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Agricultural Systems 88 (2006) 92–110
AGRICULTURAL SYSTEMS
www.elsevier.com/locate/agsy

Determinants of income-earning strategies and adoption of conservation practices in hillside communities in rural Honduras

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Abstract

Based on the results of participatory diagnostic surveys conducted in 95 rural communities in the hillsides of Honduras, we determine income earning strategies at the community level; identify their main determinants; and analyze the adoption of of conservation practices. Eight income-earning strategies were distinguished that reflect differences in comparative advantage between communities. We explain the choice of income earning strategy using a multinomial logit model that includes biophysical, economic, social and institutional variables. We use a probit model to show that adoption of conservation practices is determined by the type of income earning strategy, population density, market access, and organizational variables.

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0308-521X/$ - see front matter
doi:10.1016/j.agsy.2005.06.005

Our results have some important policy implications. First, given the higher profitability of cash crops compared to staple foods, significant investments in road infrastructure are needed to better integrate hillside communities into the market economy. Second, while the potential of profitable conservation practices depends on the type of income earning strategy pursued, population density, market access and assistance from community-based and external organizations play an important role as well. The positive impact of population density on the adoption of many conservation technologies and investments becomes only effective at relatively high levels of population density which most communities in the rural hillsides of Honduras have not yet reached. Finally, given the limited coverage of basic public services such as public health, education, electricity, communication facilities and extension services in many hillside regions, it is imperative to substantially increase the low current levels of public expenditures in these areas. Subsequent research based on detailed household and plot level data from the same communities suggests that investments geared towards improved access to land, education, market access and extension with a focus on soil fertility maintenance have particular potential to raise incomes.

Keywords: Conservation practices; Econometrics; Hillsides; Honduras; Income-earning strategies; Logit; Poverty; Probit; Public expenditure

1. Introduction

In Honduras, an estimated 60% of the population (or about 4 million people) is considered rural. Most of these people live in areas classified as hillsides (defined as areas where land management is significantly influenced by the presence of slopes >12%) where the major economic activity consists of smallholder farming focusing on basic grains (mainly maize, beans and sorghum), coffee and livestock. Poverty is heavily concentrated in the hillsides: 91% of the population lives on less than USD 1.00/day/capita (Jansen et al., 2003a). Productivity of basic grains has stagnated largely due to a lack of dissemination of improved technologies and the virtual absence of extension services (Jansen et al., 2002). Besides leading to rapidly increasing food imports, this has resulted in an expansion of cultivated area at the expense of primary forest areas and increasing pressure on the natural resource base in previously established areas of hillside agriculture. Migration out of these areas towards urban areas or to other countries is seldom a viable solution since it is a costly and selective process.

Past public investments in infrastructure, education and health have been skewed towards the so-called "T of development" consisting of 55 counties located along the fertile north coast and the central corridor area, connecting the capital city of Tegucigalpa in the south and San Pedro Sula, the industrial center of the country, in the north. Hillside areas are by-and-large excluded from the "T of development". This bias of past public investments, combined with the gradual replacement of the traditional economic import substitution model of the 1960s and 1970s with its strong focus on food security, by an export growth led model in the 1980s and 1990s focused on trade, market liberalization and privatization of government services, has effectively

resulted in the exclusion of the hillside areas from the process of development. Average per capita public expenditures in the rural areas between 1985 and 2001 were only USD 12/year (Trochez, 2003).

While forestry has considerable potential to contribute to livelihoods in some of the poorest hillside areas, forest area has been reduced to due land tenure inequities (recent household survey data in Jansen et al. (2003a) show that only 25% of all parcels in the hillsides have secure tenure), high population growth rates, and land reform programs in the 1960s and 1970s (Barrance et al., 2003). The Honduras Corporation for Forestry Development (COHDEFOR) is financially dependent on the exploitation of government-owned forests while at the same time responsible for the regulation of privately owned forests, presenting a clear conflict of interest. The difficulty of obtaining legal permits for the felling of trees results in large amounts of illegally harvested wood entering the market, thus acting as a strong disincentive for the sustainable exploitation of private forestland.

There exists an urgent need to raise awareness among decision makers at different levels (national, municipal, community) regarding the needs and opportunities for public investments in these areas. Moreover, given that rural poverty not only causes significant human suffering but is also closely associated with natural resources degradation, designing promising policies to stimulate the conservation of natural resources in general and the adoption of conservation practices in particular, is also important. Therefore, the principal objectives of this paper are to determine the main income earning strategies[4] at the community level; identify their determinants; and analyze the adoption of conservation technologies and investments.

The remainder of the paper is organized as follows: the following section contains a brief description of the conceptual framework and sampling frame. Section 3 describes the qualitative method used to group communities according to type of income-earning strategy and presents a brief overview of some of the salient characteristics of the communities included in our sample. In Section 4, we present the results of a number of statistical analyses used for identifying the main determinants of the different income-earning strategies as well as of the use of sustainable agricultural production practices. The paper concludes with some conclusions and implications of the results for decision makers at the national, municipal and community level.

2. Concepts and sampling frame

2.1. Conceptual framework

The conceptual framework in this paper is based on the principles of absolute and comparative advantage and centers on the following hypotheses:

[4] For the analysis of the information collected at the community level, we deliberately avoid the common terminology of "livelihood strategies". The latter are usually defined taking into account the full range of assets or capital of a community or household. Jansen et al. (2003a) apply the livelihoods concept to household data collected in the same communities.

1. Income-earning strategies at the community level can be explained by a limited number of biophysical factors and socio-economic conditions. Whereas biophysical factors define agricultural potential and absolute advantage as determined by local climate, topography, soil quality, and other biophysical factors, comparative advantage is determined by socio-economic conditions including access to roads and markets, population density, education, land tenure, presence and effectiveness of organizations, and social capital, including the ability of communities to organize successfully for appropriate collective management of natural resources.
2. The use of conservation practices in agricultural production is determined by the different income-earning strategies themselves, in combination with some of the biophysical and socio-economic factors mentioned above.

At the community level, diagnostic surveys were carried out in 95 hillside communities with the help of local non-governmental organizations (NGOs) with long-term experience in their areas of influence. These diagnostics involved characterization and diagnosis of problems, limitations and opportunities, resulting in community profiles. Highly participatory, informal but structured methods were used in close interaction with a carefully selected, representative group of stakeholders of about 20 persons in each community. Key elements in each diagnostic included the history of the community, the agricultural production environment, management of natural resources, access to public facilities and services, and infrastructure development. Examples of specific information sought include major occupations of the community's inhabitants, dominant land use types, land tenure arrangements; perceptions regarding natural resource degradation, market access, health and education; forms of community-based organization and collective action; and influence of external projects and programs. Before carrying out the diagnostic surveys, each NGO was given the appropriate amount of training by staff from the International Food Policy Research Institute (IFPRI) in close cooperation with the National Program for Sustainable Rural Development (PRONADERS, a rural development implementation and donor coordination agency attached to the Ministry of Agriculture, SAG). For each community, a detailed document was produced that contains a full description of the community based on the information collected. In addition, parts of the collected information that could be quantified were coded and stored in a database that also includes additional data from secondary sources including elevation, rainfall, rural population density, road density, market access and literacy rates.

2.2. Sampling frame

The study covers nine provinces and 19 counties. Counties were selected purposively based on several criteria including agro-ecological conditions (proxy for agricultural potential), dominant land use, population density, market access, and the presence of projects and programs. In addition, the importance of a number of counties in the northeast of the country as recipient areas of migrants (extending the agricultural frontier) warranted their inclusion in the sample. In each county, five communities were randomly selected on the basis of unpublished data obtained from

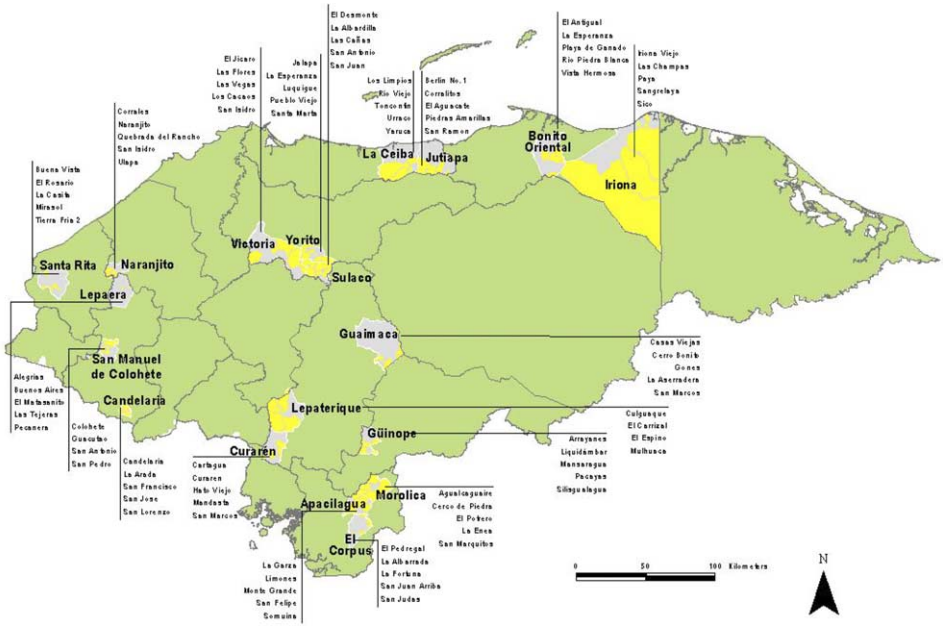

Fig. 1. Sample counties (in bold) and communities.

the latest population census (2000–2001). Fig. 1 shows the location of the 19 counties and 95 sample communities.

3. Classification and main characteristics of sample communities

3.1. Classification of sample communities

The 95 sample communities were categorized according to the dominant income-earning occupations of their inhabitants. This was done in a qualitative manner by carefully revising each of the 95 community reports and focusing on a community's reported primary, secondary and tertiary income earning occupation.[5] After a number of discussions and subsequent revisions, we arrived at the following eight income-earning strategies:

[5] Given the nature of the information gathered and the methodology used for its collection, we deliberately decided against using statistical procedures for classifying communities based on dominant occupations. Besides, factor and principal components analysis are not well suited to the data on occupations, which are discrete data. For a full description of each income-earning strategy, see Jansen et al. (2003b).

- strategy # 1: coffee + basic grains;
- strategy # 2: basic grains + livestock;
- strategy # 3: basic grains + forestry;
- strategy # 4: basic grains + off-farm work + coffee;
- strategy # 5: basic grains + off-farm work + livestock;
- strategy # 6: basic grains + off-farm work + horticulture (fruits and vegetables);
- strategy # 7: basic grains + horticulture;
- strategy # 8: fisheries + commerce + horticulture.

Strategy # 8 involves only two communities in the county of Iriona (Colón province) and is different from the other strategies because the main activities in these communities consist of fishing and handicrafts. Unlike in other communities where there is a strong focus on maize and bean cultivation, agriculture in these two communities involves crops such as cassava, plantain and banana (and some rice as well).

In order to statistically test the existence of differences between income-earning strategies, we performed a correlation analysis for each pair of communities with respect to a number of key characteristics including altitude, rainfall, population density, market access, land tenure, literacy, and presence of organizations. The results (not reported) confirm that each pair of strategies is statistically different with respect to at least one of these variables.

A key characteristic of all strategies is the strong focus on production of basic grains and the raising of minor livestock (pigs and poultry), mainly for own consumption. Even though not measured as such in the community diagnostics, the importance of off-farm work as a source of income is related to farm size (Jansen et al., 2003a). Most off-farm work consists of wage labor on other farms. Non-farm rural activities in our sample communities turned out to be relatively minor. Secondary data (Table 1, data mostly obtained from CIAT) reveal differences across communities in different income-earning groups with respect to biophysical characteristics (elevation, rainfall) and economic characteristics (population density, infrastructure). ANOVA analysis (not reported) confirms statistical differences between income-earning strategies with respect to average altitude, rainfall (primary season), market access, and land ownership. For example, the fisheries communities in the north of the country (strategy 8) are located at low altitudes, whereas communities that focus on coffee or horticulture are usually located at least 800 m above sea level. Rainfall is generally higher in communities that focus on basic grains and forestry (strategy 3) than in coffee communities. The latter also have a relatively dense road network and therefore better market access. Finally, the proportion of landless people tends to be higher in the south of the country than in the north.

3.2. Key characteristics of sample communities

The predominant characteristic of hillside communities in Honduras is the large variation with respect to their natural, human, social and physical capital.

Table 1
Secondary variable statistics, by income-earning strategy

Income-earning strategy	No. of communities[a]	Area (km^2)	Population 1988[b]	Population 2000[c]	Population 1988 (persons per km^2)	Household density 1988[b] (households per km^2)	Household density 2000[c] (households per km^2)	Road density (paved and unpaved in km/km^2)	Illiteracy rate (%)	Rainfall primary season (mm during May–September)	Rainfall secondary season (mm during October–January)	Annual rainfall (mm)	Altitude (m above sea level)
Coffee + BG	19												
Mean		34	1024	1471	39	6	9	5.0	51	922	325	1337	1057
Standard deviation		31	1140	1526	16	3	4	1.8	18	149	61	153	185
BG + livestock	9												
Mean		94	728	1456	76	9	15	2.3	44	717	456	1754	539
Standard deviation		198	392	944	123	14	22	1.3	11	509	341	428	289
BG + forestry	4												
Mean		107	841	1161	23	3	5	2.5	36	633	357	1675	875
Standard deviation		73	532	605	25	3	6	1.0	11	494	387	422	328
BG + off-farm work + coffee	7												
Mean		21	1012	1296	104	15	20	5.4	50	1010	338	1441	922
Standard deviation		24	1334	1654	118	17	23	1.9	18	165	44	167	188
BG + off-farm work + livestock	18												
Mean		32	859	992	45	7	8	4.3	49	921	252	1311	588
Standard deviation		20	437	603	34	5	7	1.3	12	340	99	340	274
BG + off-farm work + horticulture	21												
Mean		44	954	1596	71	11	13	4.4	60	1201	443	1785	571
Standard deviation		116	518	1450	43	6	7	1.8	20	295	296	414	343
BG + horticulture	9												
Mean		14	589	740	71	11	13	4.6	54	987	342	1417	1148
Standard deviation		8	416	592	64	9	11	1.2	23	295	243	442	446
Fisheries + commerce + horticulture	2												
Mean		22	500	770	26	5	7	0.9	20	1202	1294	2960	158
Standard deviation		13	447	731	11	1	2	0.1	4	32	111	189	53

[a] The total number of communities is 89 instead of 95 because no secondary data could be obtained for six communities.

[b] Source: 1988 Population Census.

[c] Source: 2000 Population Census.

Regarding the latter, sample communities greatly differ in size, ranging from 3 to 618 km^2 (average 68, standard deviation 14) with concomitant variation in population density (between 7 and 622 persons/km^2, average 102). The average percentage of people in the community that own land (with or without formal title) is 70% but varies between 10 and 100%. The level of infrastructure development differs significantly across communities (Table 1). For example, road density varies from less than 0.3 km/km^2 to over 8 km/km^2. Only 18 out of the 95 sample communities have electricity, and only 12 communities have a public telephone. Less than one-third of the sample communities have a health clinic and only 34 have access to public transportation. Even though 80% of the sample communities have a source of potable water, in general this service is limited to the main population center in the community.

In terms of natural capital, even though all sample communities are classified as hillside communities, their elevation varies from 200 to more than 1500 m above sea level. Most communities receive at least 1000 mm of rain every year but several (particularly those located in the southern part of the country) suffered from droughts during the main growing season (May–September) in 2000 and/or 2001. Only two of the 95 communities reported having irrigation facilities.

Regarding human capital, population density in most communities increased around 50% between 1988 and 2000. The average level of education is also quite variable across income-earning strategies (Table 1). Average literacy rate in the 95 communities is only about 50% but varies from less than 25% to virtually 100%.

Communities categorized across different income-earning strategies also differ with respect to access to public services (Table 2). While in the majority of the communities there exists at least one source of potable water, less than 20% have electricity and a health clinic and in even fewer communities there is a public telephone.

Regarding social capital, the degree of collective action differs significantly across income-earning strategies (Table 2). Collective action focuses mainly on infrastructural works, particularly road maintenance through food-for-work programs and maintenance or construction of other public works such as waterways and school buildings. On average there exist nearly seven collective works per community but with a high range (0–15). Compared to infrastructure-related types of collective action, the latter is much less where it concerns works related to protection of natural resources (e.g., reforestation in watersheds, control of forest fires, etc.), with an average of less than one work per community (range 0–3).

The use of conservation practices in agricultural production and the dominant income-earning strategy both are expected to be influenced by the presence of different types of organizations (community based and external) including those with a focus on infrastructure, technical assistance, etc. On average communities reported about seven community-based organizations (range 2–13) and more than three external organizations (range 1–10). The majority of community-based organizations present in the communities deal with infrastructure, with relatively few focusing on agricultural production or environmental protection, both of which

Table 2
Means for land ownership, collective action and access to public services, by income-earning strategy

Income-earning strategy	No. of communities	Land ownership (% of households that own at least some of their land, with or without formal title)	Collective action		Public services (% of communities that have)				
			# of NRM actions	# of infrastructure actions	Electricity	Telephone	Health clinic	Potable water	Public transportation
Coffee + BG	19	76	0.9	7.3	16	11	32	79	16
BG + livestock	12	74	0.4	7.3	17	8	25	83	42
BG + forestry	6	88	1.7	3.5	33	0	33	100	33
BG + off-farm work + coffee	7	63	0.6	97.	29	14	43	71	29
BG + off-farm work + livestock	19	50	0.7	5.4	11	16	32	68	37
BG + off-farm work + horticulture	21	66	0.7	6.8	19	14	38	76	33
BG + horticulture	9	89	1.6	5.7	22	11	33	100	67
Fisheries + commerce + horticulture	2	90	1.5	9.0	50	50	100	100	100

seem more the focus of external organizations. Income-earning strategies differ with respect to the types of organizations present. For example, community-based organizations with a focus on agricultural production are most commonly found in basic grains + coffee communities (strategy 4), whereas community organizations with an environmental focus are more common in horticulture-oriented communities (strategy 7). Similarly, whereas the total number of external organizations per community varies between 3 and 4, those with a focus on infrastructural works are more commonly found in coffee communities.

Finally, in general the adoption of conservationist production practices is very limited in the hillsides of Honduras. On average only 16% of agricultural producers use such practices but there exist significant differences between income-earning strategies (Table 3). The average proportion of farmers that use conservation practices is higher in communities that focus on horticulture (strategies 6 and 7) and lower in communities where livestock plays an important role (strategies 2 and 4). Tree planting is particularly common in coffee communities (shaded coffee) and in communities where forestry is important. About half of the farmers still practice burning while preparing their land, despite strong campaigns against this practice (Deugd, 2000). However, there also exist areas where this practice has been practically eliminated (e.g., the counties of San Manuel de Colohete and Candelaria in Lempira province where a FAO-sponsored soil conservation project operated for many years). Many participants in the community diagnostics expressed that in their opinion the low adoption rate of the majority of conservation practices is mostly due to their low profitability as well as the lack of technical knowledge among farmers (which in turn is due to the virtual absence of extension support for small hillside farmers).

Table 3
Mean adoption of conservation practices, by income-earning strategy

Income-earning strategy[a]	% of farmers using conservation practices	% of communities in which conservation practice is used					
		Live barriers	Contour planting	Terraces	Burning	Tree planting	Other practices
Coffee + BG	16	42	21	21	47	56	37
BG + livestock	6	33	8	17	33	8	42
BG + forestry	14	33	0	0	33	83	67
BG + off-farm work + coffee	3	14	14	14	43	43	0
BG + off-farm work + livestock	7	28	17	37	63	21	37
BG + off-farm work + horticulture	24	20	10	45	65	25	35
Fisheries + commerce + horticulture	49	88	50	50	38	13	63

[a] None of the conservation practices are used in the two communities that comprise income-earning strategy 8 (fisheries + commerce + horticulture).

4. Econometric analysis of community level information

The following section presents the results of our econometric analysis conducted to identify the principal factors that determine the various income-earning strategies. The section that follows looks at determinants of the use of conservation practices at the community level. We made use of a multinomial logit model and probit models for the identification of factors determining income-earning strategies and conservation practices, respectively (Green, 2000). In both types of models the data used are a combination of secondary information obtained from external sources (Table 1) and primary data obtained from the diagnostic surveys. Regarding the latter, given the qualitative and subjective nature of the data used, the results of the econometric analyses should be considered suggestive rather than definitive. They will be validated by similar exercises using more quantitative and precise data at the household and plot levels (see Jansen et al., 2003a).

4.1. Determinants of income-earning strategies

The results of the multinomial logit model are presented in Table 4 and exclude strategy 8 because only two communities are included in this category.

In general terms the results suggest that a community's income-earning strategy depends on a range of factors that jointly determine its comparative advantage. These factors include biophysical, economic and social factors. In agreement with Pender et al. (2001) who studied 48 communities in the Central Zone of Honduras in the mid 1990s, results regarding biophysical variables indicate that a relatively high altitude increases the probability that a community specializes in the production of coffee or horticultural crops (vegetables in particular) instead of a focus on basic grains and livestock production. Favorable rainfall during the main growing season increases the probability that a community follows strategy 2 (basic grains + forestry), strategy 5 (basic grains + off-farm work + livestock) or strategy 6 (basic grains + off-farm work + horticulture). Pender et al. (2001) also found a positive association between rainfall and off-farm work, while reporting that high rainfall is positively associated with coffee production. While we did not find such a statistical relationship, both coffee-growing strategies have significantly higher rainfall than the basic grains + livestock production strategy. On the other hand, favorable rainfall during the secondary season lowers the probability that a community's income-earning strategy focuses on off-farm work, probably because it makes own-farm production more profitable. Since only two communities reported having significant irrigation facilities, favorable rains in the secondary season are crucial for successful off-season vegetable production.

Population density shows a consistently negative and significant coefficient for five of the six income-earning strategies included in the model. For vegetable communities this result appears to be consistent with Pender et al. (2001) who reported relatively low population densities in such communities, despite a relatively high population growth. For the other strategies one would be inclined to argue that income-earning activities in densely populated communities are limited to basic grains

Table 4
Principal determinants of income-earning strategies in hillside communities in Honduras

Multinomial logit regression[a]												
Explanatory variables[b]										Diagnostics		
Income-earning strategy	Altitude (m above sea level)	Rainfall primary season (mm during May–September)	Rainfall secondary season (mm during Oct-Jan)	Population density 2000 (persons per km^2)	Market access index[c]	Index of community-based organizations[d]	Percentage of people that own land	Number of external organizations	Illiteracy rate (%)	Mean predicted probability	Proportion of observations	Difference (%)
Coffee and basic grains	0.008**	0.001	0.004	−0.023***	−0.282	−0.027	−0.039	0.433	0.065*	0.241	0.288	16.5
Standard error	0.003	0.003	0.004	0.008	0.182	0.124	0.026	0.335	0.037			
P-value	0.011	0.668	0.291	0.007	0.121	0.827	0.138	0.196	0.083			
Basic grains and forestry	0.008	0.009*	0.003	−0.030	−0.028	0.137	−0.008	−0.056	−0.201	0.044	0.042	−5.9
Standard error	0.005	0.005	0.004	0.040	0.114	0.187	0.026	0.267	0.178			
P-value	0.108	0.064	0.472	0.450	0.803	0.464	0.775	0.834	0.259			
Basic grains, off-farm work and coffee	0.009**	0.002	−0.008	−0.011**	−0.990**	0.400**	−0.055*	1.265***	0.097*	0.134	0.114	−17.1
Standard error	0.004	0.002	0.006	0.005	0.425	0.191	0.032	0.475	0.052			
P-value	0.029	0.390	0.139	0.044	0.020	0.038	0.086	0.008	0.066			
Basic grains, off-farm work and livestock	−0.004	0.005**	−0.011**	−0.027***	−0.157	0.175*	−0.076***	−0.117	0.189	0.152	0.137	11.1
Standard error	0.003	0.003	0.005	0.010	0.123	0.095	0.029	0.297	0.031			
P-value	0.226	0.097	0.027	0.005	0.200	0.067	0.009	0.693	0.544			
Basic grains, off-farm work and horticulture	−0.000	0.006**	0.003	−0.025***	−0.143**	0.083	−0.066**	−0.307	0.039	0.219	0.210	−4.2
Standard error	0.002	0.002	0.002	0.008	0.062	0.089	0.026	0.254	0.030			
P-value	0.903	0.016	0.210	0.001	0.021	0.351	0.012	0.227	0.194			
Basic grains and horticulture	0.013***	0.001	0.022***	−0.023***	−1.762***	−0.310*	0.078	1.567***	0.120**	0.106	0.083	28.0
Standard error	0.005	0.003	0.008	0.007	0.645	0.167	0.075	0.518	0.047			
P-value	0.009	0.767	0.006	0.001	0.006	0.065	0.295	0.002	0.011			

No. of obs. = 78, pseudo $R^2 = 0.52$, log probability = −68.07.

[a] Left-out income-earning strategy is ''Basic grains and livestock''.

[b] *, **, *** indicate statistical significance at $P = 0.10$; 0.05;0.01, respectively.

[c] Travel time between the center of the community and the nearest urban market, adjusted for road type and slope.

[d] Number of community-based organizations multiplied by an average performance indicator (1, poor; 2, average; 3, good).

and livestock, which carry relatively low economic returns. Within this logic high population densities are closely associated with poverty. On the other hand, 75% of the communities that focus on basic grains and livestock production are located in the north of the country (provinces of Atlántida and Colón) where average incomes are relatively high. (see also Jansen et al., 2003b). The main reasons for the relatively high incomes in the northern provinces include favorable agroclimatic conditions and relatively good infrastructure and market access. These zones increasingly attract migrants from less-favored zones in the country such as the south (Choluteca province) and the west (Lempira province). However, since the logit model already controls for most of these factors, the negative and significant population coefficients indeed seem to suggest that a high population density (and the resulting land fragmentation) tends to lock people into producing basic grains and livestock (mainly for own consumption) and as such impedes the transition to other (possibly more profitable) income-earning strategies.

The market access variable is defined as the time needed to reach the nearest urban center from the center of the community, thus taking not only distance but also road quality and slope into account. The larger the value this variable assumes, the worse is market access. The model's results show that, all other factors equal, favorable market access increases the probability that a community will specialize in coffee or vegetables (even though in the case of coffee there may be reverse causality, i.e., the national coffee institute IHCAFE has a long history of investing in road construction in many coffee growing areas). Good access to urban centers also stimulates off-farm work. These results are in agreement with Pender et al. (2001) who report that coffee, horticulture and off-farm work all are more important in communities with good road access.

Regarding the influence of organizations on income-earning strategies, our results suggest that market-oriented production is stimulated not so much by community-based organizations but rather by organizations from outside the community that enable exploitation of a comparative advantage in production of horticultural crops or coffee (even though the external organizations variable has no significant influence on the probability of the coffee + BG strategy but this may well be due to time lapses, i.e., while US agencies such as USAID played a key role in propagating coffee, their influence had waned by the early 1990s.). Community-based organizations seem to play a role in stimulating income-earning strategies that involve off-farm work.

The results with respect to the illiteracy variable probably reflect the geography of past public investments in education that traditionally have been very low in some of the major coffee growing regions including the provinces of Lempira and Yoro. The same explanation holds for the two communities in the county of San Manuel de Colohete that grow horticultural products for export to El Salvador. For these communities the positive coefficient of the illiteracy variable is even more statistically significant (5%) than for the coffee communities (10% level of significance). This may be due to the labor-intensive character of horticulture-based strategies that depend on low-wage laborers who as a group have little access to education.

Table 5
Principal determinants of conservation practices in hillside communities in Honduras

Probit regressions[a]				
Explanatory variables[b]	Type of conservation practice			
	Live barriers	Contour planting	Terrace construction	Tree planting
Coffee and basic grains	0.137	−0.140	1.153*	3.533***
Standard error	0.745	0.597	0.633	0.902
P-value	0.854	0.815	0.068	0.000
Basic grains and forestry	−0.815	–	–	–
Standard error	1.068	–	–	–
P-value	0.445	–	–	–
Basic grains, off-farm work and coffee	−1.668	0.050	0.406	2.518***
Standard error	1.040	0.787	0.681	0.912
P-value	0.109	0.949	0.551	0.006
Basic grains, off-farm work and livestock	−1.427	−0.035	0.807	2.312***
Standard error	0.891	0.739	0.668	0.867
P-value	0.109	0.962	0.227	0.008
Basic grains, off-farm work and horticulture	−0.838	−0.095	0.560	1.631*
Standard error	0.878	0.709	0.729	0.953
P-value	0.340	0.893	0.443	0.087
Basic grains and horticulture	0.697	0.308	1.154	2.497**
Standard error	0.756	0.644	0.703	1.152
P-value	0.356	0.633	0.101	0.030
Population density 2000 (persons per km^2)	−0.015*	−0.021***	−0.014*	−0.021**
Standard error	0.008	0.007	0.008	0.010
P-value	0.071	0.002	0.072	0.031
Population density squared	0.00003*	0.00004***	0.00004**	0.00006***
Standard error	0.00002	0.00001	0.00002	0.00002
P-value	0.088	0.006	0.048	0.004
Market access index	−0.402***	−0.026	−0.110*	0.029
Standard error	0.111	0.048	0.056	0.044
P-value	0.000	0.592	0.051	0.506
Percentage of people that own land	−0.009	0.007	−0.007	0.007
Standard error	0.011	0.012	0.008	0.009
P-value	0.429	0.542	0.421	0.444
No. of community-based organizations	0.201*	0.275***	0.174*	−0.013
Standard error	0.105	0.088	0.095	0.107
P-value	0.057	0.002	0.068	0.903

(*continued on next page*)

Table 5 (*continued*)

Probit regressions[a]				
Explanatory variables[b]	Type of conservation practice			
	Live barriers	Contour planting	Terrace construction	Tree planting
No. of external organizations with focus on production	0.337	0.030	−0.134	0.953***
Standard error	0.323	0.269	0.293	0.354
P-value	0.256	0.911	0.643	0.007
No. of external organizations with focus on integrated development	1.322**	0.523	−0.027	0.811*
Standard error	0.527	0.416	0.416	0.468
P-value	0.012	0.900	0.948	0.083
Illiteracy rate (%)	0.017	0.013	0.011	0.011
Standard error	0.012	0.012	0.011	0.014
P-value	0.147	0.285	0.327	0.430

[a] Left-out income-earning strategy is "Basic grains and livestock".
[b] *,**,***indicate statistical significance at $P = 0.10$; 0.05;0.01, respectively.

Finally and in agreement with a priori expectations, a higher percentage of people without their own land stimulate income-earning strategies that focus on off-farm work.

4.2. Determinants of conservation practices

Given that from a biophysical point of view the majority of the hillsides are only suitable for forestry and perennial crops, the use of conservation practices becomes especially important wherever annual cropping takes place. In Honduras, promotion of conservation practices in agriculture dates back to the late 1970s when a number of foreign-assisted projects were initiated. However, adoption of such practices is still not widespread, and it is important to find out why. Probit models were used to analyze the use of conservation practices in the communities and to identify the key determinants of specific practices including live barriers, contour planting, construction of terraces, and tree planting. While controlling for income-earning strategies, explanatory variables included in the model are population density, population density squared (to allow for U-type or inverse U-type relationships), market access, land ownership, illiteracy rate, and organizations (Table 5). Lack of data prevented us from including other potentially important explanatory variables such as soil quality, land distribution within the community, etc.

The results show that construction of terraces and tree planting are influenced by the type of income-earning strategy of a community, even after controlling for the influence of market access, population density, schooling and organizations. Not surprisingly, tree planting was the only conservation practice encountered in forestry communities. Terrace construction is relatively common in coffee communities where

people may be more aware of the negative impacts of erosion. Tree planting is least common in BG + livestock communities but common in coffee communities (shaded coffee) and in communities where off-farm work is common and may act as a source of finance to implement this practice.

While our results regarding the influence of income-earning strategy are limited to terrace construction and tree planting, Pender et al. (2001) found that contour planting is more common in communities that specialize in horticulture, coffee or forestry; live barriers are more common in coffee and forestry communities; and terrace construction is more widely adopted in coffee and forestry communities as well as in communities where off-farm work is important.

The results regarding the influence of population density on conservation practices suggest a U-type relationship. That is, up to a certain population density the four conservation practices considered here are less common in communities with higher population densities. However, after a certain point population density has a positive influence on the adoption of conservation practices. A possible explanation for this result may be that only after population density and degradation of natural resources reach certain critical levels, people start becoming aware of the need for conservation practices. To the extent that the latter are labor-intensive, their costs may also be lower in densely populated environments.

In order to determine the "bottom" of the U (i.e., where the relationship between population density and adoption of conservation practices turns positive), the ratio $(-A/2B)$ was calculated, where A and B represent the estimated coefficient of population density and population density squared, respectively. This ratio assumes values of 257, 266, 202 and 169 (persons/km^2) for respectively live barriers, contour planting, terrace construction and tree planting. It is concluded that population density in the majority of the communities has not yet reached the stage of the increasing part of the U. Only in four out of the 95 sample communities does current population density exceed 170 persons/km^2.

The use of live barriers and terrace construction is less likely in areas with poor market access, possibly because these practices are less profitable in areas far away from population centers where returns to agriculture can be expected to be lower than in areas near cities. Such a relationship was not found for tree planting or contour planting, probably because these activities involve less investment. Another possible explanation for the low adoption of conservation practices in remote areas is geographical isolation which makes assistance from outside organizations that focus on conservation practices less likely. On the other hand, our model controls for the presence of external organizations. In general, these results support the findings from Pender et al. (2001) who found that practices such as contour planting, minimum tillage, use of cattle manure and incorporation of residues are more common in communities near Tegucigalpa. The same study also reported a higher probability of the use of chicken manure and more live barriers in communities near a major road.

Except for tree planting, community-based organizations positively affect the adoption of conservation practices. Sustainable agricultural practices are often promoted by external organizations (Dercksen and Jansen, 2005; Zelaya and Reardon, 2001). We found evidence that external organizations that deliver technical

assistance to farmers play a key role in promoting live barriers and tree planting, even after controlling for income-earning strategies. In other words, external organizations affect the adoption of conservation practices in two ways, through a direct impact (Table 5) as well as via influencing the type of income-earning strategy (Table 4). These results are in agreement with those reported in Pender et al. (2001) who also found a positive influence of outside technical assistance on the use of conservation technologies.

In the literature the effect of education (approximated by the illiteracy rate in our study) on the adoption of conservation practices is usually reported to be ambiguous (Pender and Kerr, 1998). Our results regarding education are also not statistically significant. On the one hand, education increases the opportunity cost of labor and as such may negatively affect the adoption of labor-intensive conservation practices. On the other hand, educated people usually have better access to information and are better aware of the benefits of such practices. Finally, education tends to improve access to credit, which by itself has an ambiguous effect on the use of conservation practices. Pender et al. (2001) found a positive effect of education on certain specific conservation practices including contour planting, terrace construction and use of manure. But the same study reports mulching as being less common in communities with higher literacy rates. In our study, it seems likely that the opposite direction of a number of these effects lead to the reported lack of statistical significance of the effect of education on the use of conservation practices.

Finally, even though with our community data we were unable to detect a significant influence of land tenure on the adoption of conservation practices, subsequent research based on detailed household and plot level data from the same communities confirm that land ownership has a positive influence on the use of such practices (Jansen et al., 2003a).

5. Conclusions and implications of the results for technical assistance, policymaking and public investment strategies

The diagnostic surveys carried out at the community level and the results of our qualitative and quantitative analyses are important at three levels. First, they may serve to educate national policy makers regarding the alarming situation in many rural communities in the hillsides where poverty is widespread and deep. Even though the diagnostic surveys were not meant to collect the detailed information needed to calculate household incomes (this was done in the subsequent household survey carried out in the same communities), visual observation during the fieldwork regarding housing, human health, natural resource degradation etc. revealed the extent of rural poverty in Honduras. According to PRONADERS and other reliable sources of knowledge about the hillside zones in rural Honduras, living conditions in many of these areas have actually worsened over time. This impression is confirmed by the claim of many survey respondents that real wages in the rural areas have substantially decreased over the past decade, often by 30–50%.

Second, our results may serve as direct inputs into rural development projects such as the project "Reactivation of the Rural Economy" executed under the auspices of PRONADERS and financed through a loan from the Interamerican Development Bank. This project focuses mainly on hillside communities and finances investment proposals developed at the community level. The individual reports that were produced for each community should be helpful inputs into the process of identifying promising projects that are eligible for financing and increase the efficiency of rural development spending.

Third, the results of this study have some important implications for policy decisions aimed at influencing income-earning strategies in order to improve the standard of living in rural hillside communities. For example, from the results of the statistical analysis aimed at identifying the principal determinants of income-earning strategies it is clear that public investments in road infrastructure are crucial in order to link rural communities with markets and reduce transaction costs.

The results obtained from the statistical analysis regarding the use of conservation practices point towards the importance of organizations in general and community-based organizations and external organizations that provide technical assistance in particular. At the same time however, our results show that the adoption potential of conservation technologies is also determined by income-earning strategies themselves and that indeed conservation technologies need to be tailored depending on the type of income-earning strategy pursued.

Another important result concerns the influence of population density on technology use. We found support for Boserup's hypothesis that population increases have a positive effect on the adoption of sustainable production practices (Boserup, 1965). However, we also found that such effects occur only once a certain minimum population density has been reached. We may therefore conclude that the adoption of conservation technologies does not proceed automatically as population grows. Rather, specific policies and incentive structures are needed in order to speed up the adoption process.

Our qualitative analysis indicates that lack of sufficient financial capital and low private profitability of many conservation practices (at least in the short run) are important factors limiting the widespread diffusion of such practices. This is a result that is not unique to Honduras but has been found in many other Central American countries as well (see, e.g., Lutz et al., 1994). Organizations that are concerned with conservation technologies should carefully take these limiting factors into account and only promote alternative technologies that are more profitable than the ones that they will replace.

Finally, the information available from the diagnostic surveys does not permit a quantitative analysis of the relationship between income-earning strategies and poverty levels. However, from the qualitative analysis it has become clear that current levels of public expenditure in the hillside regions are insufficient to enable people to achieve significant improvements in their living standards. In addition to improvements in infrastructure (roads in particular), subsequent research based on detailed household and plot level data from the same communities (Jansen et al., 2003a) suggests that improved access to land, education, market access and

extension aimed at maintaining soil fertility have particular potential to raise incomes.

Acknowledgments

The authors thank the people in the communities where the diagnostics were carried out for their time and hospitality. We express our gratitude to the numerous organizations involved in the execution of the community diagnostics. Finally, we are grateful for the useful comments and suggestions of two anonymous reviewers and the Editor-in-Chief.

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