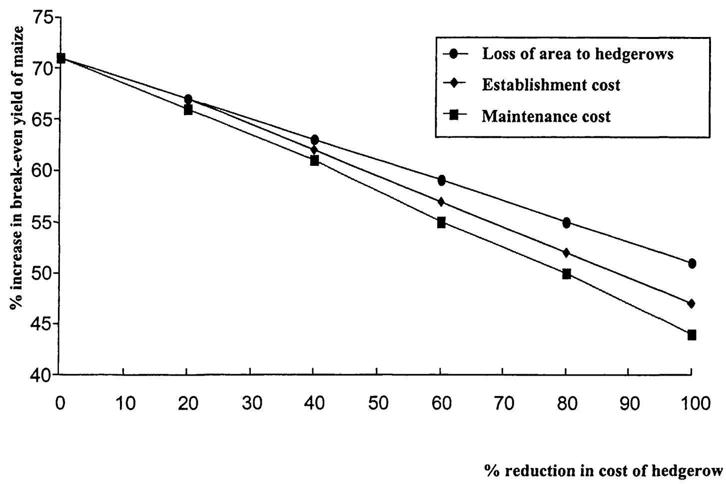

Fig. 3. Percentage increase in yield of maize needed for investment in contour hedgerows to break-even under different percentage reduction in cost.

values. The results presented in Fig. 3 indicate that among the three cost components, the breakeven increment in yield declines most rapidly with a given percentage reduction in the cost of maintenance. This result is consistent with farmer perception that the maintenance of hedgerows is a problematic aspect of the contour hedgerow technology. Careful selection of hedgerow species that require minimal maintenance could improve the benefits from adoption.

Natural vegetative strips are believed to be the least costly in terms of establishment as well as maintenance. Although the estimate of the average maintenance cost of natural vegetative strips is almost the same as that of planted species, the average establishment cost of the former is much lower (Table 7). It is not surprising, therefore, that these systems are becoming more popular. The major cost of establishment of planted species is the cost of the planting material, the cost of transportation, and the cost of shoveling to prepare the planting area. Farmers using natural vegetation do not incur these costs, hence, the overall cost of establishing hedgerows is much lower. If the cost of maintenance of natural vegetation and the loss of land could be reduced to 3 mandays and 7%, respectively, the breakeven increment in yield for the base values used in Fig. 3 is estimated to be only 25% which is a more achievable target. This will certainly make natural grass-based contour hedgerows more economically attractive compared to hedgerows of other species. Grasses that are not too tall and whose growth can be checked effectively by small quantities of herbicides could substantially reduce the maintenance cost. The loss of land could also be minimized by widening the alleys. Research to find ways to reduce these costs under a range of environmental conditions is, therefore, warranted.

5. Concluding remarks

The large body of literature on adoption of high-yielding varieties and crop management technologies in developing countries points towards a number of factors that condition the adoption of some of these seemingly profitable technologies (Feder et al., 1985; Smale et al., 1994). Even for these technologies that produce economic returns within a production cycle, the conditioning factors operate in quite complex and interactive ways. A relatively longer time required for the realization of benefits of soil conservation means that benefits are likely to be more uncertain. Informational problems limit farmers' ability to correctly anticipate the long-term productivity consequences of current land use practices. This along with failures in land and credit markets–common features of many developing countries–increases the risk and makes conservation investment economically less attractive. The risk cannot, however, be reduced simply through the usual extension approach as the processes that affect land productivity are still imperfectly understood. Empirical estimates of erosion-productivity relationships tend to be site-specific and typically have wide confidence intervals (Anderson and Thampapillai, 1990). The situation becomes worse if off-site effects are also considered. Given this uncertainty, it is difficult to predict economically tolerable rates of erosion applicable to different types of production systems. A major challenge to the researchers hence is to develop methods and tools that permit a more reliable prediction of on-site and off-site effects of various land management practices. Such information would then provide a more scientific basis for developing policy and institutional interventions to encourage adoption of soil-conserving practices. In the mean time, lessons from micro-economic studies of adoption behavior such as the ones reported in this paper may have to be utilized to guide the formulation of conservation strategies and approaches.

An important implication of the results presented in this paper is that policy support to increase farm production, as well as to encourage a switch from low-value subsistence crops to high-value cash crops would improve the returns to investment in soil conservation. Without access to improved technologies and better marketing infrastructure, farmers are unlikely to view investment in soil conservation as being economically worthwhile. Investment in rural infrastructure and policies to facilitate the development of an efficient marketing system could, therefore, encourage adoption. Promoters of soil conservation technology have to consider it not in isolation but as an integral component of interventions designed to increase the profitability of the overall production system. A paradigm shift from that of finding a technical fix to the problem of soil erosion towards that of improving the farmers' income by facilitating a transition to more remunerative land use systems is needed. Otherwise, research efforts are unlikely to make a significant dent on the problem of continuing erosion in the sloping uplands of Asia.

The results also highlight the need to reduce the cost of adopting contour hedgerows, the need to provide a range of options, and the need for better targeting. Contour hedgerows, especially of planted species, are found to be too expensive by most farmers. Reducing the cost of establishment and maintenance will certainly improve the economics of contour hedgerows. The recent popularity of hedgerows of natural vegetation is due mainly to its cost advantage.

Contour hedgerows are but one of the many practices to reduce soil erosion. Farmers in the study area use many other complementary and substitute methods ranging from contour plowing, mulching, other physical barriers, diversion canals, and fallowing. One or a combination of these methods may be more suitable in a specific situation depending on field conditions and farmers' resource constraints. Promotion of these other methods and improvement in their effectiveness will provide more choices to farmers so that they can select methods that they consider to be the most appropriate to their situations. Most often, promotional activities narrowly target a specific technology and ignore other options that may be equally or more effective than the one being promoted. An output-oriented (such as area covered by different soil conservation methods, the extent of soil erosion reduced) rather than a physical target-oriented (meters of contour hedgerows established) incentive structure may encourage extension agents and technology promoters to take a broader perspective. In the more marginal areas where soil conservation may be most needed to prevent soil erosion, on-site benefits alone may not be sufficient to justify investment in soil conservation. Off-site effects may be large enough to justify the use of public funds to finance a conservation program in these low productivity environments.

A range of field, farm, and farmer-specific factors condition the adoption of soil conservation technology. Although factors such as low population density, low slope, insecurity of tenure, low initial productivity, and limited access to market are expected to discourage adoption, the response may vary across sites as indicated by the empirical results in this paper. Technology targeting would, therefore, require a detailed characterization and identification of conditioning variables that alter responses to different interventions.

The recent changes in the production systems in the Asian uplands indicate that factors that lead to the adoption of erosive land use practices often originate outside the upland systems. Policies that encourage a subsistence mode of agricultural production and reduce labor absorption outside agriculture are major contributing factors to land degradation in the uplands. In addition, ill-defined and unenforceable property rights to land can aggravate the degradation problem. Hence, institutional and policy reforms, as well as technologies that not only reduce soil erosion but also directly increase farmers' income are needed. A greater understanding of the dynamics of land use changes in the uplands is likewise essential in designing technological, institutional, and policy interventions for reducing soil erosion and enhancing sustainability.

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