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Household participation in a Payments for Environmental Services programme: the Nhambita Forest Carbon Project (Mozambique)

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ABSTRACT. Quantitative research on household participation in the Payments for Environmental Services (PES) programme remains scarce. This paper aims to determine the key factors influencing household participation in a PES programme in Mozambique. Questionnaire-based quarterly surveys were conducted with 290 randomly

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selected households. We used the instrumental variables technique to identify the factors influencing household participation. The instrumental variables used for forest dependence were: household head born in the village, duration of residence of the household head in the village, ethnicity of the household head, business ownership of the household head and off-farm income of the household. The results show that education of household head and households' trust towards community members positively influenced household participation in PES, while forest dependence influenced it negatively. Future PES projects may thus need to focus more on developing social capital and the resource dependence of households.

1. Introduction

Human society derives a variety of benefits from ecosystems, known as ecosystem services or environmental services (ES)(MEA, 2005). Payments for Environmental Services (PES), an incentive-based environmental policy tool, has gained much traction recently (Landell-Mills and Porras, 2002; Pagiola *et al.*, 2005; Wunder, 2005, 2007; Zbinden and Lee, 2005; Jack *et al.*, 2008). PES is a voluntary and conditional transaction between an ES buyer and an ES provider, on the provision of a well-defined ES or a land use presumed to deliver that ES (Wunder, 2007).

PES programmes have been used to finance conservation in many geographic regions (Landell-Mills and Porras, 2002; Pagiola *et al.*, 2007; Fisher *et al.*, 2008; Jindal *et al.*, 2008) and have largely focused on watershed protection, biodiversity conservation and carbon sequestration.[1] In the developing world, Costa Rica, Mexico and China have been leading efforts to make direct payments through governments to landowners or land users – typically at the household level – for undertaking specific land use practices that would increase the provision of water, biodiversity or carbon services (Uchida *et al.*, 2007; Bennett, 2008; Jack *et al.*, 2008; Pagiola *et al.*, 2008; Gong *et al.*, 2010).

Households that participate in PES programmes generally derive a small net financial benefit (Wunder, 2008; Mahanty *et al.*, 2013). However, a key challenge for PES programmes is selecting the households to participate in a project. Relatively limited research has investigated household participation issues (Miranda *et al.*, 2003; Kosoy *et al.*, 2008; Pagiola *et al.*, 2008, 2010; Arriagada *et al.*, 2009; Fisher, 2012; Mahanty *et al.*, 2013), despite the fact that PES programmes often have a stated objective of benefiting the poor. In Africa, only one case study has examined the reasons, including cash payments and other environmental values, for household participation in a PES programme in Uganda (Fisher, 2012). While these studies have provided some insights, none of them has empirically examined how a household's forest resource dependence will influence the participation decision, particularly where participants self-select to participate.

Building on the previous work, we focus on one of the few longstanding African PES cases: Nhambita in Sofala Province, Central Mozambique.

[1] See Landell-Mills and Porras 2002; Pagiola *et al.* 2002, 2008; Wunder 2005, 2006, 2008; Uchida *et al.* 2007; Bennett 2008; Jindal *et al.* 2008; Kosoy *et al.* 2008; Muñoz-Piña *et al.* 2008; Gong *et al.* 2010; Hegde and Bull 2011.

Using econometric analysis, we determine socio-economic factors influencing household participation, focusing on self-selection bias in the participant sample. The programme in question had a fairly low household participation rate (30 per cent), which may raise concerns about the adequacy of ES provision and the programme's capacity to alleviate poverty. Our findings add to the PES debate by highlighting participation determinants, particularly in an African context characterized by extreme poverty. The remainder of this paper introduces the study site, describes the experimental design, identifies the key results and discusses the main findings.

2. Methods

2.1. Study area

This study was undertaken in Chicale *Regulado* (Traditional Authority), located in the buffer zone of the Gorongosa National Park (GNP) in Sofala Province, Mozambique (figure 1). Chicale *Regulado* covers a total area of

Figure 1. *Study area location*

Fig. 1 - Colour online, B/W in print

about 20 km^2, with over 1,100 households spread over five villages: Nhambita, Bue Maria, Munhanganha, Pungue and Mbulawa (Hegde, 2010). The first three are located close to each other within the GNP buffer zone. Mbulawa is located outside of the GNP, while one part of Pungue is located inside the Park and the other outside. Table 1 summarizes some of the key characteristics of the five villages under study.

Traditionally, households in Chicale *Regulado* practise shifting cultivation, where they clear and burn the *miombo* woodland to start their *mashamba* (farm). They grow subsistence crops mainly for three to four years, including corn, sorghum, peas, cucumbers and other vegetables, after which they clear land in another location and leave the former *mashamba* site to regenerate for 20–25 years. Households require permission from the *Regulo* (traditional chief) to clear any fresh forest, but enforcement of this is weak.

In 2002 a small-scale agro-forestry based carbon sequestration pilot programme, known as the Nhambita Carbon Livelihoods Project, was implemented in the *Regulado* (Hegde, 2010). The programme offered conditional cash payments to smallholders for planting trees on their farm. Initial programme funding, provided by the EU, was used for programme implementation, livelihood support activities and to cover part of the transaction costs in the pilot phase (2002–2008). Since 2008, the programme has been financed from revenue generated from carbon sales (Envirotrade, 2010). A consortium of partners, consisting of EnviroTrade (a private firm based in the UK, and the lead partner), the University of Edinburgh and the Edinburgh Centre for Carbon Management, is implementing the programme. The programme aims to conserve and regenerate the *miombo* woodlands by offering both conditional financial compensation (i.e., PES) and alternative livelihood options through a community development[2] component. The pilot phase was limited to the villages of Nhambita, Bue Maria and Munhanganha, and was later expanded to Mbalawa and Pungue.

Households participating in the programme must ensure specific minimum seedling survival rates during the first three years, and avoid the clearing or burning of forestland other than that which has been preagreed on (thus eliminating commercial charcoal and firewood extraction). In cases of non-compliance, payments will be stopped and the farmer may be asked to return earlier received payments. Seven annual instalments are paid: 30 per cent (year 1), 12 per cent (years 2–6) and 10 per cent (year 7).[3] After year 7, tree-based benefits (i.e., harvested fruits, small-diameter timber) are assumed to provide sufficient proper incentives for tree retention.

[2] Because of this wider community development component being bundled along with the conditional PES component, this project also partly resembles an Integrated Conservation and Development Project (ICDP).

[3] The logic of frontloading the payments is to cover the high initial costs and facilitate a productive transition.

Table 1. *Key characteristics of the villages*

Characteristics	*Nhambita*	*Bue Maria*	*Munhanganha*	*Mbalawa*	*Pungue*
Location	Within buffer zone	Within buffer zone	Within buffer zone	Outside park	On the park boundary
Distance to tarmac road	9 km	18 km	10 km	1–6 km	1–4 km
Access to markets	Poor	Poor	Poor	Medium	Fair
Main forest products	Own use: wild food, grass, fuel, poles, limited use of clay for pottery and timber	Own use: wild food, grass, fuel, poles, limited use of timber and fish	Own use: wild food, grass, fuel, poles, limited use of timber and fish	Own use and sale: wild food, fuel, bamboo, charcoal, poles, timber, gold panning	Own use and sale: wild food, fuel, bamboo, poles, fish, gold panning
Farming	Mainly subsistence	Subsistence & commercial (cotton; sesame)	Mainly subsistence	Mainly subsistence	Both subsistence and commercial (tobacco; vegetables)
Major environmental resource collected	Poles, wild food, clay for pottery	Poles, wild food, fish	Poles, wild food	Poles, wild food, bamboo, charcoal, gold panning	Fish, poles, wild food, gold panning
Number of households	64	42	65	414	441
Households sampled	18	15	16	115	126
PES households	18	13	11	38	25

The carbon sequestered is monitored[4] under a Plan Vivo[5] system. The Verifiable Emission Reduction (VER) credits generated are sold in voluntary carbon markets. Part of the proceeds is deposited into a trust fund used to pay participant farmers (conditional payments), while another portion finances village development activities (community benefits). Initial contracts were for US$9 per tCO_2 equivalent, but the average price over the course of the programme was US$4.50, which was higher than prevailing prices in the voluntary carbon market (UOE, 2008; Jindal *et al.*, 2012).

2.2. *Research design*

Quarterly household surveys were our main source of data. The surveys explicitly integrated quantitative environmental resource use data with household income and tree planting data for PES participant households. In addition to the four quarterly surveys, two annual household surveys and two village focus group discussions were undertaken (Hegde, 2010). Questionnaires developed by CIFOR-PEN[6] were customized for our objectives.

Households in each village were selected randomly.[7] We opted for a large sample (335 households), given local heterogeneity, but lost 45 due to temporary or permanent migration, thus ending up with 290 households.

We used gross[8] income to measure household welfare, defined as the sum of cash income, net gifts/transfers and monetized subsistence income including environmental income (all non-cultivated products collected for subsistence or cash). Incomes were reported in the local currency, *metical* (plural, *meticais*; MTS[9]).

Environmental resources were valued by asking households to report sale prices.[10] When not marketed, an individual willingness-to-pay (WTP)

[4] Project staff undertake field monitoring of seedling survival prior to PES releases to farmers, and monitor their clearing and burning practices. Future plans for the project include remotely sensed monitoring.

[5] The system calculates on-farm carbon fixed, determining payments to farmers. Nhambita is registered with Plan Vivo, and its compliance to Plan Vivo standards has been validated by the Rainforest Alliance.

[6] The Poverty and Environment Network (PEN) is a project housed at the Center for International Forestry Research (CIFOR) which seeks to collect uniform tropics-wide data on forest and environmental resource use through a common research method (http://www.cifor.cgiar.org/pen/_ref/home/index.htm). A copy of a questionnaire used can be obtained from the first author.

[7] Since an official household census was unavailable, we updated the household rosters with village headmen (*Nfumos*) by listing all households under their responsibility (Cavendish, 2000). A sample was then drawn using a random number table. Where the selected household was not available (due to multiple listing or sickness), the next household on the alphabetical list was chosen.

[8] Sum of cash income and subsistence income, without subtracting associated costs (e.g., labour costs, inputs, transportation).

[9] All calculations are based on the old currency; after 2006 the last three digits have been removed (1US$ = 26, 500 MTS).

[10] We used consistent conversion rates to turn local measures into standard metrics.

value was solicited (Wunder *et al.*, 2011), which was averaged at the village level on a quarterly basis. Most products were not traded, yet households generally reported consistent WTP values, which we cross-checked with locally traded substitute prices wherever possible.

Fieldwork was undertaken from January to December 2006. Eight enumerators – each of whom had at least a high school education – were recruited and trained. These enumerators conducted the interviews in the local language (*Sena*), under the supervision of the lead author.

2.3. *Analytical framework*

Evaluating the costs and benefits of participating in any programme to modify household behaviour is critical to the implementation of an economic incentive programme such as PES (Ostrom, 1999; Jumbe and Angelsen, 2007). Notably, economic theory underpinning agricultural household behaviour has been extensively studied and reported (e.g., Singh *et al.* 1986).

The following assumptions are made in this analysis. We assume an imperfect labour market in that a household may rent out labour, but does not hire labour (which was typical).[11] We assume that markets for agricultural and forest products function perfectly (such markets existed even in remote areas), allowing us to focus on income and consumption, rather than individual goods (Jumbe and Angelsen, 2007).

Our model is static, as it does not involve any feedback effect. In following Jumbe and Angelsen (2007), households maximize a twice-differentiable quasi-concave utility function, which depends on total consumption[12] (C) and leisure (L_H):

$$Max\ U = U(C, L_H : H) \tag{1}$$

The household faces a set of technological, time and budget constraints. Household labour (L) is allocated to forest production (L_F), agriculture (L_G), wage labour (L_W), PES planting and tending (L_P) and leisure (L_H). Household income includes the value of agricultural commodities (Q^G) and forest commodities (Q^F), valued at their respective market prices (P^G and P_F), as well as wage income (wLw) and exogenous income (E). Agricultural production depends on land area, family labour and exogenous production technology (Ω). Collection of forest commodities depends on labour hours spent, access to forest resources (D), technology (ϕ) and exogenous forest resource characteristics (R). Access to forest resources also depends on household and village characteristics (H and V). We posit that PES programme participation limits access to forest resources. When the market wage is below shadow wage rate (ω), a household prefers working in agriculture, leisure and possibly forestry.

[11] Jumbe and Angelsen (2007) also observed this in Malawi. Yet Nhantumbo and Kowero (2003) considered both hiring in and hiring out labour.

[12] Consumption of a composite commodity consisting of forest, agricultural and market-purchased goods, with the price set to unity.

We are interested in the household participation decision, and thus write the model in a semi-structural form:

$$U = U^*(P; P_G, P_F, \omega, E, \Omega, \phi, L_P, H, V, R), P = 0, 1 \quad (2)$$

The net gain from participation (B) is defined as:

$$B = U^*(1) - U^*(0) = B(P_G, P_F, \omega, E, \Omega, \phi, L, H, V, R) \quad (3)$$

A household will participate in the programme if the difference in utility between participation and non-participation (B) is non-negative, i.e.,

$$\begin{aligned} P &= 1 \quad \text{if } B \geq 0 \\ P &= 0 \quad \text{if } < 0. \end{aligned} \quad (4)$$

In this model, participation is assumed to affect utility in four ways. First, participation limits the access to forests, therefore $D(1) < D(0)$. Higher prices of forest products (charcoal, fuelwood and timber) will reduce benefits from participation. In general, we can expect that households that are heavily involved in fuelwood and charcoal production have less incentive to participate in PES. Secondly, participant households face reduced agricultural productivity (from less swidden agriculture),[13] and labour costs associated with planting and tending the trees. Factors such as low agricultural prices (P_G), and poor technologies (ϕ) will increase the value of B. Thirdly, participant households require more labour for planting and tending the trees. The higher the labour cost for participation (L_P), the lower B is. For the households participating in the labour market, the opportunity cost of time is given by the market wage rate (w). Participation cost increases with the wage rate. For households outside the labour market, we can expect poor households to have a lower shadow wage, and hence to be more likely to participate, *ceteris paribus*. Fourthly, we assume that social capital[14] influences participation (i.e., participation requires that a household perceive the community as friendly, helpful and trustworthy). Research has shown that trust is an important indicator of social capital which facilitates cooperation (Knack and Keefer, 1997; Thoni *et al.*, 2012). We also probed each household's perception of the community as a liveable place which influences long-term decisions such as PES-induced tree planting, and migration plans which are common in rural Africa.

[13] Hegde and Bull (2011) found a reduction in crop yields among PES participant households.

[14] Following the World Bank (1998), the term 'social capital' is used broadly here to include the institutions, relationships, attitudes and values that govern interactions among individuals and contribute to economic and social development. It includes the shared values and rules for social conduct expressed in personal relationships, trust, and a common sense of 'civic' collective responsibility.

2.4. Empirical model

The decision to participate in the PES programme depends, inter alia, on provided cash income, maintaining resource access, costs for crop production and labour requirements. Our key model is the probit participation model, which is a function of factors influencing household participation, including forest dependence. However, forest dependence is potentially endogenous.[15] This implies that households depending on forest income (e.g., charcoal producers) may prefer unrestricted forest access, and thus opt not to participate in PES. We thus specify the following interrelationships between forest dependence and PES participation:

$$y_i^* = Z_i\beta + u_i \quad \text{(forest dependence)} \tag{5}$$

$$P_i = W_i\zeta + \phi y_i + e_i \quad \text{(participation)} \tag{6}$$

where y_i^* is a latent variable for forest dependence; P_i is a dummy variable for the participation; $i = 1, \ldots, N$ denotes households; y_i denotes forest dependence as the ratio of forest cash income (sum of cash income earned from sale of forest products) to the household income; Z_i and W_i are vectors of exogenous variables that determine forest dependence and participation, respectively; β, ζ and ϕ are unknown parameters, and e_i and u_i are the error terms. Since the aim of this study is to examine the link between forest dependence and participation, we focus on the coefficient in equation (6).

From (5) and (6) y_i and y_i^* are related as $y_i > 0$ if $y_i^* > 0$ and $y_i = 0$ if $y_i^* \leq 0$. Further, y_i^* and e_i are correlated because the same characteristics influence P_i and y_i^*. As a result of this relationship, determining the impact of forest dependence on participation is not straightforward, since the correlation between y_i^* and e_i will produce biased estimates of determinants of PES participation.

Given the considerable overlap between the determinants of forest dependence (5) and participation (6), we jointly estimate the two equations. Instrumental variables (IV) probit based on Amemiya Generalized Least Squares (AGLS) with endogenous variables permits a solution to this problem (Maddala, 1983; Newey, 1987). Specifically, it produces a new $\hat{y}_i$ (predicted y_i^*) that is uncorrelated with the resulting error term, e_i. Because Z is assumed to be uncorrelated with e_i, it serves as the instrument in producing $\hat{y}_i$. Inclusion of instrumented $\hat{y}_i$ into the participation equation purges any correlation between forest dependence and the new error term, u, and produces unbiased estimates of PES participation determinants (Alon, 2007).

The IV included in Z_i are the following: (i) household head born in the village: dummy = 1 if the household head was born in the village; (ii)

[15] Endogeneity here arises because forest dependence is potentially a choice variable, correlated with unobservable variables relegated to the error term. For instance, less able workers might sell more fuelwood and charcoal, and therefore self-select not to participate. Therefore, a failure to control for this correlation would produce a biased estimate of the effect of forest dependence on participation.

duration of residence: number of years the household head has been living in the village; (iii) ethnicity: dummy = 1 if household head belongs to the village major ethnic group; (iv) business ownership: dummy = 1 if the household operated some kind of business; and (v) off-farm income: income earned from wages and remittances. These are plausible instruments for forest dependence. There is literature suggesting that household factors such as ethnicity, migrant status and off-farm income determine forest use in Africa and elsewhere (Sah and Heinen, 2001; Jumbe and Angelsen, 2007; Balslev *et al.*, 2010; Houehanou *et al.*, 2011; Nawrotzki *et al.*, 2012). If the household head was born in the village, s/he is likely to have more knowledge about the surrounding forest resources, favouring increased forest extraction. Similarly, research has found that migrant village members use forest resources more heavily than long-term resident natives (Sah and Heinen, 2001). The purpose of the ethnicity variable was to capture any influence on the collection of woodlands products. Business and off-farm employment provide alternative livelihoods to the collection and sale of woodland products, which may explain the correlation between off-farm income and forest dependence. There is no reason for these variables to be correlated with PES participation, as the programme was open to all community members regardless of their socio-economic attributes. The model was estimated in the IV probit framework using Stata 10 (StataCorp, 2010).

3. Results

3.1. Factors influencing programme participation

Table 2 summarizes the variable definitions used in the empirical modelling. Table 3 presents the results from the probit regressions. The first model is a simple probit model of PES participation, ignoring the endogeneity between forest dependence and PES programme participation. The second model is an IV probit model that instruments forest dependence.

In the simple probit model, size of agricultural land, household head's education level, length of head's residence in the community, trust, household size and household location in the pilot programme area (Site 1) positively influenced the household participation decision.

The results of the IV probit estimation offer some interesting insights. To begin with, the Wald test of exogeneity[16] provides evidence that forest dependence is, indeed, an endogenous variable. The validity of the instruments was tested using the Amemiya–Lee–Newey over-identification test (Baum *et al.*, 2006),[17] from which we fail to reject the null hypothesis of the

[16] It tests whether rho (which is the correlation between the errors in the full probit equation and reduced-form equation for the endogenous regressor, forest dependence) is equal to zero. Accepting the null hypothesis would have meant that the suspected endogenous variable is in fact exogenous and, therefore, a normal probit could be used.

[17] It tests the joint null hypothesis that the excluded instruments are uncorrelated with the error term (and therefore are valid instruments).

Table 2. *Definitions of variables used in instrumental variables model*

Variables	*Definition*	*Expected sign*
Dependent variable		
Participation	Dummy variable (0,1) indicating whether a household participated in the PES programme or not (i.e., signed a contract voluntarily and planted and was managing seedlings)	
Independent variables		
Forest dependence	Ratio of forest cash income (sum of cash income earned from sale of forest products) to the household income	
Head's education	Education level of head of household (years)	+ve
Size	Number of members in a household	+ve/−ve
Woman head	Dummy variable taking a value of 1 if household head is a woman; 0 otherwise	−ve
Agri. land	Area of agricultural land (ha) held by a household	+ve
Forest dependence	Proportion of income from sale of forest products (timber, bamboo, fuelwood, charcoal, etc.) in the total cash income (%)	
Good place	Dummy variable taking a value of 1 if a household rated highest on a score of 3 that the community is a good place to live in	+ve
Trust	Dummy variable taking a value of 1 if a household rated 3 on a scale of 1–3 that it finds that the fellow villagers can be trusted in general	+ve
Pilot project site	Dummy variable (1,0) indicating whether the household is located in either Nhambita, Mbalawa or Munhanganha where the pilot project was first introduced	+ve
Carbon dependence	Amount of carbon income a household would have earned by participating in the project, which is estimated based on the average payment[a] per ha for the most dominant agroforestry system and expressed as a share of the total cash income	−ve
Household size	Sum of the members in a household	+ve

Notes: [a]The average payment per ha was estimated to be about MTS 3,416,000 (equivalent to US$129), which represented the upfront 30% payment for the mixed rows planting system which was the most dominant. It is 'potential' income because not all households participate in the project. It is a variable that reflects the carbon price facing a household.

Table 3. *Determinants of participation*

	Probit		*IV Probit*	
Variables	*Coefficients*	$P > \|z\|$	*Coefficients*	$P > \|z\|$
Forest dependence	0.0012	0.827	−0.0429	0.000
	(0.0056)		(0.0121)	
Agri. land	0.1752	0.016	0.0726	0.381
	(0.0729)		(0.0829)	
Head's education	0.1593	0.000	0.0905	0.050
	(0.0420)		(0.0462)	
Carbon dependence	−0.0004	0.203	−0.0002	0.399
	(0.0003)		(0.0003)	
Trust	0.6070	0.002	0.3854	0.046
	(0.1917)		(0.1933)	
Good place	−0.3121	0.265	−0.1119	0.678
	(0.2801)		(0.2696)	
Pilot project site	1.5329	0.000	0.7909	0.032
	(0.2397)		(0.3691)	
Woman head	0.3710	0.144	−0.0465	0.846
	(0.2541)		(0.2398)	
Household size	0.0950	0.004	0.0476	0.139
	(0.0328)		(0.0322)	
Constant	−2.8358	0.000	−1.0358	0.181
	(0.4402)		(0.7759)	
Observations	290		290	
/athrho	–		0.9257	0.011
			(0.3639)	
/lnsigma	–		2.7628	0.000
			(0.0841)	
Rho	–		0.7286	
			(0.1707)	
Sigma	–		15.8436	
			(1.3322)	
Wald $chi^2(6)$	85.46		53.65	
Pseudo R^2	0.2402		–	
Prob > chi^2	0.0000		0.0000	
Wald test of exogeneity (/athrho = 0)			$chi^2(1) = 6.08$	Prob > chi^2 = 0.0137
Test of over-identifying restrictions			2.402 $chi^2(4)$	*P*-value: 0.6623
Amemiya–Lee–Newey minimum chi^2 statistic				

validity of the instruments used in the model specification and conclude that the instruments are valid. The results indicate that forest dependence had a statistically significant negative influence on PES programme participation. Household head's education and trust positively influenced the household participation decision. The statistical significance of the pilot project site variable implied that programme participation was likely to

be higher in the piloted 'first-generation' programme areas where at least one cash payment had been made.

4. Discussion

Our research identified various factors influencing household participation. Forest dependence is a key factor that negatively affected participation, as could be expected for a PES programme restricting degrading forest uses. At the time, the Nhambita programme had low household participation rates (about 30 per cent). They improved subsequently to about 80 per cent, but forest-dependent groups such as charcoal producers unsurprisingly remained marginalized (Jindal *et al.*, 2012). Charcoal production is a key driver of land-use change in Nhambita. Herd (2007) estimated that 35 ha of woodlots were lost annually in the Chicale *Regulado* from charcoal production. Programme implementers were thus considering establishing special woodlots for charcoal production and providing more fuel efficient kilns to provide productive alternatives to charcoal producers (Jindal *et al.*, 2012).

Trust[18] was another key factor influencing household participation. Trust fosters cooperation, underpinning economic development in low-income countries with less well-developed financial sectors, insecure property rights and unreliable contract enforceability (Knack and Keefer, 1997; Thoni *et al.*, 2012). The importance of trust is also confirmed by the positive relationship between programme participation and the pilot project site variable. Household participation was high in the pilot project site given that the pilot stage households had already received the first-year carbon payments when participation was opened up in the second year, which increased households' sense of trust in the programme and motivated more people to participate. Some households indicated during focus group discussions that when the PES programme was introduced they mistrusted it, since the idea of making payments for tree planting did not make any sense to them; they were convinced only when they saw payments were made. While initial trust is important, consistent contract enforcement and regular payments will reinforce a sense of household trust during the programme implementation stages.

The positive relationship between education and participation confirms the conventional knowledge on the relationship between education and technology adoption including for PES participation (Zbinden and Lee, 2005). Education is known to improve knowledge and skills and to foster an attitude of being more receptive to innovation, such as a PES programme (Pattanayak *et al.*, 2003).

On the other hand, variables such as crop-land availability and potential carbon incomes were not statistically significant for PES participation. This contrasts with findings in Latin America, where land tenure and size were key threshold factors for PES enrolment (Grieg-Gran *et al.*, 2005). In Africa,

[18] Trust was measured by asking a household to rate on a scale of 1 to 3 how trustworthy fellow villagers were perceived to be.

smallholder farmers operate on multiple smaller plots (typically 0.5–1 ha). The programme offered the flexibility of using the same agroforestry system on multiple plots or combining different systems on the same plot (e.g., boundary planting, mixed row planting with crops and fruit orchard). Nevertheless, the size of land was not a significant variable.

Similarly, households that had more cash income other than PES (from produce sales, wages, business) had greater likelihood of participation (see Jindal *et al.* 2012 for a similar finding). Similarly, Zhou *et al.* (2008) also noted that an increase in household farm income improved the probability of adoption of water-saving technology among Chinese farmers. Perhaps regular income flows increase farmers' risk-bearing ability, resulting in more land being allocated to cash crops (Fafchamps, 1992). As expected, the female-headed households are less likely to participate in the programme, having lesser labour resources as required for tree planting and nurture.

Planting trees on farms and homesteads is a common practice in rural Africa, so the PES-induced activities did not pose technological limitations for participation (Pagiola *et al.*, 2008). The economic incentive should be the key factor influencing the participation. However, participants are contractually bound to commit their land to tree cover for 25 years, yet cash payments cease after seven years.

The Nhambita programme had in place a strong institutional framework involving voluntary participation, flexible and reasonable contracting terms, and a robust monitoring, verification and certification system (Hegde and Bull, 2011; Jindal *et al.*, 2012). Upon initiation, the programme invited all smallholder farmers to join. The participating farmers signed voluntary contracts to plant indigenous and fruit tree plants[19] on their *mashamba* (either on farm boundaries or in mixed rows along with crops) and manage the same for 25 years[20] in return for conditional cash payments. However, the long-term success of the programme may depend on some continued enforcement of the contracts.

Cash payment to the participating households was estimated to be MTS 5,270,505 per household for the planted area, representing 30 per cent payment; this is equivalent to MTS 3,416,000 per ha (MTS 1,626,667 per ha/year, or about US$60). This constituted 10 per cent of households' (very low overall) cash incomes – an important share (Hegde, 2010; Hegde and Bull, 2011), though not as high as some PES schemes in Latin America reaching 30 per cent (Miranda *et al.*, 2003; Kosoy *et al.*, 2008). However, some risk from tree planting for crop yields may not have been effectively offset by the programme (Hegde and Bull, 2011). Still, the tree species planted also represented an economic asset for the farm households

[19] Trees planted included: fruit trees including mango (*Mangifera indica*), cashew (*Anacardium occidentale*), tamarind (*Tamarindus indica*) and ber (*Ziziphus mauritiana*); timber trees including Rhodesian teak (*Pterocarpus angolensis*) and rosewood (*Swartzia madagascariensis*); and multipurpose trees including gliricidia (*Gliricidia sepium*). Please refer to Envirotrade (http://www.envirotrade.co.uk) for a full list of trees planted.

[20] At the time, contracts were for 25 years. The contract terms were changed subsequently, increasing the duration to 100 years (EnviroTrade, 2010).

beyond the programme period. Considering all the factors, the private benefits of participation may predominantly outweigh private costs.

While the programme paid the farmers for PES planting, it also generated broader community-level development benefits, such as building schools or digging wells, which were shared with non-participant households. This component also catalysed forest-based enterprises such as carpentry, beekeeping and nursery units, improved gardening techniques, and so on. In total, the programme provided full-time employment for about 100 people, as well as limited seasonal employment for forest fire prevention. Besides cash payments to households for VERs and provision of direct employment, the programme also distributed guinea fowls for rearing, beehives for beekeeping and red gram seeds for cultivation (Hegde and Bull, 2011).

The high transaction costs of contracting with multiple smallholders can be a key anti-poor participation obstacle in PES programmes (Grieg-Gran *et al.*, 2005). Transaction cost was not a dominant factor in our selection of PES participants. The Plan Vivo system applied in the Nhambita PES programme is generally believed to be cost effective in working with a large number of small-scale farmers and rural communities (Cacho *et al.*, 2005). The contract terms offered were quite flexible. However, it is likely that about two-thirds of carbon revenues were spent on programme overheads and transaction costs, including though community development activities (UOE, 2008). Correspondingly, more PES paid conditionally for more years to farmers might also, hypothetically speaking, have attracted higher participation rates. Strategies were considered to reduce transaction costs, e.g., by bundling practices for enhancing ES (UOE, 2008; Jindal *et al.*, 2012). If the programme succeeds in paying farmers larger proportions of revenues from carbon sales, this may also strengthen incentives for participation.

5. Conclusion

The PES model is experiencing growing adoption in developing countries, but little empirical research informs us about the extent of participation by the ES providers, particularly resource-poor households, especially in Africa. Our analysis focused on the household-level factors that influenced participation in the Nhambita PES programme in Mozambique. The programme offers cash payments to smallholder farmers for agroforestry planting, resulting in carbon sequestration. Three key insights emerge from this study. First, the PES programme targeted forest clearing and burning, including charcoal and fuelwood production, as the main threats to the *miombo* woodlands. Yet households that were strongly engaged in these practices chose not to participate in the PES programme, as their opportunity costs were likely not covered. While the participation rates have increased since the completion of our field research (Envirotrade, 2010; Jindal *et al.*, 2012), further efforts were still needed to increase participation levels, particularly among the most forest dependent households (Jindal *et al.*, 2012). Secondly, the results highlight that social capital, such as indicated by the degree of trust, can be a powerful factor influencing

household participation in PES programmes. As PES involved long-term contracts with landowners, implementers should pay particularly attention to strengthening social capital. Thirdly, an important part of the carbon revenue was used for community-level infrastructure such as building schools and wells, but this expensive ICDP component may eventually have absorbed too large a share of the carbon revenues, thus leaving PES payments proper insufficiently attractive, triggering too modest household participation.

On aggregate, we believe that the Nhambita PES programme and its valuable pilot lessons hold good potential for informing various PES initiatives and incentive programmes in sub-Saharan Africa. This also includes the emerging Reducing Emission from Deforestation and forest Degradation (REDD) activities in Mozambique, and the community participation and benefit-sharing mechanisms that this process entails.

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