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Abstract

As the use of Payments for Environmental Services (PES) approaches in developing countries has grown, concern has arisen over the ability of poorer households to participate. This paper uses data from a PES project being implemented in Quindío, Colombia, to examine the extent to which poorer households that are eligible to participate are in fact able to do so. The project provides a strong test of the ability of poorer households to participate in a PES program as it requires participants to make substantial and complex land use changes. The results show that poorer households are in fact able to participate at levels that are broadly similar to those of better-off households. Moreover, their participation was not limited to the simpler, least expensive options. Transaction costs may be greater obstacles to the participation of poorer households than household-specific constraints.

Keywords

Payments for Environmental Services (PES), poverty, silvopastoral, Colombia

1. Introduction

Recent years have seen growing use of Payments for Environmental Services (PES) to finance conservation in developing countries (Landell-Mills and Porras, 2002; Pagiola et al., 2002; Wunder, 2005; Pagiola and Platais, 2007). Latin America has been particularly receptive to the PES approach. PES programs are in operation in Colombia (Echevarría, 2002b), Costa Rica (Pagiola, 2007), Ecuador (Echevarría, 2002a; Wunder and Alban, 2007), El Salvador (Díaz et al., 2002), Mexico (Muñoz et al., 2006), and elsewhere, and others are under preparation or study in several countries, in many cases with World Bank support.

As use of PES approaches grows, there is a need to understand how they affect the poor. PES programs can channel substantial flows of resources into rural areas. Costa Rica's PES program, for example, makes payments of about US$16 million annually (Porras et al., forthcoming). Many have assumed that PES will contribute to poverty reduction by making payments to poor land users, while others have warned of potential dangers (Kerr, 2002; Landell-Mills and Porras, 2002; Pagiola et al., 2002; Grieg-Gran et al., 2005; Pagiola et al., 2005). There has been little empirical verification to date of whether these resource flows reach the poor, however.

A key question concerning the link between PES programs and poverty is whether poorer households are able to participate (Pagiola et al., 2005). PES programs generate benefits (in terms of payments) only to those households that participate and supply the desired services. Worries that poorer households may not be able to participate in PES programs have been heightened by several case studies indicating that many participants in Costa Rica's PES program are relatively well-off (Ortiz et al., 2002; Miranda et al., 2003; Zbinden and Lee, 2005). Similarly, better-off *ejidos* are over-represented among participants in Mexico's PES program, while very highly marginalized *ejidos* are under-represented (Muñoz et al., 2006). Determining whether poorer households will be able to participate, and what measures might be needed to ensure that they can, is thus critical if PES programs are to contribute to poverty reduction objectives.

This paper uses data from a PES project being implemented in the Quindío area of Colombia to examine the participation of poorer households. The Quindío area is one of three pilot sites for the *Regional Integrated Silvopastoral Ecosystem Management Project*, which is using PES to encourage the adoption of silvopastoral practices in degraded pastures, so as to generate increased biodiversity conservation and carbon sequestration (Pagiola et al., 2004). Quindío provides an interesting setting to study the ability of poor households to participate in a PES program because it includes a very wide range of income levels, with many households falling below the poverty line and many with very high income levels. In addition, the Silvopastoral Project offers a wide range of participation options in Quindío, ranging from simple and inexpensive land use changes to substantial and complex changes (with correspondingly higher payments). We are thus able to go beyond examining binary participation/non-participation decisions and look at intensity of participation. That some of the choices offered by the project are complex and onerous provides a particularly strong test of poorer households' ability to participate.

This analysis complements an earlier analysis of poor household participation in PES at another Silvopastoral Project site, in Matiguás-Río Blanco, Nicaragua (Pagiola et al., 2007a). That analysis found that poorer households were in fact able to participate in the program, and indeed by some measures participated to a greater extent than better-off households. The Quindío area differs in important respects from Matiguás-Río Blanco, however. Quindío has larger farms than Matiguás-Río Blanco, and a much wider range of income levels—in particular, the proportion of poor households is much smaller in Quindío, and the best-off households are much richer than any household in Matiguás-Río Blanco. Initial conditions were also very different: silvopastoral practices were almost unknown in Quindío prior to the project, but were relatively well-known in Matiguás-Río Blanco.

We begin by defining PES and discussing the factors that might hinder poorer households' ability to participate in PES projects, drawing on the review by Pagiola et al. (2005) and on the rich literature on technology adoption by smallholders in developing countries. We then describe the project and the Quindío site. We use data collected at the study site to analyze participation patterns, with particular attention to participation by poorer households, and then undertake an econometric analysis to determine the factors that affect participation decisions. We conclude by discussing the implications of our results for PES program design.

2. Payments for environmental services and poverty

PES is a market-based approach to conservation financing based on the twin principles that those who benefit from environmental services (such as users of clean water) should pay for them, and that those who contribute to generating these services (such as upstream land users) should be compensated for providing them (Pagiola and Platais, 2007; Wunder, 2005). The approach thus seeks to create mechanisms to arrange for transactions between service users and service providers that are in both parties' interests, internalizing what would otherwise be an externality. The PES approach is attractive in that it (i) generates new financing, which would not otherwise be available for conservation; (ii) is likely to be sustainable, as it depends on the mutual self-interest of service users and providers and not on the whims of government or donor financing; (iii) is likely to be efficient, in that it conserves services whose benefits exceed the cost of providing them, and does not conserve services when the opposite is true.

PES programs are not intended to be poverty reduction programs. The objective of PES programs is to address environmental and natural resource management problems, by providing a mechanism to internalize externalities. For this objective to be achieved, poverty cannot be used as a criterion for participation. Omitting land users who contribute to service delivery because they are not poor would undermine the basis for the program, as would including land users who do not contribute to service delivery solely because they are poor. The fundamental criterion for participation must be the capacity to provide the desired services. However, the perception that areas of high poverty are highly correlated spatially with areas that provide environmental services has led to an expectation that PES programs could contribute to poverty reduction.[1]

In a PES program, land users are paid to maintain or switch to land uses that provide environmental services that others value. Participation in the program is voluntary, and participants receive payments for doing so. This creates a *prima facie* presumption that participants are at least no worse off by participating than they would be if they did not. Were this not the case, they could simply decline to participate. Payments by PES programs, in

[1] There have been few efforts to document this presumed relationship between poverty and areas important for service provision, however, and these show mixed results. For example, Nelson and Chomitz (2002) find that watersheds in Guatemala and Honduras where substantial active deforestation is occurring on steep slopes tend to have the highest concentration of poverty. Conversely, Pagiola et al. (2007b) find very little correlation between poverty rates and the importance of an area for water service provision in Guatemala.

addition to covering opportunity costs, have the further advantage that they are highly predictable. Unlike returns to crop production, which depend on the vagaries of weather and market conditions, the amount of PES payments is fixed for the duration of the contract, as long as participants comply with its terms. PES programs have thus often proven highly attractive to land users. About three times more land is typically offered to Costa Rica's and Mexico's PES programs every year than available funding can cover (Pagiola, 2007; Muñoz et al., 2006).

The potential benefits of PES programs will only be realized by those who participate. Pagiola et al. (2005) group the factors that might affect household participation into three categories: factors that affect eligibility to participate; factors that affect desire to participate; and factors that affect ability to participate. These categories form a logical sequence: the ability to participate only become an issue for households that wish to do so, and that in turn is only relevant for households that are eligible to participate. In this paper, we focus on the factors that affect the participation of eligible households, and particularly on how they affect the participation of poorer households.

Participation requires adopting the land uses promoted by the program. When a PES program calls for retaining existing land uses (as in the Costa Rica program's forest protection contract), participation is likely to be relatively straightforward. But when a PES program calls for switching to new practices, as is the case in the Silvopastoral Project, participation decisions become more complex. The literature on technology adoption and program participation provides many insights into the factors likely to affect participation (Feder et al., 1985). The literature on adoption of agroforestry practices (Pattanayak et al., 2003; Mercer, 2004) is particularly pertinent, as the practices promoted by the Silvopastoral project are very similar.

Tenure issues are often critical, particularly in cases where PES programs require long-term investments, such as reforestation or adoption of silvopastoral practices. Tenure variables were significant in 72% of agroforestry adoption studies that included them, with greater tenure security being consistently associated with greater adoption (Pattanayak et al., 2003). Thacher et al. (1997) and Zbinden and Lee (2005) found tenure-related variables to be highly significant in explaining participation in Costa Rica's PES program and its predecessor programs.

When the new practices to be adopted are complex, access to technical assistance may play an important role. Access to extension was found to significantly affect agroforestry adoption in 90% of studies that included it (Pattanayak et al., 2003), including two studies in Costa Rica (Thacher et al., 1997; Zbinden and Lee, 2005).

Adopting new land use practices may also prove difficult if households cannot finance the necessary investment. Savings, remittances, or off-farm income may help some households undertake the necessary investments. Assets and credit both tend to increase adoption of agroforestry practices, and their role is very often significant (Pattanayak et al., 2003).

Many of the factors that affect a household's ability to participate in PES may well be more salient for poor households. Poorer households in Latin America are less likely to have secure tenure, tend to have fewer savings and less access to credit, and are less likely to receive technical assistance (de Janvry and Sadoulet, 2000; López and Valdés, 2000). Whether poor households will be able to participate in PES programs (assuming that they are eligible and interested in doing so) is thus a legitimate source of concern.

3. The Silvopastoral Project

The Regional Integrated Silvopastoral Ecosystem Management Project is piloting the use of PES in three areas: Quindío, in Colombia; Esparza, in Costa Rica; and Matiguás-Río Blanco, in Nicaragua (Pagiola et al., 2004). The project is financed by a US$4.5 million grant from the Global Environment Facility (GEF), with the World Bank as the implementing agency. The project was developed with support of the multi-donor Livestock, Environment and Development Initiative (LEAD), hosted by the Food and Agriculture Organisation (FAO). It is being implemented in the field by local non-governmental organizations (NGOs). In Colombia, this work is being conducted by the Centre for Research on Sustainable Agricultural Production Systems (*Centro para la Investigación en Sistemas Sostenibles de Producción Agropecuaria*, CIPAV).

Cattle production has long been an important cause of the loss of natural habitat and biodiversity in Latin America (Downing et al., 1992; Kaimowitz, 1996; Murgueitio, 2003). Despite the correction of many of the policy distortions that encouraged deforestation, pressure from expanding livestock production continues to result in large-scale deforestation in many areas. In addition to the environmental problems caused by the initial loss of forest, extensive grazing is often unsustainable. After an initial period of high yields, soil fertility is depleted and grass cover diminishes, resulting in soil erosion, contamination of water supplies, air pollution, further loss of biodiversity, and degradation of landscapes. Lower income for producers results in continuing poverty and can lead to pressure to clear additional areas.

Silvopastoral practices, which combine trees with pasture, offer an alternative to prevalent cattle production systems. Silvopastoral practices include (1) planting high densities of trees and shrubs in pastures, thus providing shade and diet supplements while protecting the soil from packing and erosion; (2) cut and carry systems, in which livestock is fed with the foliage of specifically planted trees and shrubs (‘fodder banks’) in areas previously used for other agricultural practices; and (3) using fast-growing trees and shrubs for fencing and wind screens. These practices provide deeply rooting, perennial vegetation which is persistently growing and has a dense but uneven canopy.

The on-site benefits of silvopastoral practices to land users may include additional production from the tree component, such as fruit, fuelwood, fodder, or timber; maintaining or improving pasture productivity by increasing nutrient recycling; and diversification of production (Dagang and Nair, 2003). While these benefits can be important, they are often insufficient by themselves to justify adopting silvopastoral practices—particularly practices with substantial tree components, which have high upfront planting costs and only bring benefits several years later. Estimates prepared for the project show rates of return of between 4 and 14%, depending on the country and type of farm (Gobbi, 2002). Other studies found similar results; White et al. (2001), for example, found rates of return to adoption of improved pasture in Esparza, Costa Rica, of 9 to 12%. These estimates, of course, only consider the on-site benefits of silvopastoral practices. The biodiversity conservation and carbon sequestration benefits are not considered in the farmers’ decision making.

Because of their increased complexity relative to traditional pastures, silvopastoral practices also have important biodiversity benefits (Dennis et al., 1996; Harvey and Haber, 1999). They have been shown to play a major role in the survival of wildlife species by providing scarce resources and refuge; to have a higher propagation rate of native forest plants; and to provide shelter for wild birds. They can also help connect protected areas. Silvopastoral practices can also fix significant amounts of carbon in the soil and in the standing tree biomass (Fisher et al., 1994; Pfaff et al., 2000). Both biodiversity and carbon sequestration benefits are off-site, however, so land users will tend not to include them when they are deciding which practices to adopt. Silvopastoral practices can also affect water services, though the specific impact is likely to be site specific (Bruijnzeel, 2004; Murgueitio, 2003). GEF funding for the Silvopastoral Project is based on the desire to secure these biodiversity and carbon sequestration benefits.

Most PES programs focus on very few land uses. Costa Rica's program, for example, pays for conserving existing forest, for establishing timber plantations, and for instituting agroforestry practices (Pagiola, 2007). This approach has the virtue of simplicity, but it fails to recognize that there is a spectrum of effects. Within the broad rubric of silvopastoral practices, the extent of biodiversity conservation and carbon sequestration will depend on the density and diversity of species used. Pastures with low tree density will provide fewer biodiversity and carbon benefits than pastures with a high tree density. Likewise, biodiversity benefits will be greater when a diversity of native species with different canopy heights is used. To encourage adoption of more beneficial practices, the Silvopastoral Project offers payments that are proportional to the level of services provided. To do so, it developed indices of the biodiversity conservation and carbon sequestration services that different land uses provide, then aggregated them into a single 'environmental services index' (ESI). The ESI distinguishes 28 different land uses, each with its own ESI score (see Table 1).[2] PES recipients receive a one-time payment of US$10/point for baseline ESI points and a payment of US$75 per incremental ESI point (computer over their entire farm area), per year, over a four-year period.[3]

As a pilot project, the Silvopastoral Project had limited funding, so participation was limited to 80 households. A series of public workshops were held in the area to explain the project, with support of the Quindío livestock association. Two field visits were also organized to the El Hatico Nature Reserve in the Cauca valley, where silvopastoral practices are already in use. Households who expressed an interest were then accepted on an essentially first-come basis, provided they met some minimal criteria on size of herd.

In an effort to distinguish project-induced land use changes from changes induced by other factors, both surveys also include a control group, as recommended by emerging guidelines for project impact assessment (Ferraro and Pattanayak, 2006).[4] However, assigning applicants randomly to either the participant or the control group was judged to be infeasible because of strong household desire to participate. Accordingly, a matching approach was adopted, with control group households with similar characteristics (in terms of size, type of activities, and agroecological conditions) being selected from the same area. Budget constraints, particularly on the cost of monitoring, meant that the control group had to be limited to 30 households.

The Silvopastoral Project offers a strong test of ability to participate, as many of the measures it supports are both expensive and technically challenging to implement. Should either investment requirements or technical capacity prove to be formidable obstacles for poorer households, there would be a clear division in the types of PES-supported activities they implement.

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2. The ESI is described in detail in CIPAV (2003) and Pagiola et al. (2004). Not all practices recognised in the ESI are relevant for Quindío.
3. The Silvopastoral Project's use of short-term payments is controversial, as emerging PES guidelines indicate that payments in PES programs should be on-going rather than finite (Pagiola and Platais, 2007; Wunder, 2005). For a discussion of the pros and cons of the project's short-term payments, see Pagiola et al. (forthcoming).
4. To our knowledge, this was the first World Bank project to include a control group.

4. Study site

The Quindío area is located in Colombia's Central Cordillera, in the watershed of Río La Vieja, at an altitude of about 900-1,300m above sea level. Farms range from 10-20ha to some of 50-80ha. In this former coffee area, many of the larger farms are owned by urban professionals and managed by employees (*mayordomos*).

Coffee production was once the dominant land use in Quindío, but it has been replaced by pasture in the last decade due to low coffee prices, and now accounts for less than 1% of the area. As shown in Table 1, extensive grazing is the main land use in Quindío.[5] Degraded and treeless pastures dominate the landscape, accounting for about 65% of the area. Livestock production is primarily for meat production, with a small proportion being used for milk production. Overall tree cover is low, although there is a significant amount of forest remnants, most of which is riparian forest. Silvopastoral practices such as pastures with trees, fodder banks, and live fences are practically non-existent. Only 7 in 110 farms surveyed had any fodder banks, for example, with an average of less than 1ha each.

5. Data collection

We use data from three data sets to examine participation decisions in Quindío. A baseline survey conducted in late 2002, during project preparation, collected detailed information on household characteristics. A second survey, conducted in March-May 2004, collected information on land use changes and factors affecting it in the first year of implementation.[6] These surveys include all PES recipients at the site as well as the control group. The baseline survey included data on 110 households. However, 6 observations had to be discarded because households sold their land, and another 3 because households dropped out of the PES program, leaving 72 households receiving payments and 29 members of the control group, for a total of 101 observations.

Finally, detailed land use maps are prepared annually for each farm in the PES recipient and control groups, using remote sensing imagery. Quickbird imagery with a 61cm resolution was used to prepare detailed land use maps for each farm, which were then extensively ground-truthed to match each plot to one of the ESI's 28 land uses. These mapping data give accurate and consistent measures of area and ensure that land uses are classified consistently into the project's categories.

As our interest is on the ability of poorer households to participate, measuring household income is critical. In general, expenditure is preferred to income as an indicator of household welfare, as it tends to be less variable (Ravallion, 1992). However, the baseline survey only collected data on income. We computed household income by adding all income sources reported by participants, including net income from agricultural, forest, and dairy production; livestock sales; off-farm work; net income from non-farm enterprises; and remittances. Dairy, agricultural, and forest products consumed by the household are included in the calculation of income using market prices, and the value of family labor is imputed using local wage rates for unskilled labor. As these data are based largely on information self-reported by the farmers, they are subject to both recall problems and possible biases. As our primary interest is in assessing differences in participation within our sample, these biases are unlikely to affect our results as

5 Figures in this paragraph refer only to the area managed by project participants and control group members.
6 The questionnaires for both surveys are available from the authors on request.

long they are similar across income groups. Our income measure correlates very well with other measures of household wealth, including value of assets, farm size, and herd size.

We used our estimates of household income per capita to classify households into three groups (Figure 1). There is a clear jump in income levels above 20 million Colombian Pesos (COP),[7] so we grouped households with income above this level into a 'high income' group. Below this income level, there is no evident clustering. We thus divided the remaining households into two groups of similar size, with the division falling at COP2 million. We classified households with income between COP2 million and COP20 million into a 'middle-income' group, and those with incomes below COP2 million into a 'low-income' group.[8] The small size of our sample precluded a finer breakdown (for example, into quintiles).

6. Participating households

The characteristics of participating households are summarized in Table 2. The average household in the sample is composed of 4.5 members, and has about 36ha of land and a herd of about 57 livestock units.[9] The average per capita income is about COP10 million. As can be seen, the average characteristics of the sub-group of PES recipient households differ slightly from those of the control group. This is to be expected, given the relatively small sample size and the range of conditions in the area.

Breaking down PES recipients into income groups shows both similarities and differences. Low income households have significantly less land and smaller herds than middle income households, which in turn have significantly less land and smaller herds than high income households. Low income households also have more members, although the proportion of dependents is highest among middle income households. Access to services is relatively high in the area, but low income households are less likely to have water services and more likely to live further from the nearest village. There are no significant differences in the topography of farms, with each income group having roughly similar proportions of flat, undulating, and steeply sloped land. Access to credit and to technical assistance (TA) is highest among high income households, but the differences are not significant.

Initial land uses were dominated by pastures with no or few trees in all three income groups, accounting for 60% of the land of low and middle income groups and reaching 80% of the land in the high income group. Whereas high income households had practically no other productive activities, however, middle income and especially low income households complemented their pastures with small areas dedicated to other productive activities. Low income households had 13% of their land under semi-permanent crops (mostly bananas), 7% under fruit crops, 2% under shade-grown coffee, and 2% under annual crops. Middle income households followed a similar pattern but on a smaller scale, dedicating 6% of their land to semi-permanent crops, and about 1% each to fruit crops, shade-grown coffee, and annual crops. The balance of land use among all three groups consisted of some form of forest cover (primarily riparian forest), which accounted 14% of land in low income households, 24% in middle income households, and 17% among high income households.

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7 In August 2004, US$1 = COP2,670.

8 The official poverty line in Colombia was about COP200,000 in 2003 (World Bank, 2002, adjusted for inflation between 1999 and 2003 using the consumer price index given in the World Bank's *World Development Indicators* database). About half the low income group has incomes below this level.

9 Livestock are converted into livestock units (*Unidad Gran Ganado*, UGG) using the following conversion factors: adult cows, 1.0 UGG; oxen or breeding bulls, 1.55 UGG; calves, 0.33 UGG; yearlings, 0.7 UGG.

7. Changes in land use

The Silvopastoral Project made its first payments, for the baseline ESI points, in July 2003. After monitoring land use changes, it made its first payment for incremental ESI points in May 2004. Additional payments were made in May 2005, May 2006, and May 2007. We limit our analysis to the first three years of the project, as data are not yet fully available for 2007.

Table 2 compares land use by PES recipients prior to the project (in 2003) and after the third year of the project (in 2006). Overall, the PES program has induced substantial land use change: About 1,200ha (over 42% of the total area) experienced some form of land use change. A wide variety of changes were observed, ranging from very small changes such as sowing improved grasses in degraded pastures to very substantial changes such as planting high-density tree stands or establishing fodder banks. The area of degraded pasture fell by 70ha (almost 90% of its original area) and that of natural pasture without trees by almost 500ha (almost 70% of its original area).[10] Most of the gains were experienced in pastures with high tree density, which increased by over 400ha, while natural pasture with high tree density added another 70ha. The area of fodder banks also rose dramatically, from less than 5ha to over 31ha, while that of intensive silvopastoral systems (Leucaena planted at 5,000 trees/ha) went from 0ha to 96ha. About 347km of live fencing were established. Semi permanent crops, fruit crops, and coffee found little favor, with their overall area declining by 62ha, while timber plantations and pure forest uses fared little better, their total area increasing by only 27ha. Overall, these changes increased the total ESI score of PES recipients by 44%. These changes were vastly greater than the changes observed in the control group, among whom less than 12% of land area experienced any change, for an increase in ESI points of only 10%.

Figure 2 breaks down the observed land use changes among PES recipients according to the income group of households undertaking them. As can be seen, households from all three income groups contributed to the observed land use changes. In particular, low income households accounted for 35% of the decline in degraded pastures and 45% of the decline in improved pasture without trees. They only accounted for 9% of the decline in natural pasture without trees, but this is primarily due to their having the least area in this use of any of the income groups.

Figure 2 also makes it clear that land use changes by poorer households were not limited to adopting technically simpler and less onerous practices. Low income households converted pastures with no or low tree density into pastures with high tree density, with a small share also being dedicated to fodder banks and intensive silvopastoral practices. In contrast, the middle income group made the simplest possible change on almost half of the land they converted, replacing natural with improved grasses (mainly star grass, *Cynodon plectostachyus*) in pastures with no or few trees.

Table 3 examines various indices of household participation across income groups. Low income households converted about 9ha each, compared to about 19ha for middle income households and about 33ha for high income households. These changes accounted for 39% of low income farms, however, compared to 40% for middle income households and 53% for high income households. Moreover, these differences in proportion of farm converted are not significantly different (at 10% level). Thus even though the changes undertaken by low income households are small in absolute terms, they are comparable to those undertaken by middle

[10] These figures are for *net* changes in the area under each practice, and so understate total changes. For example, some natural pastures with high tree density were converted to improved pastures to high tree density, reducing the apparent net change in natural pastures with high tree density.

income households in relative terms. In terms of changes in ESI points, the absolute increase is again smallest for low income households and largest for high income households, but in relative terms the 50% increase achieved by low income households exceeded the 36% achieved by middle income households and rivaled the 60% of high income households. Once again, these differences are not statistically significant. Participation rates by low income households are thus broadly similar to those of other groups—lower by some measures, but higher by others.

Table 4 shows how different groups financed the investments they made, according to their responses on the first-year participant survey. Some investments, of course, were undertaken entirely with family labor and did not require financing. The most frequently mentioned source of funds was savings (40% of all households), followed by income from off-farm activities (19%) and the sale of animals (18%). The initial 'baseline' payment made by the Silvopastoral Project was an important source of funding only for 6% of households, perhaps because the payment was so small, given the low initial ESI levels. There are few significant differences in funding sources across income groups, except that low-income households have access to financing from NGO projects and rely more heavily on off-farm income.

8. Household participation decisions

A simple examination of the data on land use change indicates that lower-income households are in fact able to participate at similar rates as higher-income households in this particular PES program, even though it requires some technically complex and onerous land use changes. To shed further light on participation decisions and the factors that may affect them, we undertook an econometric analysis of participation rates.

The literature on adoption decisions usually looks at the binary choice of whether or not to adopt a given practice, using cross-sectional data on adopters and non-adopters, and examines how different factors affect the probability of adoption (Pattanayak et al., 2003). This approach is not relevant in our case, for two reasons. First, the pilot nature of the Silvopastoral Project means that the participation decision is not entirely up to farm households. The project only had funds for a fixed number of participants; many non-participants wanted to participate.[11] Second, a binary adoption/non-adoption choice would fail to capture the nature of participation decisions in the Silvopastoral Project. As noted, the ESI recognizes 28 different land uses, and the project pays participants according to the increase in their total ESI score. Rather than participation per se, what is of interest here is the intensity of participation. The formal question we want to pose, then, is how household characteristics affect the intensity of participation, with a particular focus on whether poorer households are less able to participate than better-off households. Our approach is similar to that of Nkonya et al. (1997), who examined the intensity of adoption of improved seed in Tanzania using continuous variables (hectares planted with improved maize seed or amount of fertilizer applied per hectare of maize), and of Rajasekharan and Veeraputhran (2002), who examine the share of farms using intercropping in Kerala, India.

The dependent variable for our analysis can be formulated in many different ways. The simplest is the area converted: the greater the area converted, the higher the participation. Households with less land—including many low income households—will clearly score poorly on this indicator, however. Using the proportion of farm area converted avoids this problem, but faces others. Converting 5ha of land to improved practices takes greater effort than converting

[11] All control group households complained of not being allowed to participate (E. Murgueitio, pers. comm., 2007).

1ha, yet if the first household has 10ha and the second only has 1ha, the first household (50% converted) will appear to be participating 'less' than the second (100% converted). However expressed, area-based indicators also fail to measure whether the changes are large or small. Sowing improved pasture grasses in a treeless pasture requires substantially less effort than converting it to pasture with high tree density, yet will have the same value in terms of either area converted or percent of farm area converted. Area-based indicators also omit investments in live fencing. One option to incorporate a measure of intensity is to weight the area converted by the ESI of the land use change, and then add the points for live fencing. The ESI is not intended as a measure of effort, but higher-ESI land uses tend to involve more effort than lower-ESI uses. This measure is also appealing as it is the outcome of interest to the 'user' of the environmental services being sought. This measure can also be stated in different ways. The increase in total ESI is the simplest measure (and is readily available, as it forms the basis for payments to participants), but like the area converted it is constrained by total farm size. Stating it in terms of increase in ESI per hectare or percent increase in ESI addresses this problem. As each of these alternatives has its advantages and disadvantages, we use them all in separate models.

We thus ran five separate regressions, one with each dependent variable. We follow Rajasekharan and Veeraputhran (2002) in using a one-tailed Tobit to model farm area, as this variable is restricted to non-negative values. Likewise we employ a two-tailed Tobit model to model the percentage of the farm area converted, as this ranges between 0 and 100. Change in ESI, change in ESI per hectare, and percent change in ESI can take any value, and so are modeled using OLS.[12]

Our choice of explanatory variables draws on the factors identified by Pagiola et al. (2005) as likely to affect participation in PES, and by Pattanayak et al. (2003) and the studies they cite as likely to affect adoption of agroforestry practices, with modifications for the particularities of Quindío.[13] Eligibility is not an issue in our study, as we focus on an area that was selected for inclusion in the project. The desire to participate *per se* is also not an issue, as we are only looking at households who have chosen to participate. However, as the Silvopastoral Project offers a wide range of participation options, variables that affect desire to participate remain relevant, as they may affect the desire to undertake more intensive practices. Our main concern, however, is on factors that may impede a household's ability to participate. Within these factors, tenure is not an issue in Quindío, as the site was selected partly for the absence of such problems.

Many studies have shown that farm characteristics often have an important impact on adoption decisions. Most previous studies report a positive effect of farm size on adoption of various practices, which has been interpreted as indicating higher flexibility of the farming system or the existence of economies of scale (Rajasekharan and Veeraputhran, 2002; Thacher et al., 1997; Nowak, 1987). The size of the herd could affect adoption through the demand for fodder. The availability of labor would seem likely to be important, although it is not often significant (Pattanayak et al., 2002). We include a measure of the availability of family labor (adults/ha). We also include measures of the experience (age) and gender of the household head to capture characteristics of the farmers themselves which have often been found to be important.

[12] In principle, percent change in ESI could not be less than -100%. In practice, however, this limit is not binding, as no household even approached it. Indeed, only four households had a negative change in ESI.

[13] We face limitations in the number of explanatory variables that can be included because of the relatively small sample size. In this case, increasing the sample was not an option: our data include every single project participant.

Farmers with lower accessibility will tend to face higher input costs and lower output prices at the farm gate. As the main expected benefit from silvopastoral practices comes from higher milk production, this could play an important role in the desirability of adopting practices. We include a measure of distance to the nearest village to capture this aspect. The topography of the farm could also affect the profitability of different measures, although here the direction of the impact is less clear. Land on steep slopes may benefit more from silvopastoral practices in that it is more vulnerable to degradation under traditional extensive grazing. On the other hand, the cost of implementing practices may be higher. We include a variable on the percentage of farm area with flat topography, without making any prediction as to how it will affect results.

To examine whether the initial investment cost of many of the practices promoted by the Silvopastoral Project affect ability to participate, we include variables on value of assets and off-farm income. We use the value of assets rather than access to credit as very few households used credit to finance investments in silvopastoral practices, as shown in Table 4. The value of assets is expected to be positively related with participation. Off-farm income is measured as the income share of off-farm jobs held by all household members. Off-farm income can be a financing source for investment in new practices, but can also result in a higher opportunity cost of labor. Technical complexity of adoption of many practices may be overcome with training in their implementation. Indeed, the Silvopastoral Project provided such technical assistance to a (randomly-selected) subset of participants. We include a binary indicator for whether households received such support.

As poverty is multidimensional, we also include dummies for whether households are the low income or middle income groups, to capture other aspects of poverty that may not be captured by the previous variables. Finally, we include a dummy variable for PES recipients, to test whether the payments have in fact resulted in a change in land use behavior after correcting for other factors.

In all cases, we use data from the baseline survey – collected prior to the project's start – as explanatory variables, to avoid potential endogeneity problems.

9. Results

Table 5 summarizes the results of the analysis.[14] The first two columns report the results of Tobit models for area changed and proportion of farm changed, and the last three columns the results for the OLS models for change in ESI, percentage change in ESI, and change in ESI per hectare. Except for the OLS model of change in ESI, measures of model fit are relatively low, but this is not surprising with cross-sectional data, particularly when sample sizes are small. They are comparable to those obtained by Rajasekharan and Veeraputhran (2002) and Ervin and Ervin (1982).

Most estimated coefficients have the expected sign, and the results are consistent both across models and with the results of other studies. As expected, farm area is positively

[14] Tobit were tested for heteroscedasticity in the error distribution using the Wald test, and OLS models using the Breusch-Pagan test. Results for these tests rejected the null hypothesis of homoscedasticity of errors, which if ignored would result in inconsistent Tobit estimates (Maddala, 1983) and lost of optimality of the OLS estimator (Greene, 2000; Mittelhammer et al., 2000). In the absence of prior information about the structure of the heteroscedasticity, we used the White's heteroscedasticity-consistent covariance matrix estimator (White, 1980). We found no evidence of either moderate or strong muticollinerarity in any of the regression models using the Belsley (1991) diagnostic in the Tobit models and the Belsley et al. (1980) diagnostics in OLS models.

associated with intensity of adoption measured in area converted or ESI increases. However, farm size has a small, and non-significant impact on the proportion of the farm converted, and a negative impact on proportional changes in ESI and changes in ESI per hectare. This suggests that the correlation between farm size and area converted is simply due to larger farms having more area to convert (and, hence, being able to accumulate a larger absolute increase in ESI) rather than to economy of scale effects. Family labor is significant and positive in the area models, but gives non-significant results in the ESI models. This is not surprising: whereas converting a larger area requires more labor than converting a smaller one, switching to higher ESI land uses does not necessarily increase labor use. Experience has a small positive impact on intensity of participation in some formulations and a small negative impact in others, but is not significant in any model.[15] Other studies have often found a positive effect, though rarely a significant one and have generally attributed it to experience reducing the risk of adoption (Pattanayak et al., 2003). Male-headed households converted a greater proportion of their farms, but achieved a smaller relative increase in ESI.

Among the factors that are likely to affect the profitability of adoption, distance from the nearest village has a significant negative impact on the extent of area converted, but the impact on ESI is not significant. The proportion of the farm on flat terrain has a negative impact, but it is not significant except in some of the ESI models. As noted above, there is no strong a priori reason to expect a particular sign on this variable, but the results suggest that more intensive silvopastoral measures may be more attractive on steeper slopes, perhaps because higher levels of tree cover provide better protection against degradation.

Among the factors that affect the ability of households to participate in the program, assets have a very small but negative sign.[16] Access to technical assistance, on the other hand, has a positive impact in every model, but is only significant in one case. The lack of significance is somewhat surprising, given the complexity of some of the practices being promoted, and their near-total absence from the landscape prior to the project.

The strongest result in these models is that being a PES recipient has a large positive impact on the extent of adoption of silvopastoral measures, irrespective of how adoption is measured. This confirms the observed sharp contrast in land use change between PES recipients and control group measures, and indicates that the contrast was not due to self-selection of strongly motivated land users into the program or to differences in characteristics across groups.

Finally, the income group dummies show some interesting patterns. Both the low income and the middle income group dummies have consistently negative coefficients, except in the area changed models, but in most cases the effect isn't statistically significant. This suggests that income level has relatively little impact on participation that isn't already captured by other variables (such as farm size) which may be correlated with poverty. The only significant impact is that both low income and middle income households convert a lower share of their farm than high income households. This may well be due to both groups using a portion of their farm for other productive activities – indeed, low income households actually expanded the area under shade-grown coffee to a small extent, and replaced part of their monoculture fruit crop areas with diversified fruit crops.

[15] Education (in years) gave very similar results to age.
[16] An alternative formulation using access to credit prior to the project gave similar results.

10. Conclusions

The experience of the Silvopastoral Project in Quindío indicates that relatively poorer households are able to participate in a PES program at similar levels as relatively better off households. Though their participation rates were somewhat lower, relatively poorer households were neither shut out nor limited to the simpler and cheaper forms of participation. These results are particularly strong in that the Silvopastoral Project imposes much greater burdens on participants than most PES programs.

The conclusion that relatively poorer households are able to participate at roughly similar levels as better off households obviously needs to be approached with some caution.[17] It is possible that the high levels of participation by poorer households may be due to self-selection bias: only those households able to participate may have joined. We believe this is unlikely, for two reasons. First, the project offered a very wide range of participation options, including many that are not very onerous, even for poorer households. Indeed, households could in principle have done absolutely nothing; they would then have received the baseline payment but would not have received any payment beyond that. In fact, no PES recipient household chose that route. Second, as noted previously, many non-participating households in the area wanted to participate as well, but were prevented from doing so by the project's own limits on the number it could accept. But even if there were some self-selection at play, it is significant that even among relatively poorer households, there are many that are able to participate in a PES program, and even to undertake expensive and technically challenging land use practices.

It is interesting to compare the participation patterns of poorer households in Quindío to those of poorer households at the Silvopastoral Project site in Matiguás-Río Blanco, in Nicaragua (Pagiola et al., 2007a), as the payment program was identical at both sites: the same payments were offered for the same land use changes. At Matiguás-Río Blanco, poorer households participated at higher rates than better off households by all measures except absolute area converted and absolute increase in ESI point: they converted larger proportions of their farms and increased their ESI points proportionally more. In Quindío, in contrast, poorer households participated at generally lower rates, though the differences were not always significant. That poorer households were able to participate in both cases is encouraging: poverty may not be as significant an obstacle to participation in PES programs as is often assumed. But the differences also warn against generalizations across dissimilar sites.

Our detailed results help us identify several specific factors that tend to affect participation. In particular, households with smaller and more remote farms participated at lower levels than other households. This information can help design PES programs so that they reduce potential obstacles to the participation of poorer households. Although there is little that a PES program can do about poorer farms being less accessible or smaller, knowing that such farms may face greater difficulties in participation may justify targeting them with additional support.

A PES program can also help farmers participate by providing TA. Again, this need is only likely to arise when PES programs require participants to undertake land use changes, and even then only if these are complex and little known. In Quindío, were silvopastoral practices were practically unknown before the project, households that received TA did not necessarily adopt silvopastoral practices on a larger area or convert a larger portion of their farm, but they did shift to considerably more complex practices that generate substantially higher levels of

[17] It is also important to recall that this case study does not speak to possible differences in eligibility to participate, due to spatial considerations, tenure problems, or difficulty in meeting other program requirements.

environmental services (there are exceptions: six of the seven farmers who limited their changes to sowing improved pasture grass in pastures with few or no trees were TA recipients). In contrast, TA was found not to be significant in participation decisions in Matiguás-Río Blanco, where silvopastoral practices were already relatively well known prior to the project (Pagiola et al., 2007a).

The need for initial financing is less clear from our results, despite the high initial cost of many silvopastoral practices. Households in Quindío, including lower income households, seemed quite able to finance the investment costs from savings, sale of assets such as animals, and income from off-farm work. Again this is in contrast to Matiguás-Río Blanco, where access to credit was more significant (Pagiola et al., 2007a). The differences are probably due to the much lower overall income levels at the Nicaragua site, where two thirds of households are either poor or extremely poor. The lesson here is that program requirements and household characteristics interact to create possible problems. When a PES program supports maintaining existing practices—as in the majority of contracts in Costa Rica's program, for example—there are no investment requirements. Financing constraints may be important when land use changes are required for participation, however. Even then, our results indicate that this constraint is not as absolute as it is sometimes made out to be. The results in both Quindío and Matiguás-Río Blanco demonstrate that even poor households often have a variety of ways to finance profitable investments. Nevertheless, it is likely that poorer households will have fewer such alternatives: fewer savings, fewer assets that might be sold, worse access to credit. Providing some initial financing may be desirable for PES programs that involve initial investments in areas with many poor households. In Matiguás-Río Blanco, the baseline payment made by the Silvopastoral Project proved to be an important source of financing for participants (Pagiola et al., 2007a). In Quindío, however, baseline payments were much lower because of the lower level of initial ESI points, and so played little role in financing investments. Thus a PES design feature that helped in one case will not always work in others. If there were reason to fear that initial financing would be a constraint in Quindío, an approach similar to that taken in Costa Rica's reforestation or agroforestry contracts, which frontload payments in the first year, might have been preferable.[18]

As in Matiguás-Río Blanco, the biggest threat to the participation of poorer households in PES programs is likely to arise from the transaction costs involved rather than from their ability to participate. As can be seen in Table 3, low income households converted 39% of their farms, on average, and increased their ESI score by about 50%. These participation rates are not far below those of high income households, who converted 52% of their farms and increased their ESI score by 60%. But from the perspective of the service buyer, what matters is the total absolute increase in environmental service generation (whether proxied by area, as is commonly the case, or by more sophisticated measures such as the ESI), and the unit cost of achieving it. The cost, in turn, has two components: the cost of the payment, which is identical for a given increase in ESI for all households, and the transaction cost of contracting with each household. This second cost is likely to be largely fixed per household, irrespective of farm size. Thus high income households converted a total of 621ha and achieved a total increase in ESI of 230 points. At first glance, the results for low income households appear almost identical: they converted a total of 699ha and achieved a total increase in ESI of 220 points. The number of low income households is much larger, however, so on a per contract basis, the comparison is less favorable:

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18 This approach has its own problems, however, by weakening conditionality in the program (Pagiola and Platais, 2007).

low income households converted 9ha and increased ESI by 7.3 points per contract, while high income households converted 33ha and increased ESI by 23.0 points per contract. It takes between three and four contracts with low income households, therefore, to achieve the same results as a single contract with a high income household. The larger the transaction costs, the more attractive it will be for PES programs to focus on large land holdings. As farm size tends to be highly correlated with income, in practice this will mean focusing on better-off households. This is not a purely hypothetical concern: In Ecuador, the PROFAFOR program has decided to adopt a 50ha minimum size for the forest plantations from which it buys carbon sequestration services (Wunder and Alban, 2007). Keeping transaction costs as low as possible—in addition to being desirable in itself—is thus imperative if poorer households are not be shut out of many PES programs.[19]

[19] The Silvopastoral Project as presently conducted is a poor example of this, as it has relatively high monitoring costs dictated in part by its pilot nature and in part by the need to distinguish small differences in land use so as to compute ESI scores. Work is underway as part of the project to determine the nature of the tradeoff between monitoring costs and effectiveness.

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Table 1. Land use among Silvopastoral Project participants, Quindío, Colombia

	Environmental services index (points/ha)	*Before project*		*Year 3 of Project*	
		(ha)	*(%)*	*(ha)*	*(%)*
Annual crops	0.0	94.9	2.6	136.9	3.8
Degraded pasture	0.0	92.4	2.5	16.1	0.4
Natural pasture without trees	0.2	771.3	21.2	251.2	6.9
Improved pasture without trees	0.5	1,456.3	40.1	1,226.6	33.8
Semi-permanent crops (plantain, sun coffee)	0.5	284.4	7.8	251.0	6.9
Natural pasture with low tree density (< 30/ha)	0.6	6.2	0.2	23.9	0.7
Diversified fruit crops	0.7	76.2	2.1	69.7	1.9
Fodder banks[a]	0.8	4.6	0.1	34.9	1.0
Improved pasture with low tree density (< 30/ha)	0.9	60.3	1.7	208.1	5.7
Natural pasture with high tree density (>30/ha)[b]	1.0	0.0	-	70.2	1.9
Shade-grown coffee	1.3	30.6	0.8	38.0	1.0
Improved pasture with high tree density (>30/ha)[b]	1.3	2.2	0.1	406.0	11.2
Bamboo (*guadua*) forest	1.3	45.3	1.2	53.9	1.5
Timber plantation[a]	1.4	2.0	0.1	5.8	0.2
Riparian forest	1.5	445.9	12.3	456.8	12.6
Intensive silvopastoral system	1.6	0.0	-	117.5	3.2
Primary and secondary forest[a]	2.0	207.2	5.7	207.2	5.7
Total area		**3,630.6**	**100.0**	**3,630.6**	**100.0**
Recently established live fence (km)		4.3		278.5	
Multistory live fence or wind break (km)		0.7		81.2	

Notes: Totals may not add up because of rounding .
Includes all land in farms of PES recipients and control group members.
Land uses recognized by the project but not found at this site are omitted.
a. Similar land uses with small areas have been aggregated; ESI shown is for use with largest area.
b. The project distinguishes land uses with recently planted trees from the same land uses with mature trees for the purpose of computing the ESI score; here these land uses have been aggregated to their mature state, and the corresponding ESI score is shown.

Sources: ESI from CIPAV (2003); land use from Silvopastoral Project mapping data.

Table 2: Characteristics of sample households, Quindío, Colombia

Variable	*PES recipients* *Low income*	*Middle income*	*High income*	*All*	*Control group*	*Entire sample*
Income per capita (million COP)	-0.7[ab]	7.0[ac]	39.9[bc]	8.2	14.3	10.0
Assets (million COP)	4.8[ab]	8.8[a]	17.9[b]	8.4	8.7	8.5
Farm area (ha)	23.3[ab]	49.2[a]	62.1[b]	40.2[d]	25.4[d]	36.0
Cattle (livestock units)	44.3[a]	77.4[b]	184.2[ab]	60.1	48.5	56.8
Flat (% farm area)	19.1	25.9	24.5	22.9[d]	36.9[d]	26.9
Distance to nearest village (km)	7.9[a]	7.2	4.3[a]	7.1[d]	5.24[de]	6.6[e]
Water (% with water service)	90.0[a]	96.9	100.0[a]	94.4	96.6	95.0
Farm resident (%)	36.7	22.0	40.0	30.6	17.2	26.7
Family labor (man-days/ha/yr)	11.1[a]	7.4[b]	3.1[ab]	8.3	nd	nd
Household size (members)	5.2[a]	4.9[b]	3.6[ab]	4.9[d]	3.7[de]	4.5[e]
Dependency ratio (children per adult)	0.25[a]	0.55[a]	0.36	0.40[d]	0.22[de]	0.35[e]
Age of household head (years)	46.8[ab]	40.7[a]	38.7[b]	42.9	43.9	43.2
Literacy of household head (%)	96.7	93.8	100.0	95.8	93.1	95.1
Education of household head (years)	4.0[a]	5.2	8.6[a]	5.2	4.3	4.9
Off-farm work (% with off-farm employment)	10.0	15.6	20.0	13.9	10.3	12.9
Technical assistance (% with current access)	33.3	34.4	50.0	36.1[d]	10.3[de]	28.7[e]
Credit (% with access to credit)	23.3	25.0	40.0	26.4	13.8	22.8
Number of observations	30	32	10	72	29	101

Notes: [a],[b],[c],[d],[e] indicate means are significantly different in paired t-test at 10% test level. nd = no data
Low income < COP2 million; middle income > COP2 million, < COP20 million; high income > COP20 million
Children are household members under 12

Table 3: Participation rates among PES recipients by income group, Quindío, Colombia

Income group	*Total land (ha)*	*Change in land use (ha)*	*Change in land use (%)*	*Live fencing Initial (km)*	*Live fencing Increase (km)*	*Environmental services index (total points) Initial*	*Environmental services index (total points) Increase*	*Environmental services index (points/ha) Initial*	*Environmental services index (points/ha) Increase*	*Change (%)*
Per household:										
Low income	23.3	9.2	39.4	0.02	3.6	14.6	7.3	0.63	0.31	50.3
Middle income	49.2	19.4	39.5	0.04	5.4	34.2	12.3	0.69	0.25	35.9
High income	62.1	32.6	52.5	0.04	6. 5	38.4	23.0	0.62	0.37	59.8
All	**40.2**	**17.0**	**42.3**	**0.03**	**4.8**	**26.6**	**11.7**	**0.66**	**0.29**	**44.0**
Total area:										
Low income	698.8	275.1	39.4	0.49	109.1	437.4	219.8	0.63	0.31	50.3
Middle income	1,573.3	621.5	39.5	1.21	171.4	1,093.1	392.2	0.69	0.25	35.9
High income	621.1	326.2	52.5	0.37	64.5	384.5	229.9	0.62	0.37	59.8
All	**2,893.2**	**1,222.8**	**42.3**	**2.07**	**345.0**	**1,915.0**	**841.8**	**0.66**	**0.29**	**44.0**

Notes: Totals may not add up because of rounding.

Sources: Computed from Silvopastoral Project mapping data.

Table 4: Financing sources for first-year investments in silvopastoral practices by PES recipients, by income group, Quindío, Colombia

(% of participating households citing source as among two most important sources)

	Low Income	*Middle Income*	*High Income*	*All Farms*
No cash needed – used family labor	3.3	3.1	10.0	4.2
Savings	43.3	37.5	40.0	40.3
Borrowed money				
▪ Bank (private, rural, community)	6.7	3.1	0.0	4.2
▪ Cooperative	3.3	0.0	0.0	1.4
▪ Local lender (prestamista)	6.7	0.0	0.0	2.8
NGO projects	10.0[a]	6.3	0.0[a]	6.9
Sold animals	16.7	21.9	10.0	18.1
Sold other assets (land, equipment, etc)	10.0	9.4	20.0	11.1
Traded services for service	3.3	6.3	0.0	4.2
Payment from Silvopastoral project	6.7	0.0	20.0	5.6
Remittances from family members abroad	0.0	6.3	0.0	2.8
Income from off-farm activities by family members	20.0	25.0	0.0	19.4
Other	3.3[a]	3.1[b]	0.0[ab]	2.8

Notes: Percentages do not add to 100 because of multiple responses.
[ab] indicate means are significantly different in a paired t-test at 10% test level.

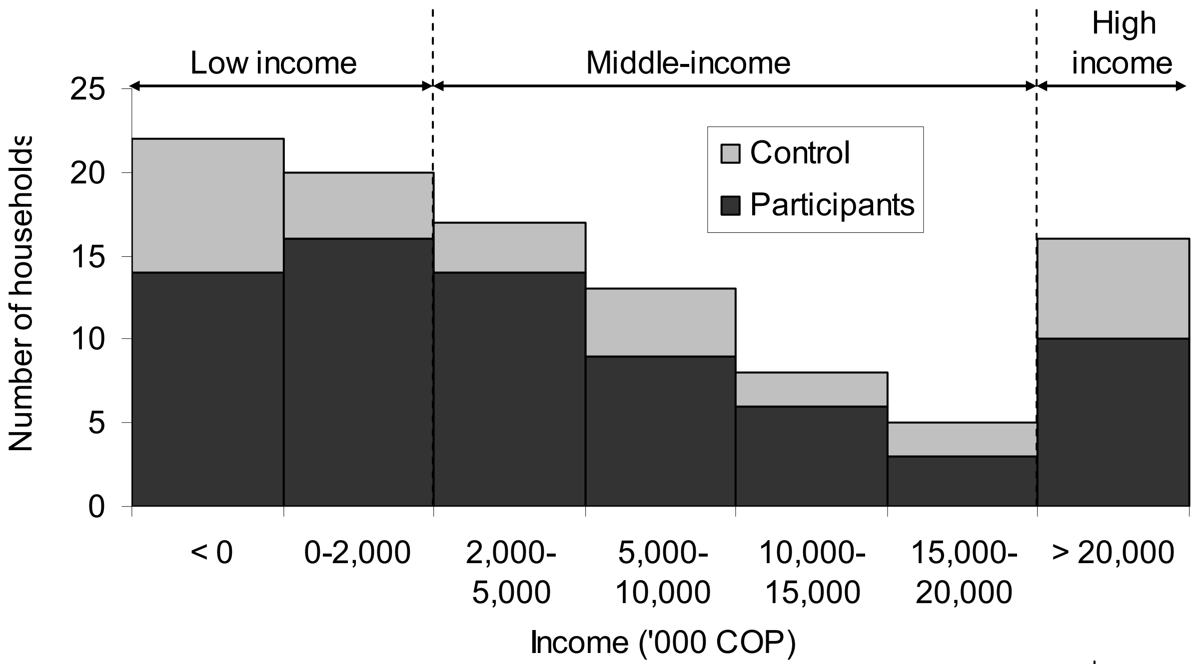
Sources: Computed from data in 1st year participant survey.

Table 5: Estimation results

Independent Variable / Dependent variable: / Model:	*Area changed (ha)*	*Proportion of farm changed (%)*	*Change in ESI (points)*	*Change in ESI (%)*	*Change in ESI per ha*
	Tobit	*Tobit*	*OLS*	*OLS*	*OLS*
Constant	-25.98**	22.91	-9.73*	59.83**	0.34***
	(11.97)	(18.59)	(5.67)	(25.52)	(0.12)
Farm area (ha)	0.48***	0.06	0.19***	-0.24***	-0.00***
	(0.09)	(0.06)	(0.03)	(0.09)	(0.00)
Livestock units	0.05	-0.03	0.05**	0.16*	0.00*
	(0.05)	(0.05)	(0.02)	(0.09)	(0.00)
Family labor (adults/ha)	14.10***	28.14**	3.54	11.53	0.07
	(5.37)	(12.88)	(2.43)	(19.26)	(0.10)
Age of household head (years)	0.13	0.05	0.09	-0.28	-0.00
	(0.10)	(0.21)	(0.06)	(0.29)	(0.00)
Male-headed household (1=yes, 0=no)	6.70	18.59**	2.64	-15.26	-0.04
	(4.53)	(9.48)	(2.06)	(17.50)	(0.06)
Distance to nearest village (km)	-0.49*	-1.61***	-0.20	-0.74	-0.01
	(0.28)	(0.52)	(0.15)	(0.83)	(0.00)
Flat topography (% farm area)	-0.04	-0.09	-0.03	-0.31**	-0.00**
	(0.04)	(0.08)	(0.03)	(0.12)	(0.00)
Assets (1,000 COP)	-0.00*	-0.00**	-0.00	-0.00*	-0.00*
	(0.000)	(0.000)	(0.000)	(0.00)	(0.000)
Income share of off-farm job	5.43	-12.20	-2.98	-44.50	-0.27
	(9.43)	(29.36)	(3.89)	(28.13)	(0.19)
PES with technical assistance (1=yes)	1.84	5.67	3.52**	13.85	0.07
	(2.17)	(6.11)	(1.44)	(11.26)	(0.06)
PES participant (1=yes)	8.64***	22.20***	4.72***	36.88***	0.26***
	(3.20)	(8.01)	(1.46)	(10.41)	(0.06)
Low income (1=low income)	1.87	-15.21*	-0.55	-5.46	-0.06
	(6.65)	(8.31)	(3.53)	(11.00)	(0.06)
Middle income (1=middle income)	0.74	-18.49**	-1.08	-5.73	-0.04
	(6.42)	(7.83)	(3.30)	(9.28)	(0.05)
R^2			0.78	0.30	0.39
Pseudo R^2	0.83	0.25			
Number of observations	101	101	101	101	101

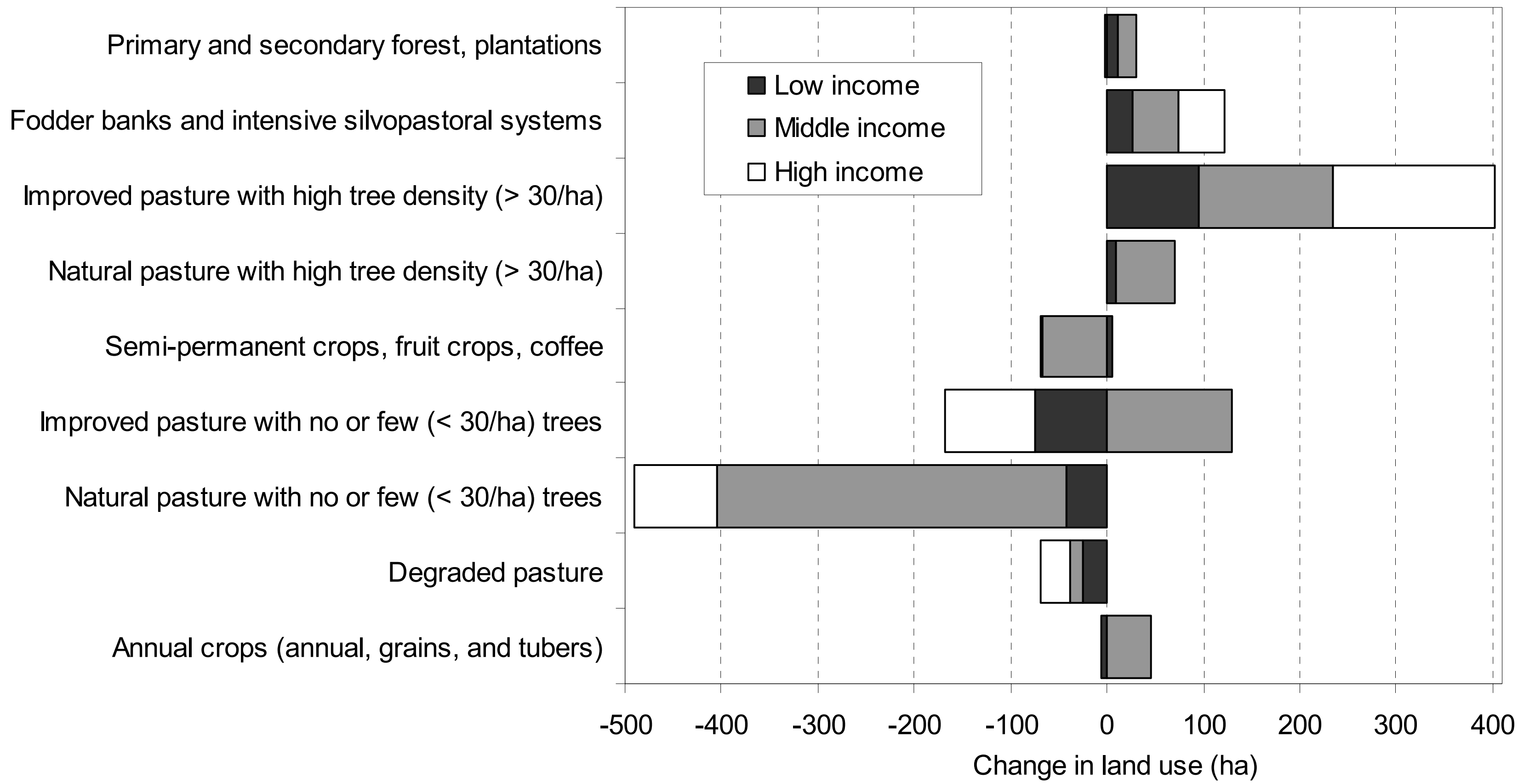
Notes: Robust standard errors in parentheses.
*, **, *** indicates coefficient estimate is significantly different from zero at 90%, 95%, or 99% confidence level.

Figure 1: Distribution of reported annual household per capita income among Silvopastoral Project participants, Quindío, Colombia



Source: Authors' computations from Silvopastoral Project baseline survey.

Figure 2: Land use change by PES recipients, 2003-2006, by income group, Quindío, Colombia



Source: Authors' computations from Silvopastoral Project mapping data.