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Adoption of Contour Hedgerows by Upland Farmers in the Philippines: An Economic Analysis

Ma. Lucila A. Lapar, Sushil Pandey, and Herman Waibel

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Adoption of Contour Hedgerows by Upland Farmers in the Philippines: An Economic Analysis

Ma. Lucila A. Lapar, Sushil Pandey, and Herman Waibel*

Introduction

Soil degradation through physical loss (or erosion) is an important problem, especially in the sloping uplands of the humid and subhumid tropics. These areas have highly erodible soils and high-intensity rainfall. Farmers in the humid tropics of Asia grow a range of subsistence crops in sloping and marginal uplands and often use highly erosive practices (Garrity et al 1993). In addition to decreasing *in situ* productivity, these practices also reduce the sustainability of lowland agriculture through siltation and damage to irrigation infrastructure (Francisco 1994).

Under what conditions will farmers adopt practices that conserve soil? Experiences from many projects indicate that the problem is often not the lack of technology per se but an ill fit of the technology being promoted with the socioeconomic 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 bench terraces have had little success in creating wider impact because of their high costs. Other less costly technologies such as contour hedgerows (CH), contour plowing, and cover management have also been adopted, but sporadically. Overall, various interventions designed to promote the adoption of conservation techniques seem to have had a limited impact on soil conservation.

The soil degradation problem in the Philippine uplands could be the direct result of several factors: (1) lack of or limited effective technical or social solutions to alleviate poverty and environmental problems in these areas, (2) unclear official responsibility for land use, (3) unclear property rights to sloping public upland areas, and (4) greater degrees of poverty and illiteracy in upland communities, making it difficult to transfer knowledge and provide services for more sustainable agricultural production (Sajise and Ganapin 1991, USAID 1995).

Several government projects with funding from international donors were begun to introduce and spread hillside conservation farming practices aimed at managing sloping upland soils for sustainable crop production. Programs in agroforestry and watershed management—for example, the Integrated Social Forestry Project of the Department of Environment and Natural Resources (DENR) and the Central Visayas Regional Project of the Department of Agriculture (DA)—have always had a soil conservation component. More often than not, these programs provide direct incentives to farmer-participants to adopt the suggested soil conservation technology. Some nongovernment organizations (NGOs) have likewise begun community development projects with soil conservation components, such as those undertaken by the World Neighbors and the Mag-uugmad Foundation, Inc. Although some of these initiatives successfully convinced farmers to adopt soil conservation technology, others were not quite as effective. Apparently, direct incentives alone

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do not guarantee adoption even if such incentives appear to have increased adoption rates under several government-sponsored projects.

This socioeconomic study of the adoption of CH technology by upland farmers in the Philippines is part of a project by the Upland Rice Research Consortium in South and Southeast Asia that aims to address the major constraints to productivity and sustainability of upland rice-based farming systems. The major objectives of the study are to (1) analyze costs and returns associated with adoption, (2) estimate productivity effects of adoption of a soil conservation technology, (3) determine the socioeconomic factors that affect farmers' adoption decisions, (4) evaluate farmers' perceptions of the advantages and disadvantages of adoption, and (5) derive policy implications from empirical findings. Although the study looks at soil conservation in general, it focuses on a particular soil conservation technology, the contour hedgerow. This soil conservation practice has been widely promoted in the Philippine uplands since the early 1980s. Funding for the study came from the Federal Ministry for Economic Cooperation (BMZ)/German Agency for Technical Cooperation (GTZ).

This report is structured as follows. The first part discusses CH systems and gives some background information regarding various efforts to promote this technology in upland areas of the Philippines. The next section presents a microeconomic model for analyzing factors that influence adoption. The next part describes the characteristics of production systems and discusses incentives for soil conservation. The next section analyzes the relationship between property rights and soil conservation, followed by descriptive results of empirical work conducted in the Philippines. Subsequent sections present an econometric analysis of the productivity effects of CH and the factors determining adoption. A benefit-cost analysis of CH systems for the Philippines follows. The final section synthesizes the results and implications for policy and technology development and dissemination.

The contour hedgerow technology

Contour hedgerow intercropping or alley cropping on sloping lands is an agroforestry practice of planting leguminous plants on the contour to provide green leaf manure to fertilize annual crops and serve as a barrier to soil loss (Garrity 1994, Ehui 1993). The hedgerows are cut back at the time of planting of the food crops and are periodically pruned during cropping to prevent shading and to reduce competition with associated food crops. The major advantage of the CH system is that it allows simultaneous fallow—i.e., the cropping and fallow phases can take place concurrently on the same land, thereby making permanent cropping possible and overcoming the need for fallowing, which is characteristic of shifting cultivation systems (Garrity 1994, Ehui 1993). This technology appears to be an appropriate form of soil erosion control for areas with sloping land, permanent plow agriculture, intense rainfall, and land scarcity (Fujisaka 1993, Ehui 1993).

The CH system has emerged as the latest example of paradigm shifts in soil conservation (Garrity 1994). Soil conservation earlier emphasized the engineering approach; it then yielded to the biological approach that focused on the role of agroforestry in conserving soil. Subsequently, the pruned leguminous tree hedgerow concept of contour farming became popular as a way of creating simultaneous fallow. Results of global research on CH are not easy to generalize, but two major conclusions can be drawn from them. First, pruned tree hedgerows are not able to maintain an adequate nutrient supply to sustain annual cropping indefinitely without external nutrient application. Hence, hedgerows are not a viable alternative to fallow rotation in the absence of external nutrients, but rather an intermediate pathway between fallow rotation and continuous cropping with inorganic fertilizer. Second, farmer adoption of contour hedgerows has been limited because of the added labor needed for pruning and maintenance. Many options with the same soil conservation functions but less labor requirement and more economic benefits have been explored to overcome the limitations of pruned tree hedgerows. These options include the use of fodder grass strips and "cash perennials" such as fruit trees, coffee, and mulberry, among others.

The CH technology has been introduced into the Philippine uplands with various adaptations (Garrity et al 1993). *Leucaena* hedgerows were introduced in the mid-1970s. Applied research in various locations in the Philippines showed that *Leucaena* hedgerow intercropping produced crop yield increases ranging from 23% to 100% (Guevarra 1976, Vergara 1982, Alferez 1980). *Leucaena* hedgerows also provided a barrier to soil movement on sloping lands, resulting in a large reduction in both runoff and soil loss (O'Sullivan 1985). By the early 1980s, the DA advocated *Leucaena* hedgerow intercropping as a technology that was better able to sustain permanent cereal cropping with minimal or no fertilizer inputs and as a soil erosion control measure for sloping lands (Garrity et al 1993). The extension of this system among Filipino farmers was encouraged by the work of the NGO Mindanao Baptist Rural Life Center, which developed a 10-step program for farmer implementation of *Leucaena* hedgerows. This program was called the Sloping Agricultural Land Technology (SALT) and, by the mid-1980s, the DA adopted it as the basis for its extension effort in the uplands. The DENR likewise used it as the technical basis for its social forestry pilot projects. Some adoption of *Leucaena* hedgerows occurred in the high-intensity extension projects, but there was little evidence of widespread farmer interest in the SALT system. This could be due to the lack of secure land tenure, large initial investment in labor, difficulty in obtaining planting materials, and technical training and information required for sustained implementation (Garrity et al 1993). Aside from *Leucaena,* hedgerows of other species were also used—*Gliricidia sepium, Flemingia congesta, Acacia vellosa, Leucaena diversifolia*, and *Cassia spectabilis.*

Contour bunding with hedgerows was introduced by the World Neighbors, another NGO, as part of an approach oriented toward developing a high degree of direct participation by farmers in devising and implementing local solutions to the perceived dominant constraints to crop cultivation on steeply sloping lands (Garrity et al 1993). The bunds provided a base for the establishment of double-CH of leguminous trees or forage grasses and a barrier to surface runoff, which leaves the field in contour ditches. The CH concept was also applied to strongly acidic upland soils by the International Rice Research Institute (IRRI) and the DA (Fujisaka and Garrity 1988). Field experiments showed that, after 3 yr of hedgerow intercropping, a striking natural development of terraces occurred (Garrity et al 1993). Yield increases were also observed (Basri et al 1990, Mercado et al 1992). On the other hand, crop yields were seriously reduced in rows adjoining the hedges, with or without the application of external nutrients. This is also referred to as the scouring effect that degrades soil resources in alleyways. Experience in Claveria, Misamis Oriental in Mindanao, showed that farmer adaptations of the CH technology evolved into a technology featuring an A-frame contour layout, with plowing and shoveling as options, and farmer-selected combinations of native and planted grasses (such as species of *Setaria* and *Brachiaria brizantha*), pasture legumes (such as *Stylosanthes guianensis*), tree crops (such as mulberry), and perennial crops (such as pineapple) (Fujisaka 1993). An indigenous contour hedgerow technology was also reported to be practiced in Matalom, Leyte (Ly Tung and Alcober 1991).

Adoption of contour hedgerows has been short-lived. Farmers were observed to have "abandoned" the hedgerows or allowed them to lie fallow because of several technical reasons (Fujisaka and Cenas 1993). This led to the observation that the technology had "failed." Garrity (1994), however, contends that fallowing of hedgerows is not really an indication of failure but rather a rational response of farmers to the continued decline in soil productivity in the absence of external nutrient inputs. Contour hedgerows can be managed in a fallow rotation system. They do not completely eliminate fallowing; rather they enhance the process by shortening the fallow period while lengthening the cropping period. They also reduce labor for reopening of land and for subsequent weeding. Furthermore, they can produce wood, fodder, and other products of economic value.

Recent work funded by the Australian Centre for International Agricultural Research investigated farm-level factors associated with the adoption of contour hedgerows in eight case-study areas in the Philippines (Garcia and Gerrits 1995, Garcia et al 1995-97). Empirical results indicate that readily measurable personal attributes of farmers such as age and education were not important in explaining adoption, but the less easily measured personality traits related to innovativeness and managerial ability were clearly critical, particularly among early adopters (Cramb and Nelson 1997). In terms of farm-specific factors, adoption was more likely on fields that are larger and steeper, have more erodible soils, are located closer to the homestead, have relatively more uniform terrain, and are oriented down (rather than across) the terrain (Cramb and Nelson 1997). Insecurity of land tenure as well as liquidity constraints arising from low cash income are among the major constraints to adoption identified in the study. Results of cost-benefit analyses show that hedgerow intercropping can potentially sustain maize production relative to the traditional method of open-field farming by controlling erosion and contributing nitrogen to the cropping alleys (Nelson et al 1996a).

The experience with contour hedgerows over the past 20 years suggests that it is a potentially beneficial technology that has certain limitations. In spite of the improved basic knowledge about this technology, there is still room for technical and economic analysis to develop practices that are more easily adoptable and adaptable by farmers in a wide range of socioeconomic and biophysical conditions.

A microeconomic model of soil conservation

Several socioeconomic factors affect farmers' decisions to adopt or not adopt a soil conservation technology. These factors determine the general socioeconomic milieu in which the farm operates and may be considered farm-specific, farmer-specific, or technology-specific. Institutional and policy factors determine the incentives for adopting conservation practices. These include security of tenure, economic returns to agriculture vs other enterprises, and access to technical assistance and inputs. Farmer-specific factors are farmers' goals, their perceptions, and their resource constraints. Farm-specific factors are related to the biophysical characteristics of the production system such as soil characteristics, field slope, and climate. Technology-specific factors are features of the technology available to farmers. Figure 1 presents these factors and their interactions.

The factors indicated in Figure 1 are the same ones that have been studied widely in the context of adoption of modern crop varieties and associated crop management technologies (Feder et al 1985). But soil conservation technologies differ from varietal and crop management technologies in that the former represent an investment that generates a stream of benefits into the future while the latter generate returns within a shorter time horizon. For soil conservation to be economically viable, the present value of the stream of benefits must exceed the present value of its cost. Appendix A presents a formal multiperiod model for analyzing the economics of soil conservation. Based on this model, two important factors that critically determine the economics of soil conservation are the discount rate and farmer perceptions about the size of future benefits.

The discount rate measures the rate at which farmers are willing to trade off future consumption for current consumption. Future consumption is valued less when the discount rate is higher. A poor farmer who is striving to survive is likely to have a very high discount rate and may not be willing to sacrifice current consumption for future benefits, even though those benefits could potentially be high. On the other hand, farmers who have a lower discount rate are more likely to adopt soil conservation practices, with other things remaining the same.

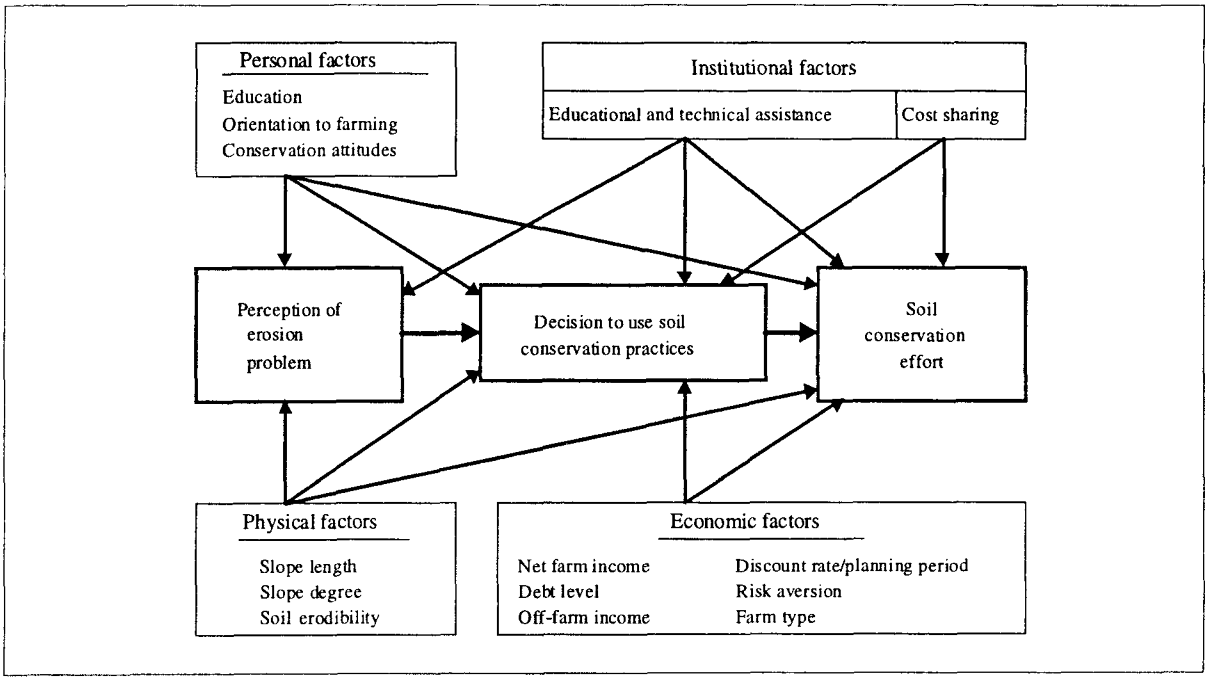

Fig. 1. Decision-making process for the use of soil conservation practices (Ervin and Ervin 1982).

As benefits accrue in the future, farmer perceptions of the size of the future benefits also play a critical role in adoption decisions. Informational problems about the effect of soil management practices on future benefits may lead farmers to substantially underestimate the size of such benefits.

The nature of the production system and soil conservation

The characteristics of the production system at any time result from an interplay between farmers' attempts to change it in a particular way to meet their goals and the environmental factors that determine what is feasible. The three major determinants of the nature of the production system are population density, market access, and agroclimatic conditions (Boserup 1965, 1981, Pandey 1996). Figure 2 shows a simplified construct based on population density and market access. When 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 yield. As a result of the lack of investment, land quality suffers over time until the field is finally abandoned and the farmer moves to a new area. During the long fallow period, natural regeneration may restore soil productivity enough to allow recultivation of the field. Incentives for soil conservation under this situation will be minimal.

When the land frontier is closed, further increases in population provide incentives for intensifying agricultural production so that sedentary farming systems evolve (type II). Farmers attempt to be self-sufficient by producing a range of agricultural outputs under a subsistence mode of production in the absence of markets. As the scope for increasing area is limited, the only option available is to improve 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 investing in soil quality is also a way of improving productivity, whether farmers will actually do so will depend on several factors that determine economic incentives. Where such incentives are lacking, soil degradation will continue

		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. 2. Effect of market access and population pressure on land use and sustainability (Pandey 1996).

until migration reduces population pressure or the area itself is abandoned.

When population density is low but market access is well developed, plantation-type commercialized production systems will probably emerge (type III). Annual or perennial food/fiber or industrial crops predominate depending on market conditions. On the other hand, commercialized production systems based on food and cash crops 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 the soil and encourage adoption of conservation practices. 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 if limited security of tenure restricts the planning horizon, farmers may allow the land to degrade.

Intensification, property rights, and soil conservation

Extended 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. Under what conditions is land-use intensification 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 that determines incentives to conserve land quality. If property rights to land are well defined and enforceable, farmers will have incentives to conserve the soil because future benefits from soil conservation will accrue to farmers who make 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 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 then abandoned the fields. Because these fields did not belong to the farmers, they had no incentive to conserve the productive capacity of such fields.

Possession of a legal title to land is not necessary, however, 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 recognition system provides the security of tenure that a legal title does not necessarily provide. The community land recognition system can assign rights to own, use, and transfer land in the same way that a legal title does, but often at a much lower cost because of community enforcement. In fact, government attempts to replace the community land recognition system with legal titles that are costly to enforce have often increased the insecurity of land tenure in many societies (Bromley 1992).

How do property rights to land evolve as land use is intensified? The theory of induced innovation indicates that when land-use intensity is low, property rights to land tend to be nonspecific and use-based (Hayami and Ruttan 1985, Binswanger and Pingali 1987). As land-use intensity increases because of 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 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 the adoption of agricultural practices that are not sustainable. If such areas happen to be sloping uplands with highly erosive soils, land degradation in such societies can be a severe problem. The adoption of conservation practices can be encouraged under such conditions by reducing the pressure to intensify and by developing an appropriate system of property rights.

The existence of well-defined and enforceable property rights to land is a necessary but not a sufficient condition for adoption. The adoption of soil conservation practices depends 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 linked to 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 perennial crops is minimal because 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 a 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 long-run sustainability is threatened. The history of upland development in the Philippines, Vietnam, and Thailand highlights the effects 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 1970s and 1980s has been attributed mainly to the stagnant productivity of rice in the lowlands, a high rate of population growth, and the low absorptive capacity of the nonfarm sector. This migration, coupled with poorly defined property rights in the uplands, is considered to be the main 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 1980s 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 upland production systems in Thailand (Shinawatra 1985). 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, rapid growth in the nonfarm sector helped to siphon off the excess population from these fragile upland areas and subsequently reduced 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 is a case in point. Despite a fivefold 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.

Microeconomic evidence from the Philippine uplands

Study area and sampling design

Claveria and Cebu are the two major sites in the Philippines where the CH technology was actively promoted in the early 1980s. World Neighbors, in collaboration with the DENR, promoted a range of soil conservation practices including contour hedgerows. The soil conservation technology was a component of the overall technology to encourage a shift in production systems from food crops to cash crops. Overall, the CH technology spread around the initial target area and the Cebu case is often cited as a successful example of soil conservation technology adoption (Garcia and Gerrits 1995).

In 1985, IRRI began a farming systems research project in the acid uplands of Claveria, Misamis Oriental, in collaboration with the DA. A contour hedgerow-based farming system was promoted using the farmer-to-farmer extension approach based on the strategy used by 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 CH systems of these farmers in 1995. Although contour hedgerows were considered not useful and subsequently abandoned by about 25% of the initial adopters, others modified and/or maintained their hedgerow structures.

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

The sampling design used to select farmers was stratified and purposive. Because the study aimed to carry out an in-depth analysis of adoption behavior, farmers were divided into two strata—adopters and nonadopters. Adopters were farmers who have established contour hedgerows in at least one parcel of their farms, who were cultivating and maintaining their contoured parcels, and who had engaged in crop production during the year before the survey. The sample consisted of 39 adopters and 21 nonadopters from nine *barangays* (villages) in Claveria and 35 adopters and 35 nonadopters from six barangays in Cebu[1]. To reduce the effect of environmental variations, nonadopters were selected from the same barangays and, where possible, farmers with fields adjacent to the CH fields of the adopters were chosen. 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, the nature and extent of adoption of contour hedgerows, adoption of soil conservation practices other than CH, and farmers' perceptions regarding advantages/disadvantages of CH was collected. Interviews with key informants including government officials, nongovernment organizations, and other government agencies engaged in soil conservation were also conducted. The farm-level data on production systems collected during the survey pertain to the 1995 cropping season.

Demographic characteristics of respondents

The heads of households who have adopted contour hedgerows are, on average, about 2 yr younger than the heads of nonadopting households (Table 1). This age pattern is similar to that observed in Cebu, where the average age of the heads of adopting households is about 5 yr lower than the average age of nonadopters (the difference is statistically significant at the 10% level based on the t test). On the other hand, a different age pattern is shown in Claveria, where the heads of adopting households are about 3 yr older than the heads of nonadopting households (but the difference is not statistically significant).

The heads of adopting households also have more schooling than those of nonadopting households. On average, the heads of adopting households have spent about 2 more years in

Table 1. Selected demographic characteristics of respondents, by adoption status.

Characteristic	Claveria		Cebu		All	
	Adopters	Nonadopters	Adopters	Nonadopters	Adopters	Nonadopters
Mean age[a]	45.8 (11.8)	42.9 (1.0)	44.1* (12.2)	49.7 (13.3)	45.0 (11.9)	47.2 (12.8)
Mean years in school[a]	6.8 (3.3)	6.2 (3.6)	5.3*** (2.7)	3.0 (2.3)	6.1*** (3.1)	4.2 (3.2)
Mean household size[a]	6.8 (2.9)	6.5 (2.6)	5.7 (2.4)	6.0 (2.4)	6.3 (2.7)	6.2 (2.5)
Mean distance of home from nearest road (km)[a]	0.78 (0.93)	1.07 (1.00)	0.12 (0.20)	0.24 (0.49)	0.47 (0.76)	0.55 (0.82)

[a] Numbers in parentheses are standard deviations.*** t test for difference in means is statistically significant at the 1% level.* t test for difference in means is statistically significant at the 10% level.
Source of data: IRRI socioeconomic survey of upland farmers, 1996.

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[1] Appendix B shows the distribution of sample respondents by *barangay* in the two survey sites.

school than the heads of nonadopting households (the difference is statistically significant at the 1% level) (Table 1). Across sites, the heads of adopting households in Cebu attend school longer than do the heads of nonadopting households (statistically significant at 1%). Heads of adopting households in Claveria also have slightly more schooling than the heads of nonadopting households, but the difference is not statistically significant.

On average, the household size of both adopters and nonadopters is about the same—6.3 and 6.2, respectively (Table 1). By survey site, the nonadopters in Cebu have a slightly larger household size than the adopters, on average, while those in Claveria have almost the same household size as the adopters, on average. These differences are not statistically significant, however.

The distance of the house from the nearest road is one indicator of access to market. Adopters have relatively better market access than nonadopters in both Cebu and Claveria, as indicated by the shorter average distance of adopters' houses to the nearest road compared with that of nonadopters (Table 1). But these differences are not statistically significant.

Membership in the *alayon*, a local farmers' group with labor exchange mechanisms, is relatively higher among adopters than nonadopters (Table 2). Discussions with respondents indicate that membership in the alayon has helped relax the labor constraint in the construction of contour hedgerows. Adopters have also been members of such groups longer than nonadopters, on average.

The proportion of households with members who have previous training in soil conservation is larger among adopters than among nonadopters (Table 3). Adopters have also undergone the training much longer than nonadopters. With more family members trained or with knowledge about conservation practices and their benefits to farming, the household will more likely adopt a soil conservation practice.

Characteristics of landholding

Adopters operate a slightly greater number of parcels than nonadopters, on average, and this is statistically significant at the 10% level based on

Table 2. Membership profile in alayon.

	Claveria		Cebu		All	
	Adopters	Nonadopters	Adopters	Nonadopters	Adopters	Nonadopters
Percent share of alayon members	5	0	20	3	12	2
Total number of respondents	39	21	35	35	74	56
Av no. of yr as member of alayon[a]	1.9 (1.3)	–	1.3 (1.9)	0.1 –	1.4 (1.7)	0.1 –

[a]Numbers in parentheses are standard deviations.
Source of data: IRRI socioeconomic survey of upland farmers, 1996.

Table 3. Respondents and/or their household members with training in soil conservation and duration of training.

	Claveria		Cebu		All	
	Adopters	Nonadopters	Adopters	Nonadopters	Adopters	Nonadopters
With training in soil conservation[a]	21 (54)	1 (5)	21 (60)	6 (17)	42 (57)	7 (12)
Av no. of wk of training undertaken[b]	2.6 (4.9)	0.4 –	0.6 (0.8)	0.6 (0.3)	1.4 (3.3)	0.6 (0.3)

[a]Numbers in parentheses are percent shares of total. [b]Numbers in parentheses are standard deviations.
Source of data: IRRI socioeconomic survey of upland farmers, 1996.

the t test (Table 4). In terms of total area cultivated, adopters have a larger farm size than nonadopters, on average, although this is not statistically significant. Only in Cebu is the difference in farm size statistically significant. In Claveria, both the number of parcels operated and total area cultivated are slightly larger for nonadopters than for adopters, on average, although the difference is not statistically significant. For parcel size, there is no statistically significant difference between adopters and nonadopters. Across sites, the average parcel size of farms is relatively larger in Claveria than in Cebu.

The average slope of land cultivated by adopters is about 28% compared with about 25% for nonadopters. The difference is statistically significant at the 10% level (Table 4). Comparison by sites shows that farms in Cebu have steeper slopes than farms in Claveria, on average. Adopters at both sites likewise have farms with steeper slopes than those of nonadopters, on average, although only in Claveria is the difference in slope statistically significant.

The incidence of adoption of contour hedgerows on parcels owned and not owned is an indicator of the relationship between adoption and tenure status. Among adopters, about 42% of the parcels with CH are owned, whereas about 58% are not owned (Table 5). Across sites, the proportion of owned parcels with CH

Table 4. Selected characteristics of land operated, by adoption status.

Characteristic	Claveria		Cebu		All	
	Adopters	Nonadopters	Adopters	Nonadopters	Adopters	Nonadopters
Av no. of parcels operated household^{-1}	2.40 (1.50)	2.52 (1.36)	2.86*** (1.33)	2.02 (0.86)	2.59* (1.44)	2.21 (1.09)
Av area operated household^{-1} (ha)	2.78 (3.20)	3.50 (3.20)	2.16** (2.19)	1.28 (1.11)	2.49 (2.77)	2.11 (2.38)
Av parcel size (ha)	1.15 (1.64)	1.39 (1.14)	0.76 (0.86)	0.63 (0.63)	0.95 (1.31)	0.95 (0.96)
Slope (%)	24*** (14)	18 (11)	32 (12)	31 (10)	28* (14)	25 (12)

[a]Numbers in parentheses are standard deviations. *** t test for the difference between means for adopters and nonadopters is statistically significant at the 1% level. ** t test for the difference between means for adopters and nonadopters is statistically significant at the 5% level. *t test for the difference between means for adopters and nonadopters is statistically significant at the 10% level.
Source of data: IRRI socioeconomic survey of upland farmers, 1996.

Table 5. Frequency distribution of parcels according to ownership status and contour hedgerow adoption.[a]

Parcel	Claveria			Cebu			All		
	Adopters		Non-adopters	Adopters		Non-adopters	Adopters		Non-adopters
	With CH	Without CH		With CH	Without CH		With CH	Without CH	
Owned	37 (62.7)	18 (51.4)	21 (39.6)	23 (27.7)	10 (58.8)	19 (26.8)	60 (42.3)	28 (53.8)	40 (32.3)
Not owned	22 (37.3)	17 (48.6)	32 (60.4)	60 (72.3)	7 (41.2)	52 (73.2)	82 (57.7)	24 (46.2)	84 (67.7)
Total	59 (100.0)	35 (100.0)	53 (100.0)	83 (100.0)	17 (100.0)	71 (100.0)	142 (100.0)	52 (100.0)	124 (100.0)
Chi-square[b]	4.809**			0.759			5.383**		

[a]Numbers in parentheses are percent shares of total. [b]The chi-square test was performed for the categories of adopters (combined with and without CH parcels) and nonadopters.** Significant at the 5% level.
Source of data: IRRI socioeconomic survey of upland farmers, 1996.

among adopters is larger in Claveria than in Cebu. But the incidence of ownership among nonadopters is relatively lower. Owned parcels account for only about 32% of the total number of parcels cultivated by nonadopters. Statistical tests using the Cochran-Mantel-Haenszel chi-square also show a moderately strong positive association between ownership of land and adoption, as indicated by the statistically significant chi-square statistic. This positive association holds true in Claveria but not in Cebu.

Table 6 shows a disaggregation of tenancy status into three types as observed in the study—pure owner, pure renter, and both owner and renter. The last type is a respondent who, in addition to his or her own land, currenly rents land from other farmers. The proportion of pure owners among adopters is relatively larger than the proportion in the sample. On the other hand, the relative share of pure owners among nonadopters is smaller than the relative share in the sample. Pure renters have a smaller share among adopters but a larger share among nonadopters relative to the sample average. Thus, while there are relatively more renters than owners in the sample, there appear to be relatively more owners among adopters than among nonadopters.

Table 6. Distribution of respondents by tenancy status on all parcels operated in 1995, by adoption status.

Tenancy status	% share in the sample	% share among adopters	% share among nonadopters
Pure owner	29	34	23
Pure renter	53	46	63
Both owner and renter	18	20	14
Total	100	100	100

Source of data: IRRI socioeconomic survey of upland farmers, 1996.

Crop production

There are two main cropping seasons, the wet season or *panuig* and the dry season or *buklas*. The wet season usually starts in May-June and lasts until September-October. The dry season usually begins during October-November and lasts until March-April.

Maize is the main crop produced by both adopters and nonadopters during the wet season (Table 7). Farms planted to rice account for only about 6% of the total area planted by adopters and less than 1% of the total area planted by nonadopters. Comparison by sites shows that this pattern is similar to patterns found in Claveria and Cebu. These results suggest that wet-season production concentrates on food crops (maize, rice, and root crops), which are usually intended for consumption.

Dry-season production shows a different pattern, however. About one-fourth of the total area cultivated by both adopters and

Table 7. Cropping area by season, crop, and adoption status.

Season/crop	Claveria		Cebu		All	
	Adopters	Nonadopters	Adopters	Nonadopters	Adopters	Nonadopters
Wet season						
Maize (% area)	83	92	85	92	84	92
Rice (% area)	7	1	3	1	5	0.8
Root crops (% area)	1	2	2	0	1.5	1.5
Vegetables (% area)	9	5	8	6	9	5.5
Flowers (% area)	0	0	2	1	0.5	0.2
Total area (ha)	52.1	43.2	30.3	20.7	82.4	63.9
Dry season						
Maize (% area)	75	90	13.2	29.6	52	70
Rice (% area)	6	1.1	4.1	0	6	1
Root crops (% area)	5	0.1	3.1	2.8	4	1
Vegetables (% area)	4	0.2	24	10	11.5	3
Flowers (% area)	0	0	1.6	1.5	0.6	1
Fallow (% area)	10	8.6	54	56	25.9	24
Total area (ha)	52.1	43.2	30.3	20.7	82.4	63.9

Source of data: IRRI socioeconomic survey of upland farmers, 1996.

nonadopters is fallowed. Of the remaining area cultivated, about three-fifths and two-thirds are planted with food crops by adopters and nonadopters, respectively. There is a relative increase in the proportion of area planted to cash crops (vegetables and flowers) among adopters compared with nonadopters. This relative increase in area planted to cash crops by adopters during the dry season is very much apparent in Cebu but not in Claveria. Less than 5% of the total area planted by both adopters and nonadopters in Claveria has cash crops. In Cebu, on the other hand, the relative share of area planted to cash crops is larger than the relative share of area planted to food crops among adopters, whereas the relative share of area planted to food crops is about twice that of cash crops among nonadopters.

These differences in cropping patterns across sites could indicate differences in market opportunities resulting from differences in access to markets. As previously discussed, respondents in Cebu appear to have a much better access to markets because of their relative proximity to roads compared with respondents in Claveria. Thus, it appears that the cropping pattern of adopters in Cebu is in response to the prevailing market opportunities in the area. Second, by adopting a soil conservation technology such as contour hedgerows, adopters appear to have been able to take advantage of these market opportunities.

In terms of value of output[2] (in US$ ha^{-1}), adopters have a relatively larger output value than nonadopters, on average (Table 8). The value of output from CH parcels of adopters is also about three times that from their non-CH parcels, on average. Across sites, adopters in Claveria and Cebu have a relatively larger output value than nonadopters, on average. The difference in the ratio of value of output from parcels with CH compared with those without CH is lower in Claveria than in Cebu. This could be explained by the relatively higher incidence of cash cropping in Cebu.

Labor inputs per hectare incurred for crop production in 1995 are higher for adopters than for nonadopters, on average, although the difference is not statistically significant based on the t test (Table 9). Fertilizer application and harvesting account for the largest share of total labor input used by adopters in crop production, while nonadopters spend the largest share of labor in weeding operations. The difference in the observed labor use could be attributed to crop choice and cropping intensity—that is, more adopters produce vegetables and flowers, which are not only intrinsically input-intensive (require more fertilizer) but also labor-intensive, particularly during harvesting. Vegetables and flowers require more than one harvest compared with, say, maize. Statistical tests indicate that, among specific crop production activities, only in fertilizer application is the difference in labor

Table 8. Gross value of output ($ ha^{-1} yr^{-1}) produced by respondents in 1995.[a]

	Claveria		Cebu		All	
	Adopters	Nonadopters	Adopters	Nonadopters	Adopters	Nonadopters
All parcels	1,226	1,049	4,814	1,884	3,031	1,487
	(3,560)	(1,487)	(21,497)	(4,674)	(15,510)	(3,546)
Parcels with CH	1,676	–	5,226[b]	–	3,775	–
	(4,557)		(23,308)		(18,186)	
Parcels without CH	861	–	2,038	–	1,389	–
	(1,280)		(5,026)		(3,534)	

[a]Numbers in parentheses are standard deviations. US$1 = 25. [b]High value of output is due to some respondents engaging in cut-flower and high-value crop production.
Source of data: IRRI socioeconomic survey of upland farmers, 1996.

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[2]The heterogeneity of crops produced by respondents necessitated the conversion of yield into monetary terms for consistency. Output was valued at the market price prevailing at the time of harvest.

Table 9. Labor inputs for crop production (all crops) by respondents in 1995, by adoption status.[a]

Activity[b]	Adopters		Nonadopters	
	Person-d ha^{-1}	% of total	Person-d ha^{-1}	% of total
Land preparation	62 (58)	17	77 (106)	22
Seeding/planting	32 (36)	8	29 (34)	8
Weeding	62 (84)	17	88 (103)	25
Fertilizer application	79** (125)	21	39 (57)	11
Pest control	42 (82)	11	38 (102)	11
Harvesting	78 (103)	21	65 (103)	18
Postharvest	18 (54)	5	20 (52)	5
Total labor ha^{-1}	373 (373)	100	356 (332)	100

[a]Numbers in parentheses are standard deviations. [b]t tests for differences in means between adopters and nonadopters were conducted by activity. Level of significance is indicated by asterisks, as shown. ** Significant at the 5% level.
Source of data: IRRI socioeconomic survey of upland farmers, 1996.

input incurred by adopters vis-à-vis nonadopters statistically significant. In terms of input costs, adopters have spent about \$430 ha^{-1} compared with about \$130 for nonadopters, or about three times more for crop production inputs such as fertilizer, pesticides, and herbicides, on average. This difference in input costs is statistically significant at the 1% level.

To summarize, adopters show a different cropping pattern than nonadopters. That is, adopters are more likely to produce food crops during the wet season and cash crops during the dry season. In contrast, nonadopters are more likely to produce food crops during both the wet and dry seasons. This contrast in cropping patterns could be due to the market opportunities open to respondents. The results suggest that, with better market access, adopters are more likely to take advantage of market opportunities for both cash crops and food crops. Hence, there appear to be more incentives for adopters to adopt a soil conservation measure in order to maintain soil productivity and enable them to produce more output for sale in the market. The differences in crop choice between adopters and nonadopters are also reflected in the difference in value of output. Adopters have a larger output value than nonadopters. In terms of labor and input costs, adopters used more labor and inputs, particularly fertilizer, in their crop production activities in 1995. Again, these differences may reflect differences in cropping patterns where adopters are producing more labor-intensive cash crops than nonadopters.

Income sources and shares

Adopters have a relatively larger household income than nonadopters, on average (Table 10). Household income is defined as the sum of cash income from livestock, timber and fruit sales, and nonfarm activities and the value of crop production. Across sites, adopters in Cebu have

Table 10. Household income and percent share of income sources of respondents in 1995, by adoption status.[a]

	Claveria		Cebu		All	
	Adopters	Nonadopters	Adopters	Nonadopters	Adopters	Nonadopters
Household income[b](US$)	1315 (1148)	2869 (5683)	2902 (6689)	762 (1028)	2065 (4708)	1552 (3668)
% share of crop production	51.0	56.4	31.0	37.2	41.5	44.4
% share of livestock sales	20.4	17.4	22.3	22.9	21.3	20.9
% share of noncrop sales	5.6	4.7	8.8	10.2	7.1	8.1
% share of nonfarm income	23.0	21.4	37.9	29.8	30.0	26.6
Total	100.0	100.0	100.0	100.0	100.0	100.0
% share of nonwage income from nonfarm activities[b] to total nonfarm income	42	53	62	80	53	71

[a]Numbers in parentheses are standard deviations. [b]Household income is defined as the sum total of gross cash income from nonfarm activities, livestock sales, and sales of noncrop production such as timber and the value of crop production. US\$1 = 25. [b]Nonwage income from nonfarm activities includes remittances, land rent, business income, and other nonfarm income.
Source of data: IRRI socioeconomic survey of upland farmers, 1996.

a relatively larger household income than nonadopters, while the reverse is true in Claveria, where adopters have a relatively lower household income than nonadopters, on average.

In terms of sources of income, both adopters and nonadopters obtain the largest proportion of income from crop production, accounting for about one-third of total income, on average. Nonfarm income comes next, accounting for a little more than one-fourth of total income. Nonfarm income consists of off-farm wages, land rent, remittances, and business activities, usually trading. Income from the sale of livestock is ranked third among income sources. A comparison between sites shows that income from crop production is the largest source of income for both adopters and nonadopters in Claveria, whereas nonfarm income and income from crop production are the major sources of income among adopters and nonadopters in Cebu, on average. Income from livestock production accounts for about one-fifth of household income, on average. Among the livestock raised by respondents, cattle account for the largest share of sales, with adopters having a larger value of sales than nonadopters, on average. The main reason for the larger average cattle sales of adopters is that cattle dispersal is part of the adoption incentive package provided by projects that promoted the adoption of contour hedgerows in Cebu and Claveria. Noncrop production, consisting of timber and fruit production, accounts for the lowest share of household income among adopters and nonadopters, on average. Respondents reveal that the timber and fruits produced are mostly consumed at home or given as gifts to neighbors and friends, and that only a small proportion of total production is sold.

Soil conservation practices

Incidence of soil erosion and use of soil erosion control. To get an indication of the incidence of soil erosion on the parcels cultivated, respondents were asked whether they currently observe soil erosion on each of the parcels they cultivate. Hence, the incidence of soil erosion in this discussion refers to the observation by respondents of the presence (or absence) of soil erosion on each of the parcels being cultivated.

The incidence of soil erosion on all parcels cultivated is higher among nonadopters than among adopters of contour hedgerows. About four-fifths of all parcels cultivated by nonadopters are reported to have soil erosion, whereas only about two-thirds of all parcels with CH and one-half of all parcels without CH cultivated by adopters are reported to have soil erosion (Table 11). Across sites, the proportion of parcels reported as eroded is higher among parcels cultivated by nonadopters than among those cultivated by adopters in Claveria and Cebu. Statistical tests using the Cochran-Mantel-Haenszel chi-square indicate a strong negative linear association between respondents' perceptions of soil erosion and adoption of CH in Cebu and in the combined sample. This implies that the incidence of soil erosion after adoption is highly likely among nonadopters in Cebu and in the combined sample. Regression of adoption status on the farmers' perceptions of soil erosion on plots cultivated shows a statistically significant negative coefficient at the 1% level, implying that the incidence of soil erosion is negatively correlated with adoption of the CH technology.

Among contoured parcels in Claveria, the proportion of parcels reported as eroded is higher than those reported as not eroded and this could be due to the relative age of the contour structures (Table 11). The contour structures on parcels reported as not eroded have been constructed 3 yr longer, on average, than those on parcels reported as eroded. This difference is statistically significant at the 10% level using the t test. In Cebu, the proportion of CH parcels reported as eroded is almost the same as the proportion of those reported as not eroded. A comparison of erosion incidence among CH parcels in Cebu and Claveria indicates that the higher incidence of reported erosion in Claveria could be explained by the length of time that the hedgerows have been in place. The average age of CH structures among parcels observed with erosion in Claveria is about half the age of those

Table 11. Distribution of parcels cultivated where soil erosion is observed (after adoption of contour hedgerows) by respondents, by adoption status.

	Claveria			Cebu			All		
	Adopters		Non-adopters	Adopters		Non-adopters	Adopters		Non-adopters
	With CH	Without CH		With CH	Without CH		With CH	Without CH	
Reported by farmers as eroded									
No. of parcels[a]	47 (79.7)	19 (54.3)	42 (79.2)	42 (50.6)	7 (41.2)	60 (84.5)	89 (62.7)	26 (50.0)	102 (82.3)
Av slope[b]	29 (13)	23*** (11)	21*** (9)	32 (12)	37** (7)	15 (133)	30 (12)	27 (12)	17 (102)
Av age of CH[b]	5* (4)	–	–	10 (9)	–	–	8 (7)	–	–
Reported by farmers as not eroded									
No. of parcels[a]	12 (20.3)	16 (45.7)	11 (20.8)	41 (49.4)	10 (58.8)	11 (15.5)	53 (37.3)	26 (50.0)	22 (17.7)
Av slope[b]	26 (11)	9 (14)	7 (9)	33 (12)	24 (15)	26 (10)	31 (12)	15 (16)	16 (14)
Av age of CH[b]	8 (4)	–	–	9 (6)	–	–	9 (6)	–	–
Total no. of parcels	59 (100)	35 (100)	53 (100)	83 (100)	17 (100)	71 (100)	142 (100)	52 (100)	124 (100)
Chi-square[c]		1.409			22.517***			18.373***	

[a] Numbers in parentheses are percent shares of total. [b] Numbers in parentheses are standard deviations. t tests conducted to test for difference in means of slope and difference in mean age of CH of parcels reported as eroded vis-à-vis those reported as not eroded. Levels of significance are indicated with asterisks as shown below. [c] Chi-square test conducted for categories of adopters (combined with and without CH parcels) and nonadopters. Levels of significance are indicated with asterisks as shown. *** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level.

Source of data: IRRI socioeconomic survey of upland farmers, 1996.

in Cebu, such that the soil-conserving effects may not yet be clearly visible in the former compared with the latter. Interviews with adopters reveal that the terracing effect of CH becomes more pronounced after about 5 yr and only after that period is a reduction in soil erosion on the farm clearly visible.

Probit analysis determined the effect of slope and age of the CH structures. The probit model was estimated with erosion, a dummy variable having a value of 1 if the respondent perceives the parcel as eroded and 0 otherwise as the dependent variable. The independent variables are slope and age of the CH structures. The results indicate that incidence of soil erosion is negatively associated with age of CH structures and positively associated with slope, although the estimated coefficients are not statistically significant.[3]

Among noncontoured parcels cultivated by adopters, slope appears to make a difference in the incidence of erosion. Parcels reported as eroded have steeper slopes than those reported as not eroded, on average, and this slope differ-

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[3] The estimated probit model is:

$$\text{Prob(erosion)} = \underset{(0.26)}{-0.68} + \underset{(0.008)}{0.006} * \text{slope} - \underset{(0.008)}{0.005} * \text{age of CH}$$

where the numbers in parentheses are standard errors.

ence is statistically significant at the 1% and 5% level in Claveria and Cebu, respectively.

Adoption of contour hedgerow technology. The average parcel size with contour hedgerows is 0.8 ha for all adopters (Table 12). Adopters in Claveria have a larger average parcel size than adopters in Cebu (1.26 ha vs 0.49 ha). This result indicates the relative scarcity of cultivable land in Cebu compared with Claveria; it is a function of the differences in population density between the two sites.

The average slope of parcels with CH is about 30% (Table 12). Parcels in Cebu have relatively steeper slopes than those in Claveria, on average. Despite this physical condition that is highly conducive to soil erosion, there is, as discussed earlier, a lower incidence of soil erosion among adopters in Cebu. This could be explained by the longer history of adoption of CH in Cebu than in Claveria (as reflected in the average age of the CH structures).

Table 12. Selected characteristics of contour hedgerow establishments, by site.[a]

Characteristic	Claveria (n=39)	Cebu (n=35)	All (n=74)
Av parcel size (ha)	1.26 (5.44)	0.49 (0.66)	0.80 (3.50)
Av no. of parcels adopter^{-1}	1.4 (0.6)	2.3 (1.1)	1.8 (1.0)
Av total area adopter^{-1} (ha)	1.60 (0.62)	1.62 (1.58)	1.61 (1.37)
Av slope (%)	25.6 (6.5)	32.5 (12.0)	29.7 (10.6)
Av width of alley (m)	7.5 (4.4)	7.0 (5.1)	7.2 (4.8)
Av height of hedgerow riser (m)	0.7 (0.6)	0.9 (0.3)	0.8 (0.5)
Av width of hedgerow (m)	1.3 (0.9)	1.2 (0.4)	1.3 (0.6)
Av total length of hedgerows parcel^{-1} (m)	671.8 (1135.9)	461.3 (454.0)	546.5 (805.6)
Av length of CH ha^{-1} contoured (m)	1273.6 (805.9)	1288.2 (914.3)	1282.3 (868.9)
Av years of practice of the technology	5.4 (3.2)	9.8 (8.1)	8.1 (6.9)

[a] Numbers in parentheses are standard deviations.
Source of data: IRRI socioeconomic survey of upland farmers, 1996.

On average, a total of about 547 m of contour hedgerows have been established by each adopter on his/her parcel (Table 12). This is equivalent to an average of about 1,282 m of CH ha^{-1}. Across sites, the average length of CH ha^{-1} is slightly longer in Cebu than in Claveria.

Contour hedgerows are constructed on about three-fourths of the total area operated by all respondents, on average. Across sites, the extent of adoption is higher in Cebu than in Claveria (Table 13). The proportion of full adopters, or adopters who have constructed CH on 100% of their farm, is also higher in Cebu than in Claveria. A larger proportion of adopters in Claveria than in Cebu, on the other hand, have constructed CH on less than half of their farm. The much smaller average farm size in Cebu than in Claveria may explain why adopters in the former are able to construct CH on a larger proportion of their farm relative to the latter.

Construction and maintenance of contour hedgerows: NVS vs. non-NVS. Natural grasses are the predominant hedgerow species in the survey area (Table 14). This is followed by napier grass, with a larger share in Cebu than in Claveria. The relative popularity of napier grass in Cebu may be attributed to its limited grazing area such that napier grass hedgerows have

Table 13. The extent of adoption of contour hedgerows.

Extent of adoption	Claveria	Cebu	All
Percent share of contour hedgerow area to total area operated by adopters[a]	69.4 (33.0)	86.8 (23.2)	77.6 (30.0)
Percent share of full adopters[b]	46.2	62.8	54.0
Percent share of partial adopters			
At least 50% but <100%[c]	25.6	28.6	27.0
Less than 50%[d]	28.2	8.6	19.0

[a] Av share for all adopters. Numbers 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 of their farm. [d] Adopters who have established contour hedgerows on less than half of their farm.
Source of data: IRRI socioeconomic survey of upland farmers, 1996.

Table 14. Percent shares of parcels, by type of hedgerow species.

Species	Claveria	Cebu	All
Natural grass	47.1	44.8	45.8
Napier grass	18.9	37.2	29.9
Gliricidia sepium	9.4	6.4	7.6
Setaria sp.	9.4	2.6	5.3
Leucaena leucocephala	–	5.1	3.0
Others[a]	15.2	3.9	8.4

[a]Includes gmelina, guinea grass, banana, mulberry, pineapple, and ferns.
Source of data: IRRI socioeconomic survey of upland farmers, 1996.

become more valuable as fodder. Other major hedgerow species are *G. sepium*, *Setaria* sp., and *L. leucocephala*. There has also been an observed shift of hedgerow systems from non-natural vegetative strips (non-NVS) to NVS (Table 15). While many of those who started with non-NVS systems have continued to use them, about one-third have shifted to the NVS system. A larger proportion of those who changed from non-NVS to NVS systems are from Cebu. Among the reasons cited for the shift in hedgerow systems are the natural domination of grasses and the high mortality of the planted species.

Table 15. Temporal patterns of adoption of contour hedgerow species (% of parcels).

Category	Claveria	Cebu	All
Remain with NVS[a]	7.7	8.6	8.1
Change from non-NVS to NVS	23.1	48.6	35.1
Remain with non-NVS	69.2	42.8	56.8

[a]NVS = natural vegetative strips.
Source of data: IRRI socioeconomic survey of upland farmers, 1996.

The activities involved in establishing contour hedgerows include constructing the A frame, layouting, plowing of the portion already laid out, shoveling of soil to create bunds, hauling of planting materials (if necessary), and planting or seeding of hedgerow species. On average, it requires about 12 person-d ha^{-1} to construct hedgerows with NVS, while it requires about 55 person-d ha^{-1} to construct hedgerows with planted species (Table 16). The large difference in labor requirement is due to the relatively larger share of labor for shoveling the soil to form contour bunds in the non-NVS hedgerow system. The non-NVS system also requires more labor to do a field layout. Additional labor is also used to haul planting materials as well as to plant the hedgerow species.

Maintenance activities include application of fertilizer on hedgerow species (if necessary); weeding, pruning, and replanting of hedgerows; and repair of destroyed gullies. While there is a large difference in labor use for construction between NVS and non-NVS hedgerows, the maintenance activities require approximately the same amount of labor, on average, for the two systems. The largest share in total labor needed

Table 16. Average labor use per hectare for construction and maintenance of contour hedgerows, by type of hedgerow.[a]

Activity	Natural vegetative strips (person-d ha^{-1})	Planted species[b] (person-d ha^{-1})	All (person-d ha^{-1})
Construction	12.4 (13.9)	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]Numbers in parentheses are standard deviations. [b]Includes leguminous species, forage grasses, and perennial species.
Source of data: IRRI socioeconomic survey of upland farmers, 1996.

to maintain contour hedgerows in both systems is accounted for by the weeding and pruning activities that are needed to prevent shading of the crops by the overgrown hedgerow species.

The large amount of labor needed to construct and maintain contour hedgerows is cited as one of the major constraints to adoption of the technology by respondents in the survey. The results indeed suggest a large investment in labor to construct and maintain the structures.

Other soil conservation practices. Both adopters and nonadopters of the CH technology have also adopted other soil conservation practices in addition to CH such as contour plowing, mulching, strip cropping, returning of crop residues to the cultivated farm, use of organic matter/animal manure as fertilizers, crop-fallow rotation, and construction of diversion canals.

A ranking of soil conservation practices according to the proportion of respondents using them indicates that among adopters, the three most widely used practices in addition to CH are contour plowing, returning of crop residues to the farm, and the use of animal manure as fertilizer (Table 17). Among nonadopters, the top three practices are returning of crop residues, contour plowing, and crop-fallow rotation.

In summary, soil erosion is more likely to be observed among non-CH parcels than among CH parcels. Likewise, the incidence of soil erosion is higher among parcels cultivated by nonadopters than among those cultivated by adopters. This suggests that after the adoption of the CH technology, soil erosion is perceived to have been reduced. This perception is particularly apparent among respondents who have practiced the technology much longer. Natural grasses are the predominant hedgerow species observed in the survey area, perhaps because of

Table 17. Distribution of respondents by other soil conservation practices[a] observed on all parcels, by adoption status.[b]

Practice	Claveria (n=54)[c]		Cebu (n=70)		All (n=124)	
	Adopters of CH	Non-adopters of CH	Adopters of CH	Non-adopters of CH	Adopters of CH	Non-adopters of CH
Contour plowing	33 (100)	16 (76)	39 (98)	24 (80)	72 (99)	40 (78)
Mulching	18 (55)	8 (38)	24 (60)	6 (20)	42 (58)	14 (27)
Strip cropping	12 (36)	5 (24)	26 (65)	12 (40)	38 (52)	17 (33)
Returning crop residues	30 (91)	19 (90)	39 (98)	25 (83)	69 (95)	44 (86)
Use of organic matter	27 (82)	10 (48)	22 (55)	6 (20)	49 (67)	16 (31)
Use of animal manure	27 (82)	13 (62)	23 (58)	3 (10)	50 (68)	16 (31)
Crop-fallow rotation	17 (52)	11 (52)	29 (72)	24 (80)	46 (63)	35 (69)
Construction of diversion canals	14 (42)	9 (43)	23 (58)	10 (33)	33 (51)	19 (37)

[a] These are practices other than contour hedgerows practiced by adopters and nonadopters of contour hedgerows on all of their parcels. Hence, adopters and nonadopters as used in this table refer to those with and without contour hedgerows as was consistently defined throughout this paper. [b] Numbers in parentheses are percent share of total. [c] No. of observations is less than the sample size because of missing values.
Source of data: IRRI socioeconomic survey of upland farmers, 1996.

their cost advantage. It requires less labor to construct natural grass-based hedgerows than those with planted species. The extent of adoption of contour hedgerows is much higher in Cebu than in Claveria. Other types of soil conservation practices are also used by both adopters and nonadopters of CH.

Farmers' perceptions about contour hedgerow technology

The most commonly cited benefit from the adoption of contour hedgerows is the minimal soil erosion on the fields (Table 18), whereas improvement in soil fertility ranks second. It is surprising that only a few adopters consider yield increase as a major benefit from adoption. This suggests that yield gain is probably not very high and is confounded by other factors. If farmers do not perceive yield gain to be a major advantage, the idea of soil conservation may be promoted more effectively by emphasizing only the benefits that farmers perceive easily.

While half of the respondents say that they have no major problems with contour hedgerows, about one-third consider the high labor requirement[4] for construction and maintenance of structures a major concern (Table 19). Other problems cited include the increase in labor time for land preparation, the destruction of hedgerows by stray animals, the shading of crops by hedgerows, and the persistence of soil erosion despite the presence of hedgerows. For those who indicated no problem with the technology, membership in the alayon appears to be the most distinguishing characteristic (Table 20). This suggests that membership in the organization may have helped relax the labor constraint for this group. Further research is needed to identify precisely the factors that may have led to the different perceptions.

Table 18. Adopters' perceptions of the benefits from contour hedgerows.

Benefit	Percent share of responses
Minimize soil erosion	53
Improve soil fertility	16
Increase yield	11
Source of fodder	8
Easier land preparation because alley is flat	5
Minimize damage to crops	4
Others	2
No response	1

Source of data: IRRI socioeconomic survey of upland farmers, 1996. Data for Cebu and Claveria combined.

Table 19. Adopters' perceptions of problems with contour hedgerows.

Problem	Percent share of responses
None	50
Labor intensive (establishment and maintenance)	35
Increased labor time for plowing	3
Stray animal destroying hedgerows	4
Shading of crops	2
Persistence of soil erosion	2
Others	3
No response	1

Source of data: IRRI socioeconomic survey of upland farmers, 1996. Data for Cebu and Claveria combined.

The labor-intensive nature of the technology also appears to be a major constraint to adoption. About one-third of the nonadopters cite the high labor requirement as the major reason for

Table 20. Characteristics of adopters who perceived/did not perceive problems with contour hedgerows.

Characteristic	Without problem	With problem
Farmer		
Av age (yr)	45.4	44.6
Av schooling (yr)	5.8	6.5
Av gross income ($ household^{-1})[a]	1619	1820
Land-labor ratio	2.3	2.8
No. of yr of adoption	8.7	7.1
With membership in alayon (%)	20.5	5.7
Farm		
Av slope (%)	29.8	29.6
Av no. of parcels	2.7	2.5
Type of contour hedgerow (%)[b]		
Natural grass	39.5	50.6
Napier grass	26.3	29.2
Gliricidia sepium	15.8	4.5
Setaria sp.	5.3	5.6
Gmelina	5.3	–
Others[c]	7.8	10.1

[a] Exchange rate: US$1 = ₱25. [b] Percentage of parcels with contour hedgerows. [c] Includes *Leucaena leucocephala*, guinea grass, banana, pineapple, mulberry, and ferns.
Source of data: IRRI socioeconomic survey of upland farmers, 1996. Data for Cebu and Claveria combined.

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[4] On average, it requires 49 person-d ha^{-1} to construct and 14 person-d ha^{-1} to maintain contour hedgerows (see Table 16).

nonadoption (Table 21). Lack of technical knowledge about the technology and loss of cultivable area are cited as the major reasons for nonadoption by about one-fourth of the respondents. Others mentioned difficulty in land preparation in the presence of hedgerows, nonownership of the land, and lack of capital to finance the growing of hedgerows. Only a small proportion of the respondents said that they did not adopt the technology because soil erosion is not a problem in their fields.

The provision of technical assistance and training about contour hedgerows would encourage about one-third of the nonadopters to adopt the technology (Table 22). On the other hand, one-fifth of the nonadopters would be encouraged to adopt the technology if labor and capital were available. These results indicate that more farmers may be encouraged to adopt the technology by making technical knowledge and assistance easily available to more farmers. This can be achieved by strengthening the labor-sharing groups and by promoting activities that could generate added income to farmers.

Table 21. Reasons given by nonadopters for not adopting contour hedgerows.

Reason	Percent share of responses
Needs too much labor	38
Lack of technical knowledge	16
Loss of cultivable area	11
Land preparation difficult in the presence of contour hedgerows	5
Soil erosion not a problem in the field	5
Nonownership of land	5
Lack of capital	2
Others[a]	14
No response	4

[a] Includes seven different reasons with equal number of responses for each.
Source of data: IRRI socioeconomic survey of upland farmers, 1996. Data for Cebu and Claveria combined.

Table 22. Factors that would encourage adoption by nonadopters.

Factor	Percent share of responses
Technical assistance/training	34
Labor and capital availability	20
A range of hedgerow species to choose from	11
Evidence of topsoil loss and loss of fertility	5
Ownership of land	5
No need to adopt contour hedgerow as soil erosion is not a problem	14
Others[a]	7
No response	4

[a] Includes four different reasons with equal number of responses for each.
Source of data: IRRI socioeconomic survey of upland farmers, 1996. Data for Cebu and Claveria combined.

The most widely cited erosion-related problem that many nonadopters experience on their farms is the destruction of crops and loss of seedlings and inputs (Table 23). The formation of gullies due to erosion is also causing problems on the farms of 16% of the nonadopters. No farmer mentioned reduction in yield as a major problem caused by soil erosion. It thus appears that the physical manifestations of erosion are the most perceptible erosion-related problems from the farmers' point of view. It is also interesting to note that about one-fifth of the nonadopters indicate no erosion-related problems on their farms.

Nonadopters attempt to address the erosion-related problems on their farms through the construction of diversion canals (23%), contour plowing (23%), and application of more fertilizers (16%) (Table 24). Others place barriers along the slope to minimize further erosion of the soil (6%), while others simply leave the land fallow (6%). The responses also indicate that farmers use practices other than contour hedgerows that may be cheaper or more suitable to the specific conditions of their fields. Hence, CH need not be viewed as the universal solution to the land degradation problems of upland farmers, but rather as one of the available

Table 23. Erosion-related problems encountered by nonadopters on their farms.

Problem	Percent share of responses
Destruction of crops/erosion of seedlings and inputs	53
Formation of gullies	16
Costly land preparation because of exposure of hard soil	4
Others	2
No problems	21
No response	4

Source of data: IRRI socioeconomic survey of upland farmers, 1996. Data for Cebu and Claveria combined.

Table 24. Actions taken by *nonadopters* to address erosion-related problems on their farms.

Action taken	Percent share of responses
Diversion/drainage canal to divert water flow	23
Contour plowing	23
Application of more fertilizer	16
Fallowing the land	6
Placing barriers such as stone/ wood along the slope	6
Others[a]	13
No response	13

[a] Includes four different actions with equal frequency.
Source of data: IRRI socioeconomic survey of upland farmers, 1996. Data for Cebu and Claveria combined.

options. A wider range of technologies needs to be developed and promoted to give farmers more flexibility in choosing the most suitable practice, given their specific biophysical and socioeconomic conditions.

To summarize, the major benefit from contour hedgerows as perceived by the respondents is the reduction in soil erosion. Although this may ultimately contribute to yield increase, only a few farmers mentioned this as a benefit. The high labor requirement for the construction and maintenance of the hedgerow structure is perceived to be the major constraint to adoption. Providing technical assistance and training as well as relaxing capital and labor constraints to adoption would encourage nonadopters to try the technology.

Access to services and institutions

Both adopters and nonadopters have access to various services and institutions, with adopters accounting for a larger proportion of respondents with access to these services than nonadopters overall (Table 25). In terms of access to public transport, a larger proportion of adopters than nonadopters have access and this pattern holds true across sites. This relative difference in access to public transport and subsequently to markets may be associated with the likelihood of adoption of a soil conservation technology. The results indicate that more adopters than nonadopters have access to institutions, suggesting that the adopters' access may have been a factor in their adoption of the soil conservation technology. On the other hand, the lack of access of nonadopters to these services also puts them at a disadvantage in gaining access to information about new technologies and more efficient farming methods. The relatively distant locations of nonadopters' homesteads from roads relative to those of adopters (as previously discussed), however, may also explain the lack of access to these institutions.

Table 25. Distribution of respondents by access to services and institutions, by adoption status.[a]

Type of access	Claveria		Cebu		All	
	Adopters	Nonadopters	Adopters	Nonadopters	Adopters	Nonadopters
To public transportation	39 (100)	19 (90)	32 (91)	25 (71)	71 (96)	44 (79)
To government agencies/workers	27 (69)	9 (43)	30 (86)	17 (49)	57 (77)	26 (46)
To extension centers/workers	27 (69)	11 (52)	30 (86)	29 (83)	57 (77)	40 (71)
To institutions engaged in soil conservation	24 (62)	10 (48)	22 (63)	15 (43)	46 (62)	25 (45)
To credit	33 (85)	15 (71)	28 (80)	29 (83)	61 (82)	44 (79)
Total no. of respondents	39	21	35	35	74	56

[a] Numbers in parentheses are percent share of total.
Source of data: IRRI socioeconomic survey of upland farmers, 1996.

The incidence of access to institutions engaged in soil conservation among all respondents is relatively lower than access to government agencies and extension centers. As in the previous two institutions, however a larger proportion of adopters than nonadopters have access to institutions engaged in soil conservation. In Claveria, the institution currently engaged in promoting soil conservation technologies, particularly CH technology, is the International Center for Research on Agroforestry (ICRAF). In Cebu, the DA has a Resource Management Training Center located in Barangay Taptap, one of the mountain barangays in the city. This training center is engaged in providing technical assistance and training on sustainable farming systems and one of the technologies promoted is the use of contour hedgerows as a soil conservation measure. The NGO World Neighbors also has a training center that provides technical assistance and training on soil conservation technologies, including CH establishment, to its members.

A larger proportion of adopters than nonadopters have access to credit. Comparing access among respondents across sites shows that a slightly larger proportion of nonadopters than adopters in Cebu have access, while a slightly larger proportion of adopters than nonadopters have access in Claveria. Credit sources to which respondents have access include formal sources such as rural banks, development banks, and private financing companies and informal sources such as farmers' cooperatives, traders, private business corporations, moneylenders, family members, and friends. The results suggest that credit does appear to be accessible to respondents in Claveria and Cebu, although adopters may have relatively better access than nonadopters. Interviews with respondents also revealed that, although credit may be accessible, risk aversion prevented several from actually obtaining credit for use in their farm operations. Respondents revealed that the uncertainty inherent in crop production causes them to be more risk-averse about borrowing as the possibility of a crop failure may result in their inability to pay back the loan.

Econometric analysis

Econometric analysis was done to determine the factors that affect the adoption decision of upland farming as well as to estimate the productivity effects of adoption on farm production.

Factors affecting the adoption decision

Adoption of soil conservation: a conceptual model. The adoption of soil conservation practices is conceptualized as a decision-making process (Fig. 1; Ervin and Ervin 1982), which starts with the recognition of an erosion problem. That perception is viewed as a product of farmers' personal characteristics that might cause a more acute awareness of the seriousness of erosion (e.g., formal education), coupled with the actual physical characteristics of the land that they cultivate.

Once the erosion problem is perceived, farmers decide whether or not to adopt a conservation practice and, if so, what type. The different factor categories are modeled to play separate roles in that decision. Personal factors, such as more education, can be viewed as influencing farmers' disposition to use practices because of increased information on benefits and costs of erosion control. Those personal characteristics that involve acquisition costs can be interpreted as human capital. The degree of soil erosion potential of the land is an important biophysical factor that influences adoption. Economic factors may either enhance or constrain farmers' disposition toward soil conservation, whereas educational programs and technical assistance are institutional instruments to encourage farmers to use the practice.

The final step is the determination of soil conservation effort, which is a function of the effectiveness and coverage of individual practices over the land. Personal factors such as management ability affect the proper application and maintenance of practices, especially on widely varying topography and soils. Physical factors that define soil erosion potential determine potential productivity benefits over the entire farm unit. The conservation effort is also hypothesized to depend heavily on economic factors because of the relationship between the cost of practicing a particular type of soil conservation and the degree to which it reduces soil erosion.

From the conceptual model above, several variables are hypothesized to affect farmers' decisions to adopt a soil conservation technology. These variables are classified into four categories—personal, economic, institutional, and biophysical (or the degree of soil erosion potential). The following paragraphs discuss specific variables and their hypothesized effects on the adoption decision of farmers.

The effect of farmer age on the adoption decision can be taken as a composite of the effects of farming experience and planning horizons. While more 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 (i.e., a lower discount rate) and may be more likely to invest in a conservation technology. Hence, the effect of age on adoption cannot be determined a priori. Hoover and Wiitala (1980) found in their study of Nebraska farmers that age had a significant negative influence on farmers' adoption decisions.

Higher education levels should 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). As a human capital variable, education also positively affected the efficiency of farmers' adoption decisions (Rahm and Huffman 1984). Hence, adoption is hypothesized to be positively correlated with farmers' education level.

Membership in a local farmers' organization is posited to have a positive effect on the adoption of a soil conservation technology. Community or farmer organizations are effective in providing follow-up support (USAID 1995) to farmer-members. Membership in such organizations not only provides additional labor but also entails a training component that benefits farmer-members. Indeed, Sajise and Ganapin (1991) contend that the presence of mechanisms for group labor is a factor that contributes to the increase in adoption of conservation measures. In the case of CH adoption, the availability of exchange labor in alayon groups could relax labor constraints in the construction of CH structures. In a study of CH adoption in Leyte, Philippines, Gabunada and Barker (1995) indeed found that membership in the alayon group had a significant positive effect on the probability of adoption.

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 population pressure. Households with a 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 CH may discourage them from adoption. 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 subsequent reduction in cropping area may be less of a constraint relative to those with little land. Hence, households with a higher land-labor ratio may also adopt CH. The effect of land-labor ratio on adoption is therefore indeterminate a priori.

The effect of insecure tenure status often discourages farmers from engaging in conservation practices that have longer time periods because they may not be able to reap the long-run benefits (Ervin 1986). Equating land titles with secure tenure and thus with increased investment, however, is too simplistic (Lutz et al 1994). In fact, ownership may not be as significant a factor in soil conservation decisions as is sometimes thought, as suggested by the findings of studies on conservation practices by farmers in Central America (Lutz et al 1994) and in the Philippines (USAID 1995). Place and Hazell (1993) also found that legal land rights were not significant determinants in African farmers' decisions to undertake land-improving investments. These results suggest that, while land ownership is an enabling factor for conservation, it is not a sufficient condition.

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 farmers with opportunities for income-earning activities. Thus, there is more incentive for farmers 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 near the road are more likely to be visited by extension agents than ones who live far from the road. The cost of gaining access to technical knowledge and information will be lower for farmers 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 may, however, not be exogenous but may be affected by the profitability of farming operations, which, in turn, depends on the conservation decision. Thus, adoption of conservation practices and the level of nonfarm income may be determined simultaneously. The simultaneity arises from labor allocation decisions of the households for farm and nonfarm activities. The nonfarm income of the households surveyed, however, is mostly derived from remittances of family members working overseas, nonfarm business activities, and employment in the nonfarm sector. As skill requirements for these jobs are likely to be different from those for farming, farm and nonfarm employment may be considered as noncompetitive activities. In this situation, the level of nonfarm income would be largely exogenous to the adoption decision.

The slope of the field is the only indicator used as a proxy for erosion potential. Although 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.

Empirical results. A microeconometric framework based on the concept of utility maximization is used to empirically explain farmers' decisions to adopt a soil conservation technology. The underlying theoretical basis for the approach is that a net positive benefit results in a higher utility level for farmers. Hence, the probability that a farmer will adopt a soil conservation practice is the probability that the utility of the old technology is less than the utility of the new soil-conserving technology (see, for example, Rahm and Huffman 1984). This can be estimated using the probit model (Maddala 1983, Greene 1997)[5]. For the empirical model, the probability that a farmer will adopt the CH technology is estimated as a function of farm, farmer, and market characteristics.

Two separate probit equations were estimated using parcel-level data[6] for each site after an F test conducted on the data set turned out to be significant for the null hypothesis of no structural difference between the data from the two sites. A test for multicollinearity among the independent variables did not show statistically significant collinear relationships among the variables. Table 26 shows descriptive statistics of the independent variables. Table 27 shows the results of the probit model estimation.

Adoption in Claveria is significantly influenced by tenure status, slope, and age of the household head. The results suggest that adop-

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[5] The underlying assumption is that the error term e is independently, normally distributed with zero mean and constant variance σ^2.
[6] Data from 318 parcels from the 130 sample respondents were used in estimating the probit model.

Table 26. Descriptive statistics of the independent variables used in the probit model.[a]

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

[a]Numbers in parentheses are standard deviations. [b]Percent share of nonfarm income to total household income. [c]Percent share of parcels cultivated by owners. [d]Percent share of parcels cultivated by alayon members.
Source of data: IRRI socioeconomic survey of upland farmers, 1996.

Table 27. Estimated coefficients of the probit model.[a]

Variable	Claveria		Cebu	
	Coefficient	Chi-square	Coefficient	Chi-square
Constant	0.52	0.40	-1.78	7.44***
Age of household head	-0.03	5.85**	0.007	0.60
Education	-0.03	0.70	0.17	14.02***
Tenure (dummy)[b]	1.02	12.22***	-0.31	1.56
Member (dummy)[c]	0.34	0.18	0.84	4.82**
Land-labor ratio	-0.94	2.25	0.10	0.02
Slope	0.05	19.34***	0.02	4.95**
Nonfarm income	-0.005	2.32	0.005	2.61
Distance from road	-0.10	0.47	-0.94	5.14**
-2 Log likelihood ratio	165.51***		192.54***	
Probability of adoption	0.46		0.51	

[a]***Significant at the 1% level. **Significant at the 5% level. *Significant at the 10% level. [b]1 for owner, 0 otherwise. [c]1 for alayon member, 0 otherwise.
Source of data: IRRI socioeconomic survey of upland farmers, 1996.

tion of contour hedgerows is more likely among households headed by younger farmers, on parcels with a steeper slope, and on parcels owned by the farmer. The likelihood of adoption in Claveria is estimated at 46% on average, and this is statistically significant at the 1% level.

For Cebu, adoption is significantly influenced by education, membership in the alayon, slope, and distance of the farmer's house from the road. The results indicate that education is also a positive influence on adoption, and this is consistent with the results of Ervin and Ervin (1982) and Rahm and Huffman (1984). Likewise, adoption is more likely among farmers who are members of the alayon group and who live close to the road. Contour hedgerows are also more likely to be adopted on parcels with steeper slopes. The likelihood of adoption in Cebu is estimated at 51% on average and is statistically significant at the 1% level.

The dummy variable for membership in the alayon has a positive sign at both sites, implying that members are more likely to adopt than nonmembers, although it was not statistically significant in Claveria. The importance of labor exchange groups in relaxing labor constraints in the construction of contour hedgerows was highlighted by the respondents' answers to questions about constraints to adoption. High labor requirements for the establishment and maintenance of CH was the most often cited constraint to adoption among the respondents surveyed. The weak statistical performance of the membership variable in Claveria could be because, after adoption, very few farmer-adopters remained as members of the group. Discussions with farmer-respondents indicate that the alayon movement has remained stronger in Cebu than in Claveria, and this could be because the institutional organization among the alayon groups is better in Cebu than in Claveria.

The results also highlight the differences in factors that affect adoption across sites. For example, tenure status was significant only in Claveria, perhaps because of the larger proportion of owned parcels with contour hedgerows than parcels without contour hedgerows. In Cebu, on the other hand, a larger proportion of parcels with contour hedgerows were being cultivated by nonowners than parcels owned by their cultivators. These results suggest that, although security of tenure in the form of a legal title is an important decision variable in the adoption of CH, the effect could be site-specific. In Cebu, adoption was observed to be high among parcels operated by nonowners but who have assured long-term access to the land from their absentee landlords. Nevertheless, there is merit to promoting policies aimed at making property rights more favorable to adoption.

Institutional variables such as access to extension and credit were not included in the final model estimates because of collinearity and simultaneity problems. The variable that measures access to extension is correlated with the proxy variable for market access, i.e., the distance of the farmer's house from the road; hence, the latter is likely to capture the effect of the former on adoption. Discussions with farmer-respondents revealed that, although they indicated that they have access to extension services, only a few of them actually get regular extension visits from extension agents assigned to their respective areas. Moreover, among those who have relatively better access and more frequent contacts with extension agents, many are adopters, and this could be because adopters live closer to the main road than nonadopters. The credit variable, on the other hand, is endogenous because the ability to obtain credit is also determined by factors that are determinants of adoption—e.g., education, income, and access to markets, among others. Although credit was reported to be accessible to the farmer-respondents, many of them appeared to be risk-averse and hence did not obtain credit for production purposes.

Table 28 shows the estimated elasticities of the probability of adoption. The elasticity estimates suggest that the probability of adoption is more responsive to slope, education, and age variables than to the other significant variables. This suggests that policy interventions aimed at improving the educational status of upland farmers may also encourage soil conservation in the uplands, particularly in Cebu, where the education variable was statistically significant. Indeed, farmer responses indicated that providing technical assistance and training to nonadopters would encourage them to adopt contour hedgerows. Moreover, conservation programs would be more effective if targeted to areas with relatively steeper slopes and to younger farmers. Adoption could also be intensified with improved access to markets through better roads and transport facilities.

Table 28. Estimated elasticities of the probability of adoption (continuous variables only).[a]

Variable	Claveria	Cebu
Age of household head	-0.82	0.34
Education	-0.12	0.38
Land-labor ratio	-0.12	0.01
Slope	0.64	0.32
Nonfarm income	-0.10	0.12
Distance from road	-0.05	-0.08

[a] Elasticities area computed as $\beta x\phi(x\beta)/\Phi(x\beta)$ where ϕ is the probability density function and Φ is the cumulative density function (Marquis and Phelps 1987).

Although the probit estimates determine the factors that affect the likelihood of adoption, they do not indicate the factors that determine the extent of adoption (McDonald and Moffitt 1980). Hence, tobit estimates for each site are derived to address this issue, taking as the dependent variable the proportion of contoured area to total farm size. Table 29 shows the tobit estimates.

The extent of adoption in Claveria is significantly determined by slope. The results indicate that farms with slopes less than 15% are less likely to increase their extent of adoption than farms with slopes greater than 30%. Hence, farms with steeper slopes are more likely to have

Table 29. Estimated coefficients of the tobit model.

Variable	Claveria		Cebu	
	Coefficient	Chi-square	Coefficient	Chi-square
Constant	0.63	0.31	-0.06	0.003
Age of household head	–	–	-0.02	1.19
Education	-0.10	0.55	0.15	3.77**
Household size	-0.03	0.04	-0.05	0.59
Member (dummy)[a]	–	–	0.97	4.79**
Tenure[b]	0.55	0.92	-0.13	0.07
Slope 1[c]	-3.33	3.10*	1.08	1.36
Slope 2[d]	-0.05	0.01	-0.38	0.94
Nonfarm income	1.10E-4	1.39	2.75E-5	6.01**
Distance from road	0.25	0.69	-0.20	0.30
-2 Log likelihood	42.82		75.00	

[a] 1 for alayon member, 0 otherwise. [b] Defined as the proportion of owned land to total farm size. [c] Defined as the proportion of land with slope <15%. [d] Defined as the proportion of land with slope between 15% and 30%.

Source of data: IRRI socioeconomic survey of upland farmers, 1996.

an expanded adoption of contour hedgerows than farms with flatter slopes. In Cebu, the extent of adoption is significantly determined by the education and membership in the alayon of the household head and by the household's level of nonfarm income. The results suggest that households headed by more educated persons who are members of the alayon and have more nonfarm income are more likely to increase the extent of adoption of CH. Membership in the labor-sharing group alayon may enable the household to relax the labor constraint, thereby allowing it to expand its adoption of CH. Likewise, the availability of nonfarm income to relax the liquidity constraints faced by the household may also enable it to finance the investment in CH.

Productivity effects of the adoption of contour hedgerows

Empirical studies to evaluate the effect of soil conservation on productivity often face the problem of identification (Capalbo and Antle 1988)—that is, the pure effect of adoption may be spuriously correlated with factors that affect the adoption decision. Hence, the observed positive differential in output between adopters and nonadopters of a soil conservation technology, which suggests a positive relationship between adoption and productivity, may not correctly estimate the productivity effect attributed to adoption alone. This is usually true in cases of sample self-selection where observed data are an endogenous outcome of a decision process in which an individual's decisions are related to the differential between anticipated earnings in their best alternatives (Maddala 1977, 1986, Duncan and Leigh 1985). In the case of adoption, the choice to adopt or not to adopt is not a random process but rather an individual decision based on some utility-maximizing criteria (Pitt 1983, Fuglie and Bosch 1995). Failure to account for the self-selection bias would result in biased estimates of the productivity effect of the adoption of soil conservation. This has subsequent implications for policies to promote conservation programs.

Empirical studies on the evaluation of the effect of conservation practices on yield show varied results (Table 30). The effect of soil conservation on yield has been estimated mainly in three ways: (1) by direct extrapolation of experimental measurements (Comia et al 1994, Paningbatan et al 1995), (2) by using simulation models (Young 1989, Ehui et al 1990, Nelson et al 1996b), and (3) by comparing the yield of treated and untreated fields (i.e., with and without soil conservation adoption) obtained from farm surveys (Lutz et al 1994, English et al 1994, Shively 1996). Simulation and experimental studies may be useful in identifying yield differences under the conditions specified; however, they do not sufficiently allow for intrafarm and interfarmer differences in production conditions. In the case of the third method, a production function approach is generally used to account for differences in farm and farmer characteristics, with adoption specified as a dummy variable (see, for example, Shively 1996). The evaluation of the effect of soil conservation on yield in such studies can be problematic, however, because the estimated productivity effect may not be due to adoption alone but to some other factors that are correlated with adoption. For example, farmers who choose to adopt conservation practices may also be those farmers who have higher income and hence can finance the initial investment requirements of constructing the structures, as well as the optimal input requirements which could result in higher yield compared with

Table 30. Some empirical results on the effects of soil conservation on yield.

Country	Crop	Soil conservation practice	Yield increase
China[a]	Grains	Bench terraces	37%
Haiti[b]	Maize	Diversion ditches, other conservation structures	22–51%
	Sorghum	Diversion ditches, other conservation structures	28–32%
Honduras[b]	Maize	Diversion ditches	145 kg ha^{-1}[f]
Nigeria[c]	Maize	Contour hedgerows	26–45%
Philippines[d]	Maize	Contour hedgerows	100%
Rwanda[e]	Not specified	Soil conservation investments	21%

[a] Hanxiong 1993. [b] Lutz et al 1994. [c] Kang and Ghuman 1991. [d] Tacio 1993. [e] Byiringiro and Reardon 1996. [f] Percentage increase in yield cannot be estimated because no actual yield was reported.

nonadopters. Adopters may also just be better farmers than nonadopters and, hence, more likely to be more productive even without them adopting a soil conservation technology under similar biophysical conditions. This is an important empirical issue that has significant analytical and policy implications. If indeed there is a differentiation in productivity attributes between adopters and nonadopters of a particular soil conservation technology, the productivity differences based on a production function analysis using ordinary least squares (OLS) will be biased. In addition, the existence of self-selection indicates that the promotion of specific conservation practices may be more effective when targeted to potential users who have a comparative advantage in using that particular technology.

An econometric framework that adjusts for self-selection in estimating the productivity effects of soil conservation is used in this study. This endogenous switching regression framework is an improvement over the usual use of OLS in evaluating the effects of conservation on farm productivity (Maddala 1983). The full endogenous switching regression model used has been described in Lapar and Pandey (1997) and is included in Appendix C.

Table 31 presents the estimated coefficients of the endogenous switching model for Cebu. Because the estimates for Claveria did not show statistically significant productivity effects, the following discussions are based on the estimates for Cebu only.

The estimates indicate that the hypothesis of no differentiation in productivity attributes between farmers cultivating contoured and noncontoured parcels cannot be rejected because of the statistical nonsignificance of the productivity differential coefficient. The latent productivity attributes are hence homogeneous across farmers in the sample. The estimates also show a significant positive average productivity effect of 0.46. The econometric results thus indicate that, after segregating the effect of latent productivity attributes between farmers cultivating contoured and noncontoured parcels, the adoption of CH could potentially increase farm productivity by about 46% for an average farmer.

Table 31. Estimated coefficients of the production function for Cebu.[a]

Variable	OLS[b]	ESM
Constant	3.78 (0.78)***	3.57 (0.81)***
Labor (person-d)	0.43 (0.13)***	0.45 (0.13)***
Fertilizer (kg)	0.06 (0.11)	0.07 (0.11)
Season dummy[c]	0.33 (0.25)	0.35 (0.25)
Maize variety dummy[d]	0.37 (0.22)	0.34 (0.23)
Contour hedgerow dummy[e]	0.40 (0.18)**	–
Productivity effect[f]	–	0.46 (0.23)*
Productivity differential[g]	–	0.50 (0.65)
Adj. R^2	0.23	0.20

[a]Numbers in parentheses are standard errors. ***Significant at the 1% level.**Significant at the 5% level.*Significant at the 10% level. [b]OLS = ordinary least squares, ESM = endogenous switching model. [c]1 for wet season, 0 otherwise. [d]1 for modern variety, 0 otherwise. [e]1 for parcels with contour hedgerows, 0 otherwise. [f]Measures the effect of contour hedgerows on productivity after correcting for the possible sample selection bias. [g]Measures the effect of sample selection bias on productivity.
Source of data: IRRI socioeconomic survey of upland farmers, 1996.

Table 31 also presents the OLS estimates of the production function. From these estimates, the difference between yields in contoured and noncontoured fields is approximately 47%. This is very close to the average productivity estimate obtained from the endogenous switching regression model.

Cost-Benefit Analysis

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 investment in research efforts has been made to understand the nature of these relationships as well as to develop simulation models to enable the prediction of the effect of soil conservation practices on productivity. Although a range of models of different degrees of sophistication are now available, practitioners are constrained because calibration and validation of these models often require considerable data, and sometimes a reworking of some of the relationships.

Rather than conducting a full-fledged cost-benefit analysis, given the difficulties mentioned above, we have taken a somewhat simpler approach of relying on sensitivity analysis to highlight the major factors that determine the profitability of investment in soil erosion control. We have ignored the temporal patterns of changes in yield both with and without contour hedgerows and assumed that yield remained constant. The average cost of establishing CH (49 person-d), the average annual cost of maintenance (14 person-d), and the proportionate area lost to hedgerows (20%) were obtained from the survey data. The percentage increase in yield of maize required to recoup these costs at different internal rates of return was calculated assuming the life of CH to be 10 yr. Because the adoption of CH may encourage more intensification of production, two levels of cropping intensity were also considered—single and double cropping. Hence, cropping intensity takes a value of 1 for single cropping and a value of 2 for double cropping.

The results (Fig. 3) indicate that the break-even increase in percentage yield declines rapidly with the increase in base yield without conservation. In very poor environments where maize yield is only 200 kg ha^{-1}, the break-even increase in yield required is as high as 160% under the assumed internal rate of return of 0.4 and a cropping intensity of unity. Under the most favorable scenario of a maize yield of 1.6 t ha^{-1}, an internal rate of return of 20%, and a cropping intensity of 2, the required yield increase is 26%. The 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. On the contrary, 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. The results suggest that agricultural researchers face a much tougher challenge in

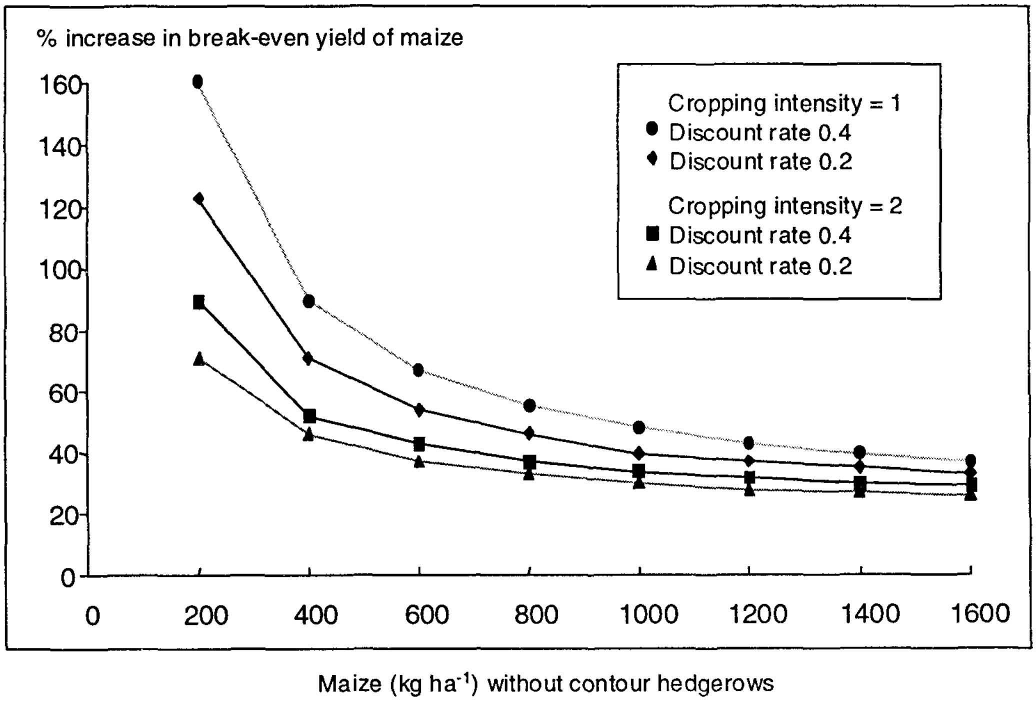

Fig. 3. Percentage increase in yield of maize needed for investment in contour hedgerows to break even at different discount rates and cropping intensities.

making investments in soil conservation economically attractive to farmers in areas with low initial productivity. Of course, the scenario presented above captures only the on-site costs and benefits, which are the normal concerns of farmers. From society's point of view, consideration of off-site effects and other externalities may shift the balance in favor of low-productivity areas.

The break-even increase in yield is reduced if the adoption of contour hedgerows encourages intensification of cropping (or generates more income through switching to high-value crops). In areas with more favorable climatic conditions, an improvement in market access may thus encourage adoption by facilitating crop intensification. Yield-increasing technologies will also similarly encourage 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 cost components matters the most? To answer these questions, the analysis presented above was repeated for different scenarios of cost reduction. The base values assumed were a maize yield of 400 kg ha^{-1}, an internal rate of return of 20%, and a cropping intensity of unity. The analysis was done by changing one of the cost components at a time while keeping the other two fixed at their base values. The results (Fig. 4) indicate that the break-even increase in yield declines with a reduction in all costs. But the break-even increase in yield remains above 50% even if the initial cost of establishing hedgerows is reduced by 80%. What seems to matter most is the reduction in annual cost of maintaining the hedgerows. The reduction in establishment cost ranks second and the reduction in area loss is last. Of the three cost components, the break-even increase in yield declines most rapidly with a given percentage reduction in the cost of maintenance. The difference between the break-even yield required for a given percentage

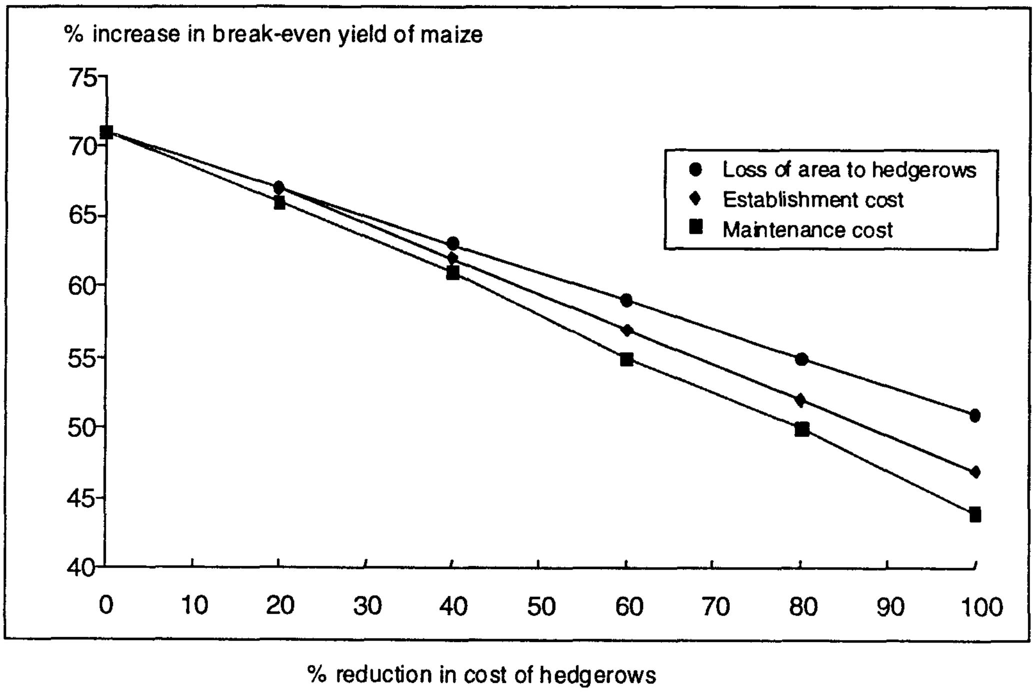

Fig. 4. Percentage increase in yield of maize needed for investment in contour hedgerows to break even under different % reduction in cost.

reduction in establishment cost and the same percentage reduction in the maintenance cost is small, however. These results are consistent with farmer perceptions that the maintenance of hedgerows is the most problematic. Hence, research aimed at reducing the annual maintenance cost of hedgerows needs to be given priority. Careful selection of hedgerow species that require minimal maintenance would improve the benefits from adoption. When comparing Figures 3 and 4, it is also clear that developing ways to make it possible for farmers to undertake crop intensification, especially in areas with low yield, may be more effective than reducing the cost of adoption.

Natural vegetative strips are believed to be the least costly in terms of establishment and maintenance. Although our estimate of the maintenance cost of NVS is similar to that of planted hedgerows, the establishment cost of the former is much lower (Table 21). These systems are thus becoming more popular among farmers. The major components of the total cost incurred in the establishment of planted species are the costs of planting material, transportation, and shoveling to prepare the planting area. Farmers who use natural vegetation do not incur these costs; hence, the overall cost of establishing hedgerows is much lower.

Concluding remarks and implications

This study undertook an economic analysis of soil conservation, specifically the CH technology. The results of the descriptive analysis of survey data from Cebu and Claveria indicate that differences in farmer, farm, and household characteristics may explain the differences in adoption decisions of upland farmers. Econometric estimates of the factors that determine the likelihood and extent of adoption indeed show that several socioeconomic and biophysical factors affect farmers' adoption decisions. Farmers' perceptions about the CH technology, including its benefits, costs, and problems, suggest that cost considerations are also paramount in farmers' adoption decisions.

An important implication of the analysis presented in this study is that policy support 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 will 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 toward that of improving farmers' income by facilitating a transition to more remunerative land-use systems is needed. Otherwise, these efforts are unlikely to make a significant dent in 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, to provide a range of options, and to improve targeting. Most farmers find CH, especially of planted species, to be too expensive. Reducing the cost of establishment and maintenance will certainly improve the economics of CH. The recent popularity of hedgerows of natural vegetation is due mainly to its cost advantage. There is also an emerging paradigm of CH for fallow rotations that might provide scope for realistic and adoptable techniques (Garrity 1994). Contour hedgerows could be managed in a fallow rotation system and hence could serve as a superior way to improve fallows in degraded land. More intensive research is needed to further explore this issue.

Contour hedgerows are but one of the ways to reduce soil erosion. Farmers in the study area use many other complementary and substitute methods such as 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 of their effectiveness will provide more choices to farmers, thereby allowing them to choose the methods most appropriate to their conditions. Promotional activities most often narrowly target a specific technology and ignore other options that may be equally effective or more effective than the one being promoted. An output-oriented (such as area covered by different soil conservation methods and the extent of soil erosion reduced) rather than a physical target-oriented (meters of CH established) incentive structure is needed to encourage extension agents and technology promoters to take on a broader perspective.

A range of field-, farm-, and farmer-specific factors condition the adoption of soil conservation technology. Factors such as low population density, low slope, insecurity of tenure, low initial productivity, and limited access to the market reduce incentives to conserve soil. Incentives are higher in the opposite situation. Careful targeting of technology in areas with favorable conditions, provision of information about the consequences of continued soil erosion, demonstration and adaptation of soil conservation technologies under farm- and farmer-specific conditions, and provision of technical assistance and training could encourage wider adoption. In areas where available technologies are less likely to be adopted, efforts are needed to widen the domain through further improvements in technology.

The diversity of factors that condition the adoption of soil conservation technologies implies that an extension approach that encourages experimentation and adaptation by farmers is likely to be more suitable for promoting conservation technologies (Fujisaka 1993). Often, promotional activities narrowly target a specific technology judged to be technically superior and ignore other options that may not be as effective but are perhaps more suited to farmer needs. In addition, farmers may already be adopting other substitute practices. Given the diversity of environmental and social conditions under which farming is carried out in developing countries, a tailor-made approach to technology development is obviously not feasible. It would be difficult to make a major impact without a broader perspective that recognizes farmers' innovativeness, knowledge, and capacity to adapt technologies. The participatory approach to technology development and adaptation may have a lot to offer in this regard, although the cost of implementing such an approach can often be high (Bentley 1994).

A question often raised in the context of investments in conservation is that of subsidy. Should the public sector subsidize the cost of soil conservation investments? Economists would argue that the case for subsidy would exist only if the externalities are large enough to cover the cost of subsidies. Although it is generally accepted that conservation practices generate off-site benefits, such benefits are rarely assessed adequately, leading to a somewhat ad hoc determination of subsidies. One of the major problems in making a satisfactory assessment of off-site effects is the lack of necessary data. Additional efforts to collect and analyze data on the effects of various land-use patterns in the upper parts of the toposequence on stream flow and sedimentation load seem warranted.

Recent changes in production systems in the Asian uplands indicate that factors that lead to the adoption of erosive land-use practices often originate outside the upland system. Macro and sectoral 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, poorly 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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Appendix A. A microeconomic model of soil conservation.

Soil conservation is an investment to enhance the future productive capacity of the soil. Hence, a microeconomic model of investment analysis can be used to study adoption behavior. Several specifications of such models are available in the literature. For the present analysis, we use the model by Clarke (1992), which is a modified version of the basic model by McConnell (1983). For the sake of exposition, farmers are assumed to maximize the present value of income (J) from farming over an infinite planning horizon by allocating labor and other inputs for current production, as well as for enhancement of the productive capacity of the soil. The basic model is specified in equation 1.

$$\text{Max } J = \int_{0}^{\infty} e^{-\delta_t} A\,[PF(Q, L_1, X_1) - qI(L_2, X_2) - c(L_1, X_1)]\,dt \qquad (1)$$

Yield is assumed to be a function (F) of the productive capacity of soil (Q) and labor (L_1) and other inputs (such as fertilizer) used for production (X_1). The production function F exhibits diminishing marginal returns to Q, L_1, and X_1. Farmers alter the productive capacity of the soil by using labor (L_2) and other inputs (X_2). The improvement in the productive capacity of the soil is defined by the function I. The cost of a unit improvement in soil quality is assumed to be constant at q. The cost of inputs used to produce the output is given by the cost function (C). The area of the farm and the discount rate are indicated by A and δ. The maximization problem above is subject to the initial stock of soil quality (equation 2) and the net change in soil quality resulting from investment, natural enhancement, and degradation through agricultural use as defined in equation 3. The natural regeneration rate is given by β and the rate of depletion of soil quality as a result of production activity is γ:

$$Q_0 = Q(0) \qquad (2)$$

$$\frac{dQ}{dt} = I(t) - \beta Q(t) - \gamma F(Q, X_1, L_1) \qquad (3)$$

The simplified representation of the production-investment problem depicted above captures the major factors that determine the extent of investment a farmer would make in enhancing the productive capacity of the soil (or soil conservation). These major factors are the length of the planning horizon, the discount rate, the land area available for production, the price of output, the marginal productivity of soil quality as well as substitutability (or complementarity) between Q and other inputs, the cost of investment in soil quality improvement, the natural rate of soil regeneration, and the rate of soil depletion associated with agricultural production. Some of these factors define the initial conditions and are given for a farm at a point in time, whereas others can be manipulated through technology and policy interventions.

The solution to the model above indicates that a longer planning horizon, a lower discount rate, and a lower cost of investment for a unit improvement of soil quality would encourage a higher level of investment in soil improvement. Similarly, as Clarke (1992) has shown, a higher output price will encourage investment if soil quality and other inputs are complementary goods. Incentives to improve soil quality will be lower if the above conditions are opposite.

The model presented above captures only the on-site economic costs and benefits that determine the present value of net returns to farmers. On-site externalities (such as preservation of soil biodiversity and aesthetic benefits) and off-site externalities (such as downstream effects of soil erosion) are additional reasons why society may want to invest more in soil conservation than what would be optimal for a present-value-maximizing farmer.

Appendix B. Distribution of sample respondents by survey site and villages.

Villages	Sample size	
	Adopters	Nonadopters
Claveria		
Ane-i	11	7
Cabacungan	2	1
Hinaplanan	2	1
Lanesi	5	3
Mat-i	3	1
Patrocenio	11	6
Plaridel	1	–
Poblacion	3	2
Rizal	1	–
Total	39	21
Cebu		
Adlaon	9	9
Lusaran	4	4
Taptap	6	6
Tabunan	6	6
Cambinocot	6	6
Sirao	4	4
Total	35	35

Appendix C. Estimating the productivity effects of soil conservation.

An econometric framework that adjusts for self-selection in estimating the productivity effects of soil conservation is presented below. This framework is an improvement over the usual use of ordinary least squares in evaluating the effects of conservation on farm productivity.

Let Y(.) be the expected output supply, defined as a function of inputs and other characteristics. The output for the ith farmer is produced according to one of the two production regimes:

$$Y_i = \begin{cases} Y_{i1} = (\beta + \delta)' x_i + (v_{i1} + \varepsilon_{i1}) & \text{if an adopter} \\ Y_{i0} = \beta' x_i + (v_{i0} + \varepsilon_{i0}) & \text{if a nonadopter} \end{cases} \tag{1}$$

where x_i is a vector of observable variables representing market conditions, prices, and resources including farm and farmer characteristics. The βs give the effect of the observable variables on output without adoption, while the parameters (β+δ) give the effect of the observable variables on output under the regime of adoption. The latent variables are divided into those that are known (the v_is) and those that are not known (the ε_is). The v_is give the effect of latent individual productivity attributes on output. We can assume that this latent variable is scaled such that $E(v_i) = 0$ for an individual selected at random from the overall population of adopters and nonadopters. The v_is are allowed to differ across the two production regimes in the full-switching regression specification to accommodate the productivity effect of differences in the characteristics of adopters and nonadopters. For example, adoption of a soil conservation technology may result in larger returns to latent farming skills such as in the management of input use and cropping patterns. The ε_is are the conventional, unanticipated random supply shocks that are not known ex ante and we assume that $E(\varepsilon_i) = 0$.

The estimation of the parameters in the output supply function (equation 1) is complicated because adoption status is endogenously determined in a way that may be systematically related to the expected output effects of adoption. That is, a farmer who adopts a soil conservation technology may also have a larger farm size, a larger income to finance input use, more education, and/or just be a better farmer. Under this endogenous sorting, adopters probably have systematically different characteristics from those of nonadopters. Thus, while $E(v_i) = 0$ for an individual farmer randomly chosen from the overall population, the latent variable v_i probably has a nonzero conditional expectation for the nonrandomly sorted subsamples of adopters and nonadopters. There is a need, therefore, to specify the nonrandom process that sorts individuals into adopters and nonadopters in order to obtain consistent estimates of the production regime parameters and determine the effect of adoption.

The process that sorts adopters and nonadopters into the two production regimes involves the decision of the individual farmer to adopt or not adopt a soil conservation technology. This can be modeled as a decision by a farmer to adopt a soil conservation technology when the expected utility from adoption is greater than the utility from nonadoption. What is observable, however, is the farmer's adoption status of being an adopter or a nonadopter. Thus, we can model the farmer's adoption decision as a binary variable (B_i) that equals one for an adopter and 0 otherwise. (B_i) is thus the result of a latent adoption status variable (α_i) that is scaled such that an individual farmer becomes an adopter when $\alpha_i > 0$. A reduced form specification for latent adoption status can be written as

$$\begin{aligned} \alpha_i &= \delta'(Y_{i1} - Y_{i0} - K^*) + \eta_i, \\ &= \delta' x_i + \eta_i, \end{aligned} \tag{2}$$

where K* is the anticipated costs of adoption, x_i is a vector of variables that determine the adoption status, δ' is a vector of parameters, and η_i is an error component reflecting random and latent factors that influence the adoption decision. Thus, the sample separation process can be written as

$$B_i = \begin{cases} 1 & \text{if } \alpha_i > 0, \\ 0 & \text{otherwise}. \end{cases} \tag{3}$$

The expected output supply conditional on the endogenous sample separation process and observable characteristics can then be written as

$$E(Y_{i1} | B_i = 1) = (\beta + \delta)' x_i + E(v_{i1} | B_i = 1) \tag{4a}$$

$$E(Y_{i0} | B_i = 0) = \beta' x_i + E(v_{i0} | B_i = 0) \tag{4b}$$

where conditioning on the observable variables x has been suppressed.[1] From (3) and (4), the full endogenous switching regression model[2] can be written as

$$B_i = \begin{cases} 1 & \text{if } \alpha_i > 0 \\ 0 & \text{otherwise} \end{cases} \tag{5a}$$

$$E(Y_{i1} | B_i = 1) = (\beta + \delta)' x_i + \rho_1 \lambda_{i1} \tag{5b}$$

$$E(Y_{i0} | B_i = 0) = \beta' x_i + \rho_0 \lambda_{i0}. \tag{5c}$$

Alternatively, it is possible and often desirable to estimate (5) using all the observations in Y_i (Maddala 1983). Note that

$$E(Y_i) = E(Y_{i1} | B_i = 1) Prob(B_i = 1) + E(Y_{i0} | B_i = 0) Prob(B_i = 0), \tag{6}$$

so that

$$E(Y_i) = \beta' x_i + \delta' [\Phi(C_i) x_i] + (\rho_1 - \rho_0) \phi(C_i). \tag{7}$$

From equation (7), consistent estimates of the structural parameters can be obtained and the effects of adoption estimated.

Three measures of the effects of adoption on output can be obtained from the preceding econometric model. The average productivity effect measure determines the effect of adoption on output for an individual farmer selected at random from the overall population of farmers. This is the expected effect of adoption on the output of an average farmer without any intervening systematic selection or conditioning on the basis of the unobserved individual characteristics. This average productivity effect is as follows:

$$\begin{aligned} E(Y_{i1} | B) - E(Y_{i0} | B) &= [\beta' x_i + E(v_{i1} | B)] - [\beta' x_i + E(v_{i0} | B)] \\ &= \delta' x_i \end{aligned} \quad 8(a)$$

The counterfactual effect (see Tunali 1985) compares the output anticipated by a farmer under the actual adoption status were he/she in the counterfactual state. That is, it compares the output anticipated by a nonadopter were that same individual an adopter and, similarly, the output anticipated by an adopter were that same individual a nonadopter. Let us call the counterfactual effect the returns to adoption and the returns to nonadoption, which are shown as equations (8b) and (8c), respectively. Alternatively, these are also referred to as conditional effects (see Sial and Carter 1992).

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[1] The conditional expectations on the right-hand side of equations (4a) and (4b) can be written as (I) $E(v_{i1} | B_i = 1) = E(v_{i1} | \eta_i > -\delta' x_i)$ and (II) $E(v_{i0} | B_i = 0) = E(v_{i0} | \eta_i < -\delta' x_i)$. The problem of intrinsic productivity differences between adopters and nonadopters can be clearly seen from (I) and (II). If latent productivity attributes are systematically related to adoption status, then the conditional expectations in (4) will not be zero. On the other hand, the problematic correlation between v_i and η_i indicates that the latter, in fact, provides information on the latent variable v_i. Thus, the parameters of interest can be consistently estimated by using this information to control for the latent characteristics v_{i1} and v_{i0}. This can be done by making distributional assumptions to substitute for the latent information. From the sample selection literature, it is possible to separately identify the effect of latent individual attributes and obtain consistent estimates of the structural parameters of the output supply function conditional on assumptions about the error structure. Following Maddala (1983), assume that the error vector (η_i, v_{i1}, v_{i0}) is distributed multivariate normal with zero expectations and positive definite matrix.

[2] $\rho_1 = Cov(\eta_i, v_{i1})/Var(\eta_i)$ and $\rho_0 = Cov(\eta_i, v_{i0})/Var(\eta_i)$ are the population regression coefficients relating v_{i1} and v_{i0}, respectively; $\lambda_i^{I} = \phi(C_i)/\Phi(C_i)$ and $\lambda_i^{II} = \phi(C_i)/1 - \Phi(C_i)$ are the estimates of η_i given the adoption status and $C_i = \delta' x_i / Var(\eta_i)$; and $\phi(.)$ and $\Phi(.)$ are the standard normal density and cumulative distribution functions, respectively. The parameters of this system can be estimated using maximum likelihood methods. Heckman proposes a two-stage procedure for estimating consistent but less efficient parameters of equation (5) (Maddala 1983). Consistent estimates of β may be obtained through separate OLS regressions of the two conditional output supply functions in (5) (see Pitt 1983, Tunali 1994, and Fuglie and Bosch 1995, for example).

$$E(Y_{i1} \mid B_i = 1) - E(Y_{i0} \mid B_i = 1) = [\beta' x_i + E(\nu_{i1} \mid B_i = 1)] - [\beta' x_i + E(\nu_{i0} \mid B_i = 1)] \qquad (8b)$$

$$= \delta' x_i + (\rho_1 - \rho_0)\lambda_{i1}$$

$$E(Y_{i0} \mid B_i = 0) - E(Y_{i1} \mid B_i = 0) = [\beta' x_i + E(\nu_{i0} \mid B_i = 0)] - [\beta' x_i + E(\nu_{i1} \mid B_i = 0)] \qquad (8c)$$

$$= -\delta' x_i + (\rho_0 - \rho_1)\lambda_{i0}$$

Note that the conditional effect is the sum of the average productivity effect (equation 8a) and the differentiation effect, the parameter $(\rho_1.\rho_0)$, or the gains or losses from latent productivity attributes, the level of which is measured by λ.

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