Adoption of dual-purpose forages: some policy implications

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Abstract

Livestock, especially ruminant, production is an important component of farming systems in upland areas of the Philippines. Moreover, since upland agriculture is becoming unsustainable because of soil erosion and productivity of crops is limited by poor soils, livestock production is a particularly valuable source of income to complement crop production. Farmers rely heavily on livestock to provide a source of savings, cash income, draft power and nutritious food. Nevertheless, scarcity and poor quality of feed are major constraints to improved livestock productivity in upland areas. Introduction of planted forages in these systems has the potential to increase substantially the quality and quantity of available forages, thus providing fodder to supplement low-quality naturally occurring forages and crop residues; concurrently, forage plants promote sustainability by improving soil quality and reducing soil erosion.

Adoption of forages by smallholder farmers in the rainfed upland areas of the Philippines is conditioned by the dual-purpose role of forage plants. A number of forage species have been used as contour hedgerow species for the reduction of soil erosion. These include *Gliricidia sepium, Leucaena leucocephala, Setaria* spp., napier grass (*Pennisetum purpureum*) and vetiver grass (*Vetiveria zizanioides*). These species were chosen as hedgerow species because of their value as fodder for livestock, in addition to their roles in reducing soil erosion, controlling weed growth, and improving and stabilising fallow areas.

A number of constraints affect the widespread adoption of forages for use as hedgerow species by smallholder farmers in the Philippine uplands. These factors include: the limited availability of seed; high mortality amongst the forage species planted; a lack of collective action; and the high initial cost of investment. Insufficient attention has been given to policy and socio-economic factors affecting adoption of forages. For example, the effects of socio-economic factors such as human capital (education, age), income and access to institutions (*e.g.* credit and extension) have not been studied in association with the adoption of forage species. Therefore, policy and technology options to address these issues are warranted.

This paper uses an econometric approach (*i.e.* probit) to identify the factors affecting adoption of forages by smallholder farmers in the upland areas of the Philippines, using data from a survey conducted in 1996 by the International Rice Research Institute (IRRI). The survey examined farmers who had adopted contour hedgerow technology at 2 upland sites, Cebu, Visayas and Claveria, Mindanao, the Philippines.

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Introduction

Livestock production is an important component of farming systems in upland areas of the Philippines. Since upland agriculture is being rendered unsustainable by soil erosion and low productivity of crops because of poor soils, the importance of livestock production as a valuable source of income to complement crop production has increased. Farmers rely heavily on livestock to provide a source of savings, cash income, draft power and food. However, livestock productivity in the Philippines is low.

Many smallholder farmers attribute poor animal performance to an insufficient quantity of good-quality feed; in particular, scarcity of feed during the dry season and limited size of grazing areas have lead to overgrazing. In sloping upland areas, crop production has declined, primarily because of soil erosion. This highlights the need for alternative sources of good-quality feeds to supplement the traditional sources of feed used by smallholders. Planted forages can fill this gap (Stür 1995; Gabunada *et al*. 1998). The introduction of planted forages in these systems has the potential to increase substantially both the amount and the quality of forage available; this additional forage can be used to supplement the low quality of naturally occurring forages and crop residues, while at the same time promoting sustainability by improving soil quality and reducing soil erosion. For example, introduced forages have resulted in increased crop and animal production in various agro-ecosystems in south-east Asia (Stür 1995).

The adoption of forages by smallholder farmers in the rainfed upland areas of the Philippines is conditioned by the dual-purpose role of the forages. A number of forage species have been used as contour hedgerow species for the reduction of soil erosion; these include *Gliricidia sepium, Leucaena leucocephala, Setaria* spp., napier grass (*Pennisetum purpureum*) and vetiver grass (*Vetiveria zizanioides*). These species were chosen because of their value as fodder for livestock, in addition to their roles in reducing soil erosion, controlling weed growth, improving and stabilising the fallow areas and soil amelioration in upland systems.

The objective of this paper was to determine the socio-economic factors that affect the adoption of planted forage species by adopters of contour hedgerows in the uplands of the Philippines, thus highlighting the role of forages not only for livestock feed but also for soil conservation. This focus was chosen because, although livestock production in the Philippines is expected to increase to meet the increasing demand for livestock products, livestock productivity across farms is extremely variable, especially in the upland region.

Methods

In 1996, to address issues about the sustainability of upland agriculture, the International Rice Research Institute (IRRI) conducted a study on adoption of contour hedgerows. This involved a survey of adopters and non-adopters of contour hedgerows as a soil conservation technology. Information collected included data on the species used in hedgerows, as well as farmer responses indicating why the species were chosen. Amongst the adopters of contour hedgerows, a significant number chose to plant forage species along the hedgerows because they could be used as feed for livestock. This observation provided the motivation to examine the dual-purpose role of forage species, *i.e.,* for both feed and soil conservation.

The study area

The survey was conducted in 2 upland areas, Cebu in the Visayas and Claveria in Mindanao. The study area in Cebu is located in a mountainous area behind Cebu City. It is an intensively farmed upland area, where farmers crop terraced areas producing vegetables and flowers for the Cebu market. Forages are grown along contour hedges, as an intercrop with crops or as cover crops amongst fruit trees. In contrast, Claveria is an extensively farmed, hilly, upland area growing corn as the major crop. Forage technologies that have been tested include hedgerows, intensively managed plots and legumes for improved fallows.

World Neighbours[1], in collaboration with the Philippine Department of Environment and Natural Resources, promoted a range of soil conservation practices including contour hedgerows in Cebu in the early 1980s. The soil conservation technology was a component of an overall technology aimed at encouraging a shift in production systems from subsistence farming to cash crops. Overall, the contour hedgerow technology has spread around the initial target area and the Cebu case is often cited as a successful example of adoption of soil conservation technology.

In Claveria, the IRRI introduced the contour hedgerow technology in 1985 through a farming systems research program carried out in collaboration with the Philippine Department of Agriculture. A contour hedgerow-based farming system was promoted using the farmer-to-farmer extension approach based on the strategy of World Neighbours in Cebu. In contrast to Cebu, adoption of the contour hedgerow technology in Claveria was not so widespread. Amongst the initial adopters, about 25% considered the technology ineffective and subsequently abandoned the practice. Others continued to maintain their hedgerow structures with some modifications and/or adaptations to the originally introduced technology.

Results

Basic characteristics of the production systems and biophysical attributes in the 2 locations are summarised in Table 1. Livestock production and use of forage species are discussed in the following sections.

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[1] World Neighbours is a non-government organisation that is engaged in developmental activities for sustainable agriculture and livelihoods.

Table 1. General characteristics of the production systems and biophysical attributes in the study area.

Feature	Cebu	Claveria
Average area per household (ha)	1.7	3.0
Average land parcel size (ha)	0.7	1.2
Cropping intensity (%)	150	190
Average slope (%)	32	24
Area under maize (%)	54	84
Area under cash crops (%)	14	5
Average yield of maize (kg/ha)	902	1284
Average gross income ($/household)[1]	1616	1470
Latitude	10°N	8°N
Altitude (m above sea level)	500	500–650
Annual rainfall (mm)	>2000	2000
Length of dry season (months)[2]	<2	2–4
Soil fertility[3]	M–H	L–M
Soil acidity (pH)	6–7	5.5–6.5

[1] Exchange rate used: US$ 1 = P 25.
[2] No. of months with <50 mm rainfall.
[3] L = low fertility (infertile), M = moderate fertility, H = high fertility.
Source: Lapar and Pandey (1999); Fujisaka (1989).

Table 2. Profile of livestock ownership among respondents in Cebu and Claveria.

	Adopters of contour hedgerows		Non-adopters of contour hedgerows	
	No.	%	No.	%
With livestock	73	98.6	56	100.0
Without livestock	1	1.4	0	0.0
Total	74	100.0	56	100.0
Average no. of animals	No.	s.d.	No.	s.d.
Cattle	2.7	2.2	2.1	1.9
Buffaloes	1.5	1.0	1.5	0.7
Goats	4.1	3.8	2.8	2.1
Pigs	2.5	2.1	3.1	3.9
Chickens	17.0	17.6	15.0	17.9

Source of data: IRRI socio-economic survey of upland farmers in Cebu and Claveria in 1996.

Livestock ownership amongst adopters and non-adopters of contour hedgerows

Both adopters and non-adopters of contour hedgerows raised livestock (see Table 2), with no marked differences in species used or the numbers carried.

Sources of feed for ruminants

Ruminants (cattle, buffalo and goats) were fed on fodder from a variety of sources. In both Cebu and Claveria, ruminants predominantly consumed native pasture. Claveria had extensive grasslands for grazing but available forage from these areas was slowly declining due to overgrazing. Consequently, fodder from native pastures was supplemented with forages from sown (planted) pastures and from hedgerows. About 73% of farmers in Cebu and Claveria used native pasture as their primary source of cattle feed, while about 15% used forage from hedgerows as their primary source of cattle feed (see Table 3a). Planted hedgerow forages included both grasses and legumes. Many farmers (45%) used sown (planted) pastures as secondary sources of feed; these pastures included both grasses and legumes planted in plots/areas rather than in hedgerows (see Table 3b). About 20% of respondents used crop residues and by-products as secondary sources of feed for cattle.

Table 3a. Primary sources of feed for cattle.

Source	Number of responses	% share
Native pasture	64	72.7
Forage species from hedgerows[1]	13	14.7
Sown pasture[2]	6	6.8
Crop residues and by-products	4	4.6
Fodder trees	1	1.1

[1] Includes forage grasses and leguminous species planted in hedgerows.
[2] Includes forage grasses and leguminous species planted in areas/plots as distinct from hedgerows.
Source of data: IRRI socio-economic survey of upland farmers in Cebu and Claveria in 1996.

Table 3b. Secondary sources of feed for cattle.

Source	Number of responses	% share
Sown pasture[2]	29	44.6
Crop residues and by-products	13	20.0
Native pasture	7	10.8
Forage species from hedgerows[1]	6	9.2
Crops	6	9.2
Fodder trees	3	4.6
Commercial feed	1	1.5

[1] Includes forage grasses and leguminous species planted in hedgerows.
[2] Includes forage grasses and leguminous species planted in areas/plots as distinct from hedgerows.
Source of data: IRRI socio-economic survey of upland farmers in Cebu and Claveria in 1996.

About 75% of respondents used native pasture as the primary source of feed for buffalo (see Table 4a); in contrast, only 20% used forage species from hedgerows and less than 5% used sown pastures. Nevertheless, as secondary sources of feed for buffalo, sown pastures were used by about 43%, native pastures by 20%, forage species from hedgerows by 16%, and crops and crop by-products by 20% of respondents (see Table 4b).

Table 4a. Primary sources of feed for buffalo (carabao = swamp type water buffalo).

Source	Number of responses	% share
Native pasture	49	75.4
Forage species from hedgerows[1]	13	19.9
Sown pasture[2]	3	4.6

[1] Includes forage grasses and leguminous species planted in hedgerows.
[2] Includes forage grasses and leguminous species planted in areas/plots as distinct from hedgerows.
Source of data: IRRI socio-economic survey of upland farmers in Cebu and Claveria in 1996.

Table 4b. Secondary sources of feed for buffalo (carabao = swamp type water buffalo).

Source	Number of responses	% share
Sown pasture[2]	19	43.2
Native pasture	9	20.5
Forage species from hedgerows[1]	7	15.9
Crop by-products	6	13.6
Crops	3	6.8

[1] Includes forage grasses and leguminous species planted in hedgerows.
[2] Includes forage grasses and leguminous species planted in areas/plots as distinct from hedgerows.
Source of data: IRRI socio-economic survey of upland farmers in Cebu and Claveria in 1996.

Table 5a. Primary sources of feed for goats.

Source	Number of responses	% share
Native pasture	45	83.3
Sown pasture[2]	5	9.3
Forage species from hedgerows[1]	2	3.7
Crop by-products	2	3.7

[1] Includes forage grasses and leguminous species planted in hedgerows.
[2] Includes forage grasses and leguminous species planted in areas/plots as distinct from hedgerows.
Source of data: IRRI socio-economic survey of upland farmers in Cebu and Claveria in 1996.

Most respondents (83%) used native pastures as the primary source of goat feed (see Table 5a). Sown pastures consisting of forage grasses and leguminous species were used as the primary source of goat feed by a small number of respondents (9%). Conversely, about 52% of respondents used sown pasture as their secondary source of goat feed (see Table 5b).

Contour hedgerow species

Contour hedgerows are defined as 'a spatially zoned agro-forestry practice' (Kang and Ghuman 1991). Comprehensive reviews of hedgerows are provided by Kang and Wilson (1987), Young (1989) and Lal (1990). Hedgerows are promoted widely as an effective, low-cost method of erosion control for annual crop cultivation on steeply sloping fields. They are constructed as permanent vegetative barriers, typically grasses or densely spaced shrubs, planted along the contour of a field in rows 5–10 metres apart. Hedgerow barriers restrict soil and water movement, and annual crops are grown in alleys between the hedgerows. Compared with structured methods of erosion control (such as terracing), hedgerows can be constructed at low cost (Shively 1999).

Table 5b. Secondary sources of feed for goats.

Source	Number of responses	% share
Sown pasture[2]	15	51.7
Crop by-products	4	13.8
Crops	3	10.3
Forage species from hedgerows[1]	3	10.3
Native pasture	3	10.3
Fodder trees	1	3.4

[1] Includes forage grasses and leguminous species planted in hedgerows.
[2] Includes forage grasses and leguminous species planted in areas/plots as distinct from hedgerows.
Source of data: IRRI socio-economic survey of upland farmers in Cebu and Claveria 1996.

Various types of contour hedgerows had been adopted in the study area, including natural vegetative strips, forage grasses, leguminous species (forage legumes), perennial crop species, rock-walls, fruit trees and a combination of hedgerow types. Natural vegetative strips were the most common type of hedgerow amongst the adopters surveyed, accounting for about 40% of the total number of land parcels with hedgerows (see Table 6). Other common types of hedgerow were forage grasses and leguminous species, used by about 24 and 21% of adopters, respectively.

Species planted in hedgerows included native or naturally growing grasses, napier grass, *Gliricidia sepium*, *Setaria* spp., *Leucaena leucocephala*, Guinea grass (*Panicum maximum)*, gmelina (*Gmelina arborea*), fruit-bearing species (pineapple, bananas), mulberry trees and ferns (see Table 7). Native grasses were the predominant species in hedgerows and were used on about 46% of all land parcels with contour hedgerows; napier grass was used in about 28%, while other planted forage species accounted for less than 10% each. The predominance of native grasses was largely due to the active promotion of natural vegetative strips (NVS) by the International Centre for Research in Agroforestry (ICRAF) in the study area.

Table 6. Types of hedgerows adopted by farmers in Claveria and Cebu.

Type	Number of responses	% share
Natural vegetative strips	53	40.4
Forage grasses	31	23.7
Leguminous species (incl. forage legumes)	27	20.6
Perennial crop species	13	9.9
Rockwalls	3	2.3
Combination of species	3	2.3
Fruit trees	1	0.8

Source of data: IRRI socio-economic survey of upland farmers in Cebu and Claveria in 1996.

Table 7. Types of species used in contour hedgerows.

Type	Number of responses	% share
Natural grasses	60	45.8
Napier grass	36	27.5
Gliricidia sepium	10	7.6
Setaria spp.	7	5.3
Pineapple	5	3.8
Leucaena leucocephala	4	3.1
Bananas	2	1.5
Guinea grass	2	1.5
Gmelina arborea	2	1.5
Mulberry	2	1.5
Ferns	1	0.8

Source of data: IRRI socio-economic survey of upland farmers in Cebu and Claveria in 1996.

Reasons for choice of species

Many respondents indicated that choice of species for establishing hedgerows was determined by a plant's potential use as fodder for livestock (57%) (see Table 8); hence, the predominance of forage species amongst established hedgerows. Availability of planting material and seed of the species also influenced choice of species (17%). Other factors affecting the choice of species included recommendations made by training/extension officers (5%) and the potential use of a plant as a source of fertiliser (5%).

Hedgerow species used as fodder are shown in Table 9; napier grass was the most popular, representing about 49% of the hedgerow species used as fodder. Other planted forages used as fodder included *Setaria* spp. (12%), Guinea grass (3%) and *Gliricidia sepium* (3%).

Table 8. Reasons for choice of species for hedgerows.

Reason	Number of responses	% share
As source of fodder	74	56.5
Planting materials easily available	22	16.8
Recommended by training/extension officers	7	5.3
As source of fertiliser	6	4.6
For fruit production	4	3.1
Species creates less shading on crops	3	2.3
No particular reason	3	2.3
As source of firewood/charcoal	2	1.5
As feed for silkworms	2	1.5
Species requires less maintenance	1	0.8
Species chosen by father	1	0.8
Others	5	3.9

Source of data: IRRI socio-economic survey of upland farmers in Cebu and Claveria in 1996.

Table 9. Hedgerow species used as fodder.

Species	Number of respondents	% share
Napier grass	36	48.7
Natural grasses	22	29.8
Setaria spp.	9	11.9
Guinea grass	2	2.7
Gliricidia sepium	2	2.8
Calamansi (native lemon)	1	1.4
Pineapple	1	1.4

Source of data: IRRI socio-economic survey of upland farmers in Cebu and Claveria in 1996.

Factors affecting adoption

Existing literature has identified a number of factors that influence adoption of an agricultural innovation. In a comprehensive literature survey, Feder *et al.* (1985) listed a range of factors including farm size, risk exposure and capacity to cope with risks, human capital, labour availability, credit constraints, land tenure and access to markets.

The adoption of planted forages is conditioned by factors that may similarly affect adoption of other agricultural innovations. Unlike naturally occurring forage species like native grasses, planted forages require some capital during the establishment phase. This capital requirement may include the cost of seed, cost of labour to establish the plots and other costs associated with initial establishment of the species in hedgerows. Moreover, extension services are necessary to provide technical assistance in the proper management of the species. This scenario for planted forages contrasts with that for naturally occurring species that are widely available and hence cost less to establish. Capacity of the farmer to finance these costs is important in determining adoption decisions. This capacity can be measured by the farmer's income or by access to external sources of funds such as credit.

Farm characteristics are also likely to influence adoption. For example, plots that are perceived to be less fertile may be more likely to be planted with leguminous species which have the capacity to fix atmospheric nitrogen; as such, they improve soil fertility.

The number of ruminants (cattle, buffalo and goats) being raised by a farmer determines his/her demand for forage as animal feed. Accordingly, the more ruminants a farmer is raising, the more likely he/she is to adopt a hedgerow species that is useful as a feed in addition to providing an effective barrier for soil erosion control.

Farmers who are better educated are generally more open to innovative ideas and new technologies that promote technical change (Rahm and Huffman 1984; Feder *et al.* 1985; Weir and Knight 2000). Hence, a farmer who has better knowledge of the benefits from adopting planted forages is more likely to adopt the practice.

The empirical model

The adoption decision is modelled as the decision between planting forage species in hedgerows and establishing other types of barriers or non-forage species, *e.g.* fruit trees or ornamental plants. For example, it can be likened to adoption of an improved variety over a traditional variety of a crop. A particular forage species is adopted when the anticipated utility from adopting it exceeds that of non-adoption.

Assume that the farmer aims to maximise anticipated utility; however, the farmer is uncertain of the utility of planting the forage species *vis-à-vis* other types of hedgerows. Although it is not observed directly, the utility (U) for a particular farmer (i) of adopting a particular technology (j) can be defined as a farm-specific function of some vector of technology characteristics, plus a disturbance term with a mean value of zero, *i.e.*, $E(e_{ij}) = 0$.

$$U_{ij} = a_{ij}G_i(X_j) + e_{ij}$$
$$j = 1 \text{ or } 0; \text{ and } i = 1,\ldots n \qquad (1)$$

where 1 represents adoption of the new technology and 0 represents continued use of the old technology. The i^{th} farmer adopts the technology, *i.e.*, j = 1, if $U_{i1} > U_{i0}$.

To implement this model in relation to the adoption of forage species, we assume that there is an unobserved or latent variable, y^*, that generates the observed variable y, which represents a farmer's decision to adopt a forage species or not. The latent variable y^* equals $\pi_1 - \pi_0$, the net benefit from adoption. When $y^* > 0$, the farmer adopts forage species in hedgerows and $y = 1$ is observed. When the farmer does not adopt forage species in hedgerows, then $y = 0$ is observed.

For farmer j, the latent variable y_j^* is assumed to relate to the observed farmer, farm, plot and other characteristics through a structural model as follows:

$$y_j^* = \delta'\mathbf{X_j} + e_j, \ (j = 1,\ldots, \text{N}) \qquad (2)$$

where X_j is a vector of farm, farmer, plot and other characteristics, δ is a coefficient vector and e_j is a random disturbance. Then y_j^* is linked to y_j as follows:

$$y_j = 1 \text{ if } y_j^* > 0, \text{ and} \qquad (3)$$
$$y_j = 0 \text{ if } y_j^* \leq 0$$

Farmer j adopts the forage species as hedgerows if $y_j^* > 0$.

The probability that $y_j = 1$ is then:

$$\begin{aligned} Pr[y_j = 1] &= Pr[y_j^* > 0] \qquad (4)\\ &= Pr[\delta'\mathbf{X_j} + e_j > 0]\\ &= 1 - F(-\delta'\mathbf{X_j})\\ &= F(\delta'\mathbf{X_j}) \end{aligned}$$

where $Pr[\cdot]$ is a probability function and $F(\cdot)$ is the cumulative distribution function. The exact distribution of F depends on the distribution of the random term e_j (Maddala 1983; Greene 1997). If e_j is normally distributed, then we have the probit model.

In this case, the adoption of forage species as hedgerows depends, amongst other factors, on farm characteristics such as farm size (area of land cultivated), land tenure (ownership of the land), plot characteristics such as soil fertility (farmer perception of soil fertility) and slope (as a percentage), farmer characteristics such as education (number of years of schooling), age of farmer (years), number of animals raised and institutional characteristics like access to credit (has obtained a loan) and extension (has contact with extension workers).

Empirical estimates

The adoption model was estimated using data from a survey of adopters and non-adopters of contour hedgerows. For this specific estimation, plot-level information from adopters of contour hedgerows was used. The binary dependent variable was defined as 1 if the plot used forage species as hedgerows and 0 otherwise. The independent variables included farm, farmer and other characteristics including a location dummy to capture the differences between the two survey sites, Cebu and Claveria. Table 10 shows mean values of the independent variables in the probit model.

Table 10. Mean values of the independent variables in the probit model.

Variable	Mean	s.d.	Min	Max
Education (years)	5.9	2.8	0	15
Household income ('000 pesos)	50.0	106. 0	1.9	756.2
Land:labour ratio	5.4	4.9	0.4	32.0
Access to credit[1]	0.8	0.4	0	1
Soil fertility[2]	0.7	0.5	0	1
No. of cattle raised	1.9	2.1	0	12
Province (location dummy)[3]	0.4	0.5	0	1

[1] Dummy variable = 1 when received credit, 0 otherwise.
[2] Dummy variable = 1 when respondent indicates soil is perceived to be fertile (based on certain physical characteristics), 0 otherwise.
[3] Dummy variable = 1 for Claveria, 0 otherwise.
Source of data: IRRI socio-economic survey of upland farmers in Cebu and Claveria in 1996.

Table 11 shows the estimated coefficients of the probit model. These data indicate that level of education of the farmer, household income, access to credit and location positively affected adoption of forage species. In contrast, land tenure (defined as ownership of land), membership of a local farmers' organisation and access to extension had no significant effect on adoption. Consequently, they were subsequently excluded from the model. The coefficient for land:labour ratio (incorporated as a proxy for labour availability and/or land scarcity) was negative, implying that farmers who have higher land:labour ratios (*i.e.*, more land per unit of labour) are less likely to adopt forage species, but its effect on adoption of forage species was not significant. A proxy variable for soil fertility (*i.e.*, soil classification based on farmer's characterisation) also indicated a negative relationship, suggesting that farmers who characterised their farms as having fertile soil were less likely to adopt forage species, possibly because they would not need the nitrogen-enhancing capability offered by some forage species; however, this association was not statistically significant.

Table 11. Estimated coefficients of the probit model.

Variable	Coefficient	Standard error	Chi square
Intercept	–1.56**	0.70	4.96
Education (years)	0.13***	0.05	6.79
Household income ('000 pesos)	0.003*	0.002	2.74
Land:labour ratio	–0.002	0.02	0.008
Access to credit[1]	0.62*	0.34	3.33
Soil fertility[2]	–0.04	0.41	0.01
No. of cattle raised	0.03	0.07	0.22
Province (location dummy)[3]	0.79**	0.38	4.22
Value of log likelihood		–74.01	
n		128	

*** ($P < 0.01$); ** ($P < 0.05$); * ($P < 0.10$).
[1] Dummy variable = 1 when received credit, 0 otherwise.
[2] Dummy variable = 1 when respondent indicates soil is perceived to be fertile (based on certain physical characteristics), 0 otherwise.
[3] Dummy variable = 1 for Claveria, 0 otherwise.
Source of data: IRRI socio-economic survey of upland farmers in Cebu and Claveria in 1996.

Level of education of a farmer as a significant positive factor in adoption of forages is consistent with the results of previous studies on adoption (Rahm and Huffman 1984; Feder *et al*. 1985; Weir and Knight 2000). Farmers with better education are earlier adopters and are more likely to utilise new technology more efficiently throughout the adoption process (Feder *et al*. 1985). Thus, the result suggests that better educated farmers are more likely to recognise the benefits of adopting forage species, from the point of view of soil conservation, sustainable farming practices and as an additional source of feed for livestock.

The role of household income as a significant factor in adoption of forage species implies the existence of a capital barrier that needs to be overcome before adoption can take place. The higher the household income, the more financial resources are available to finance both household consumption and farm production, including investments to enhance farm productivity. In this case, farmers with higher incomes are more likely to have the necessary funds to finance the initial cost of adopting forage species.

In the absence of accumulated savings or an adequate income, access to credit is required to finance technology adoption. The significant coefficient for access to credit highlights the importance of this variable in the farmer's decision to adopt forage species. Having access to credit can alleviate liquidity and working capital constraints, thereby allowing the farmer to pay the costs involved in adopting forage species.

The location dummy variables can proxy for differences in location characteristics. The positive and significant coefficient suggests that farmers in Claveria (prov = 1) are more likely to adopt forage species than farmers in Cebu (prov = 0). In addition to the problem of soil erosion, grasslands in Claveria are degrading rapidly because of overgrazing; therefore, farmers in Claveria may be more likely than those in Cebu to look for solutions such as adoption of forage species for soil conservation as well as for feed.

Some policy implications of the results

Results indicate that in addition to biological aspects that are critical to the adoption of forage species, the socio-economic aspects of the farmer and the farm are important factors in the adoption of forages amongst adopters of contour hedgerows. For example, when a farmer was facing liquidity or capital constraints, there was less likelihood of adoption of forages because of the accompanying costs of adoption. This reinforces what previous studies have shown, *i.e.*, that policies enhancing farmer income and/or facilitating farmer access to external sources of capital (such as credit), will promote the adoption of technologies, in this case, forage species. Likewise, the role of education in facilitating the uptake of technologies cannot be overemphasised. Education is not necessarily confined to formal education but instead may encompass the whole range of training and extension activities that promote information and knowledge dissemination about a new technology. Thus, programs to promote the adoption of forage species should emphasise the importance of educating farmers on the benefits of adoption. Moreover, the significant effect of the location dummy implied that the promotion of forage species might be more effective if targetted to specific areas or groups of people. In this case, forage species for soil conservation and feed are best targetted to upland areas that are experiencing problems from soil erosion and declining grazing areas. Thus, the soil conservation angle could be used as another effective avenue for increasing the adoption of forage species amongst smallholders.

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