Payments for Forest Ecosystem Services: Global and Local Assessments of Costs and Benefits

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CHAPTER 5 ■

Do Payments For Forest Ecosystem Services Generate Double Dividends?[23]

Summary

Payments for ecosystem services (PES) often serve multiple objectives, such as carbon emission reduction and poverty alleviation. However, the effectiveness of PES as an instrument to achieve these multiple objectives, in particular in a conservation-development context, is often questioned. This study adds to the very limited empirical evidence base and investigates to what extent Vietnam's move to PES has helped protect forest ecosystems and improve local livelihoods and income inequality. We zoom in on Lam Dong province, where PES was first introduced in Vietnam in 2009. Changes in forest cover are analysed using satellite images over a period of 15 years (2000-2014). Socio-economic impacts are assessed based on rural household interviews with PES participants and non-participants as a control group over a period of 7 years (2008-2014). Out results show that PES contributes significantly to forest cover, the improvement of local livelihoods and the reduction of income inequality.

[23] This chapter was accepted for presentation at the 21st annual conference of the European Association of Environmental and Resources Economists (EAERE), University of Helsinki, June 2015, and is currently under review for publication in a journal.

5.1 INTRODUCTION

Ecosystems provide multiple benefits to humanity, ranging from provisioning services such as food and water to supporting and regulating services such as nutrient cycling and carbon sequestration (MEA, 2005). Since many of these services are public goods, the private owners of the land on which ecosystems are situated often lack incentives to protect them. As a result, ecosystem services protection is less than optimal from a societal point of view. A variety of policy options are available to protect the world's ecosystems and the services they provide, of which designated protected areas are probably the most important (Andam *et al.*, 2010). In the last decade, however, there has been increasing interest in market-based instruments such as *payments for ecosystem services* (PES) (FAO, 2007; TEEB, 2010; Brouwer *et al.*, 2011; Naeem *et al.*, 2015). Although in practice there exists a wide variety of such payment schemes (Schomers and Matzdorf, 2013), PES have been generally defined as a voluntary arrangement whereby a well-defined environmental service is bought from a service provider by a service buyer, if and only if the service provider continuously secures the provision of that service (Wunder, 2005). PES is considered an important policy instrument to achieve environmental objectives while at the same time addressing equity concerns and alleviating poverty, especially in developing countries. Many PES programs therefore actively involve poor farmers (Grieg-Gran *et al.*, 2005; Pagiola *et al.*, 2005; Butler and Laurance, 2008; Roe, 2008; Wunder, 2008; Milder *et al.*, 2010; Vatn, 2010; Sayer *et al.*, 2013). However, the effectiveness of achieving both objectives with one and the same policy instrument has been questioned. There are usually significant trade-offs between nature conservation and economic development. The involvement of poor farmers, often without legal land entitlements and hence incentives to invest in the quality of the land they use, may contribute only marginally to improving ecosystems and the services they provide.

In practice it has proven very difficult to quantify the environmental and socio-economic impacts of PES, as PES is often embedded in a policy mix and part of broader socio-economic development trends (Pagiola *et al.*, 2005; Wunder, 2008; Brouwer *et al.*, 2011). Not controlling for additionality and leakage can undermine both the economic and environmental efficiency of PES schemes (Busch *et al.*, 2012). In addition, there are challenges in measuring changes in ecosystem services provision, owing to a systematic lack of information and international monitoring guidelines (Naeem *et al.*, 2015). Not surprisingly, studies on PES effectiveness consequently report diverging results. For instance, PES impacts on deforestation in tropical countries are highly case-dependent, ranging from no improvement at all (e.g. Daniels *et al.*, 2010) to modest (e.g. Sierra and

Russman, 2006; Robalino *et al.*, 2007; Sánchez-Azofeifa *et al.*, 2007) or substantial improvements (e.g. Pattayanka *et al.*, 2010). Moreover, prioritizing the provision of ecosystem services does not automatically guarantee optimal biodiversity conservation and vice versa (Naidoo *et al.*, 2008). The behavioural effect of PES on participating land owners and their management practices is not always clear (Sommerville *et al.*, 2010), while documentation of its impact on participants' livelihoods is also largely lacking. Studies examining the economic effects of PES on household prosperity show a similar trend, with both positive and negative changes in reported income levels (e.g. Kosoy *et al.*, 2007; Locatelli *et al.*, 2008; Corbera *et al.*, 2009; Jindal *et al.*, 2012). To date, there has been little research that simultaneously quantifies the socio-economic and environmental consequences of PES (Liu *et al.*, 2013; Zheng *et al.*, 2013).

Given the contested views and sometimes contradictory empirical evidence of the effectiveness of PES in delivering both ecosystem protection and improved livelihoods, the purpose of this study is to add to the limited empirical evidence base and quantify the impacts of PES on forest ecosystems, household livelihoods and income levels in Lam Dong province, Vietnam, where PES was first introduced in 2009. To this end we carry out an integrated environmental-economic impact assessment and analyse changes in forest cover using MODIS satellite images over a period of 15 years (2000-2014) and conduct in-depth rural household interviews with PES participants and non-participants to assess the impact of PES over a period of 7 years (2008-2014), before and after the introduction of PES in the study area.

The chapter is structured as follows. Section 2 introduces the analytical framework developed for analysing TC determinants in PFES schemes. Section 3 describes the course of data collection in more detail. Section 4 describes institutional settings and procedure of PFES transactions in Vietnam in general and in the two selected case studies in particular, followed by the measurement of TC. Finally, Section 5 concludes.

5.2 BACKGROUND

Since the 1990s the Vietnamese government has implemented several national forest programs, including payments for participating farmers, such as Program 327 in 1992 and Program 661 in 1998. Continuation of these programs proved difficult, however, owing to a lack of long-term funding and low payment rates, ranging from US$2.5 to 5.0 per ha per year for Programs 327 and 661, respectively (Nguyen, 2013). PES was therefore considered an attractive policy alternative in view of the fact that funding is generated through a market-

liked mechanism. In 2009, two PES pilot projects were implemented in the provinces Lam Dong and Son La as preambles to a national PES program that was officially launched in 2011. Current PES policy in Vietnam focuses primarily on ecosystem services such as water supply regulation, soil conservation and landscape beauty. It is also important to note that the PES schemes in Vietnam are not as voluntary as defined by Wunder (2005) since the Vietnamese government is greatly involved in setting payment levels and selecting ES buyers and providers (Pham *et al.*, 2013). Due to the strong influences of the central government, we acknowledge the fact that the Vietnamese PES schemes may arguably be considered a PES liked rather than a pure PES mechanism. Besides, the country's PES policy tends to prioritize the involvement of poor and often ethnic-minority farmers (Nguyen, 2013; Pham *et al.*, 2013).

This study focuses on the implementation of PES in Lam Dong province as one of the oldest PES schemes in Vietnam. The scheme was implemented under joint supervision of several governmental agencies, with the Lam Dong Forest Protection and Development Fund (FPDF) as program intermediary. ES buyers and beneficiaries are 10 water supply companies, 14 hydropower plans and 12 tour operators (Lam Dong CPC, 2014). ES sellers as official forest owners include 9 state-owned forest companies, 38 private companies, 16 forest management boards, 4 national parks and close to 1,800 individual households. In most cases, forest owners sign forest protection contracts with local farmers, making the latter the actual ES providers. Currently more than 12,000 such contracts with local households have been concluded. The FPDF collects payments from the ES buyers and distributes this among the forest owners based on their forest area, who in turn pay the local farmers once every three months.

In Lam Dong province, the Don Duong district was chosen as our study area in direct consultation with the FPDF and the local authority. The district is located in the Da Nhim watershed (ARBCP, 2010). Compared with surrounding districts Don Duong has a representative share of PES participants (11% of total district's population) (ARBCP, 2010; Lam Dong FPDF, 2014). The district is also representative in terms of ethnic-minority groups (30% of the households belong to an ethnic minority) (ARBCP, 2010). Within the district of Don Duong, four villages were selected, which are similar in terms of their bio-physical and socio-economic characteristics (for more details, see Annex D) and have a representative mix of ethnic backgrounds. The total forested area under PES in these villages is 9,728 ha. The forests in the study area are classified as production and protected forest, with the latter being the dominant forest type (ARBCP, 2010). The main livelihoods are agriculture (coffee, fruit and vegetables), forestry, hired labour, and trade.

5.3 METHODOLOGY

Household survey. Two hundred and sixty PES participants were sampled randomly based on a list of participating households provided by the local Forest Management Board. One hundred and fifteen non-participants were randomly selected in 4 villages based on consultations with the local authorities. Interviewing took place over three weeks in October 2014 with the help of a structured, thoroughly pretested questionnaire. The response rate was 81%, yielding 303 interviews in total of which 209 households participate in the PES scheme.

The questionnaire consists of five main parts (see Annex F). The first part asks respondents warm-up questions about their socio-demographic household characteristics such as the age of the household head, education level, number of family members, etc. The second part asks respondents about their specific past and current agriculture and forestry activities. The third part is devoted to the household's income sources and household expenditures, both before and after participation in the PES scheme. Non-participants are asked about their past and current income sources with no reference to the PES scheme. The fourth part zooms in on the costs incurred by farmers in both agriculture and forestry activities and the revenues from these activities. In the fifth and final part participating respondents are asked to indicate in a more qualitative manner how the PES scheme has impacted family welfare, environmental awareness and forest protection.

Econometric models. A Full Information Maximum Likelihood (FIML) treatment effects regression model was employed to examine the determinants of income change for households who participated and households who did not participate in the PES scheme in order to address possible endogeneity (Heckman and Vytlacil, 1999). PES participation is treated as an instrumental variable, implying that it is included in a set of simultaneously estimated equations both as a dependent and independent variable to explain household income change, whilst vice versa the factors that determine the decision to participate includes household income.

The treatment effects model predicts the likelihood of a farmer's participation in PES using a probit regression model and a linear Ordinary Least Square (OLS) regression model to analyse the (*relative*) household income change. In the probit selection model (Eq. 5.1), the dependent variable is defined as whether or not a household participates in PES ($PES_i = 1$ if the household participates and $PES_i = 0$ otherwise). Variables entering the regression model are grouped into: *General household characteristics* (ethnicity, age, years living

in the study area, distance to forest, dependent family members), *Income before PES,* and *Pre-PES forestry activities*. Ethnicity was included as a regressor given the prioritization to poorer, ethnic minority farmers. Both distance to forest and pre-PES income have been shown to negatively impact PES participation in a previous study in Mexico (Corbera *et al.*, 2009). The number of financially dependent family members is expected to correlate positively with household willingness to participate, as well as previous involvement in forestry activities, which is expected to positively influence households' experience and familiarity with PES activities.

$$PES_i = \beta_{01} + \beta^{GEN} General_i + \beta^{INC} PrePESincome_i + \beta^{FOR} Forestry_i + \varepsilon_i \quad (5.1)$$

$$Income_i = \beta_{02} + \beta^{GEN} General_i + \beta^{LAB} Labour_i + \beta^{AGR} Agriculture_i + \beta^{PES} PES_i + \omega_i \quad (5.2)$$

In the OLS regression (Eq. 5.2), the dependent variable $Income_i$ is defined as the *relative* change in household income before and after PES implementation. The explanatory variables are again grouped as before into *General household characteristics*, *Agriculture* (land area and main crop), *Labour* (number of working, and dependent members), and *PES* (whether or not the household participates in PES). We predicted a positive relationship between income change and belonging to the majority ethnic group and years living in the study area. We added land area and crop type since these factors drive agricultural income in particular and total income in general. The theoretical expectation regarding the number of working family members is that it correlates positively with income change. Lastly, the dependent variable PES participation in Eq. 5.1 is expected to correlate positively as one of the explanatory variables in Eq. 5.2 with changes in household income as a result of the payments involved. β is the vector of effect estimators, with the superscript referring to the group of regressors to which the estimated coefficient belongs. β_{01} and β_{02} are the intercepts and ω_i and ε_i are the vectors of residual terms. Both ω_i and ε_i are assumed to be normally distributed with mean zero and variance σ_ω^2 and σ_ε^2 respectively. The treatment effects model assumes that the level of correlation between these two error terms is significantly different from zero (Guo and Fraser, 2009).

Gini coefficient. The Gini coefficient measures the extent to which individual income is unequally distributed among a population (Li *et al.*, 2011). A Gini index of 0 represents perfect equality (i.e. everyone enjoys the same income level), while an index of 1 or 100% implies perfect inequality (Bellù and Liberati, 2006). Given the discrete nature of our data, the Gini coefficient is calculated using the following equation (Dixon *et al.*, 1987):

$$G = (n+1)/n - [2\sum_{i=1}^{n}(n+1-i)x_i]/(n\sum_{i=1}^{n}x_i) \quad (5.3)$$

where G is the Gini coefficient, n the number of observations, and x_i the income size of the i^{th} observation, sorted from smallest to largest.

Methods for estimating change in forest cover and NDVI. To obtain time-series data on MODIS VCF tree-cover for the study area, we first generated a local MODIS 250m tree cover map for each of the 15 years from 2000 to 2014. These data are available from the University of Maryland Global Land Cover Facility (http://glcf.umd.edu/data/vcf/). Annual MODIS VCF data are put together based on 23 16-day composites of the year, with cloud effects being minimized. Given a total forest area of 9,727 ha and each MODIS pixel having a size of 250m x 250m 1,138 training pixels were obtained from the MODIS VCF images over a 15-year time period from 2000 to 2014. Data on the MODIS Normalized Differential Vegetation Index (NDVI) were collected and analysed in the same manner. In this latter case, 6 out of the 23 16-day composites with less than 15% cloud cover were selected with the same spatial resolution of 250x250m. The number of NDVI training pixels was 1,148.

5.4 RESULTS

5.4.1 Costs and benefits of PES participation

In the study area, participating farmers signed a PES contract with the local forest owner, the Dran forest management board. The ES buyers are two state-owned entities: the Da Nhim and Xong Pha hydropower plants (Lam Dong FPDF, 2014). In all participating households, one person provides labour to the PES program. When asked about the main reasons for participating in the PES scheme, the most common answer is to earn more income and fulfil their responsibility in protecting the forest. Although the farmers are not the official forest owners, they consider the forest a communal heritage requiring protection and care. Forest protection consists mainly of patrolling the forest for illegal logging and fire prevention and is generally carried out by a group of 7 or 8 people. Participating farmers visit their assigned forest plot about 6 days per month. The average area of forested land assigned to a household is 28.2 ha, varying between 24.2 and 29.9 ha.

For each ha of protected forest participating households receive a fixed payment of US$ 21.3 per year[24]. This payment is calculated by the FDPF and fixed across the entire Da Nhim river watershed (Lam Dong FPDF, 2014). This yields an average annual PES income of US$ 600 per household, ranging from US$ 514 to 636 depending on the allocated area of protected forest. Although this payment rate is considerably higher than payments received in the past, 56% of the respondents consider it to be insufficient, given the costs of PES implementation. These include equipment, medicine, gasoline, and food costs and amount on average to US$ 226 per household per year. According to respondents, expenditures for the last two items, gasoline and food, are highest (33 and 58% of the total costs, respectively). The average net revenue generated from PES in 2014 is therefore US$ 374, which is approximately five times lower than the average net revenue from agriculture, which is US$ 1,905 per household per year. The amount of labour devoted to patrolling the forest, i.e. 6 days per month, is at the expense of alternative activities such as farming or hired labour, which have an estimated average opportunity cost of US$ 225 per person per year.

5.4.2 Features of the households participating in the PES program and the control group

Our sample forms a fair reflection of the ethnic composition of farmers at district level, with 61% of the respondents (n=185) belonging to the Kinh majority and the rest belonging to ethnic minorities such as K'Ho and Chu Ru. The share of PES participants belonging to the Kinh majority is slightly lower (56%) and significantly higher for non-participants (68%)[25]. On average, respondents in our sample are 41 years old, with no significant difference between farmers participating and not participating in the PES scheme. The average household size is 4.7 persons and does not differ significantly between participants and non-participants either. Of these, the number of working family members is 2.7, while the number of financially dependent family members (mostly children and elders) is 2.0 per household. Also here no significant differences exist between the samples of participants

[24]All monetary data in this paper have been converted to 2014 US dollars. The Vietnam Dong (VND) was inflated to 2014 where appropriate using Vietnam's Consumer Price Index (CPI) and translated into 2014 US Dollars using the World Bank's exchange rate *(http://data.worldbank.org/)*. In 2014, US$ 1 equalled on average VND 21,148.

[25] The Mann-Whitney test is used throughout the paper to examine the significance of observed differences.

and non-participants. Most respondents finished grade 7 (of 12), i.e. the secondary level of Vietnam's schooling system, but education levels differ significantly between PES participants and non-participants (grade 6.5 and 7.8, respectively).

The average area of agricultural land held by PES participants (1.35 ha per household) is greater than that belonging to non-participants (1.01 ha per household), but not significantly so. Land used for agricultural production, i.e. mainly crop cultivation, comprises both officially and unofficially self-reclaimed land. With regard to crop type, 82% of the households participating in the PES scheme grow coffee as their main crop, while this figure is significantly lower (approximately 20%) for households not participating in PES. Finally, PES participants tend to live on average significantly closer to the forest (21.2 km) than non-participants (26.3 km).

5.4.3 The environmental impacts of PES

To evaluate the environmental impacts of PES in the study area we used the MODIS VCF images developed by Hansen *et al.* (2003). Overall, the terra MODIS VCF provides three surface components presented as percentages of ground cover: tree, non-tree, and bare cover. In this study, we employed tree-cover as a primary indicator for forest changes. Tree-cover is measured as the percentage of pixels covered by tree canopy. Using spatially explicit time-series satellite images of tree-cover can help identify forested areas (Townshend *et al.*, 2011) and monitor historical forest disturbance and re-growth (Huang *et al.*, 2009).

Based on the history of PES in Lam Dong, we define a pre-PES period covering the years 2000 to 2008 and the PES period from 2009 to 2014[26]. Data on VCF tree-cover during the pre-PES and PES periods are used for our statistical test. We find a significant 4.9% increase in the average percentage of tree-cover after the introduction of PES in the district Don Duong: from 57.7% to 62.6% (Mann-Whitney $z=19.68$; $p< 0.001$). As can be seen from Figure 5.1, the VCF tree-cover peak (65.7%) occurs in 2009, the first year of the PES pilot phase, while the lowest value is observed just one year earlier in 2008 (57.8%). Tree-cover drops to 58.7% in 2010 to the same level as in 2008, but increases again to 62.8% in 2011 when PES was officially implemented as a national policy in Vietnam, and remains at that level until and including 2014.

[26] Comparison of forest cover inside and outside the PES area is not possible in view of the fact that most forests in the Da Nhim watershed are already in the PES scheme.

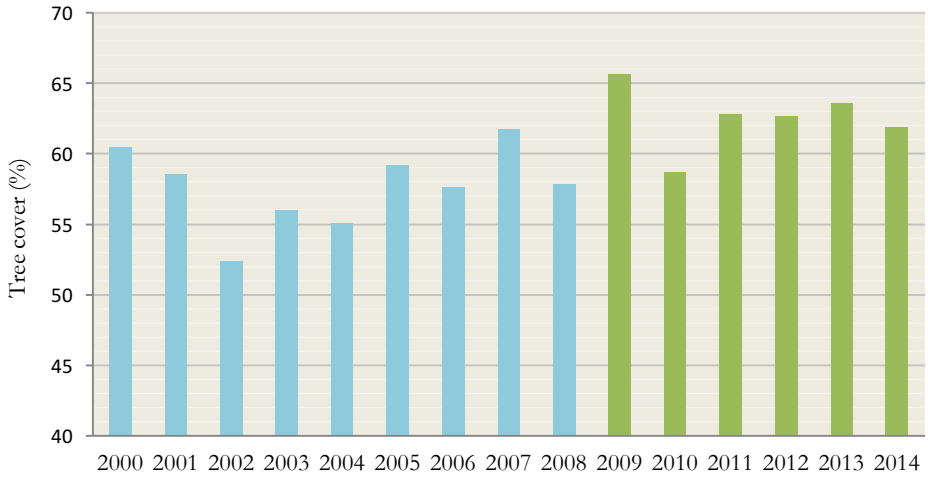

Figure 5.1 Comparison of mean VCF tree-cover in the study area between the pre-PES period (blue) and during the PES period (green)

Besides tree-cover, we also use the MODIS NDVI as a measure of photosynthetic activity and supplementary proxy for vegetation cover. We collected NDVI data for 2007 and 2008 to represent the pre-PES period and for 2013 and 2014 for the PES period. In line with the results for tree-cover, average NDVI in 2013 and 2014 proves to be significantly higher than in 2007 and 2008 (0.77 and 0.75, respectively; Mann-Whitney $z=6.78$; p-value < 0.001).

In addition to using satellite images, we also organized discussions with local forest authorities and the FPDF about the environmental effects of PES on the local forest ecosystem. Their responses confirm the results of the statistical analysis. According to the Dran forest management board's report (Dran FMB, 2014), the number of illegal logging incidents in the district Don Duong has dropped by 60% since the official implementation of the PES scheme. Moreover, there has been an improvement in environmental awareness, not only among PES participants, but throughout the community. When asked about their attitude towards forest protection and the significance of forests to society, all respondents stressed the need to protect forests as a vital ecosystem that supplies fresh water and good air quality and prevents flooding. 50% of the households not participating in the PES scheme expressed a willingness to take part in PES if given the opportunity.

5.4.4 The impacts of PES on income and local livelihoods

Change in income levels. The difference in (net) income between participating and non-participating households was measured at two points in time: in 2008 before PES was piloted in Lam Dong and in 2014, 6 years after PES was introduced in Vietnam in 2009. In order to ensure comparability across the whole time period, only those households were included in the income analysis who had participated in the PES scheme since the pilot phase in 2009. This yields a total of 219 observations (125 PES participants and 94 non-participants). As can be seen from Figure 5.2, in 2008 the total (net) income of non-participants (US$ 5,664) was almost twice as high as that of PES participants (US$ 3,086). This reflects the fact that Vietnam's PES policy prioritizes the involvement of poor and often ethnic-minority farmers[27], but also demonstrates at the same time the practical difficulty to find a control group of non-participants who has a similar income level as those participating in PES (see for example Nguyen (2013) who reported an income difference of a factor 1.4). However, as the second pair of bars in Figure 5.2 shows, the income gap between the two groups has narrowed considerably since 2008. In fact, we observe no significant difference in the 2014 income levels between PES participants and non-participants even though the average 2014 income of non-participating households is still higher than that of participating households. Also per capita income of non-participating households is 1.2 times higher than that of participating households in 2014, but again this difference is not statistically significant. Most importantly, PES participants have consistently enjoyed a significantly greater increase in income than non-participants in both absolute (US$ 1,623) and relative terms (38.5%) over the period 2008-2014. Moreover, a significant difference was detected between household income of the minority and majority groups after their participation in PES for 6 years, where the latter has a lower income than the former.

[27] No statistically significant difference in pre-PES income was found between the majority and minority ethnic groups participating in PES, implying that both groups were equally poor (or rich) before participating in the PES scheme.

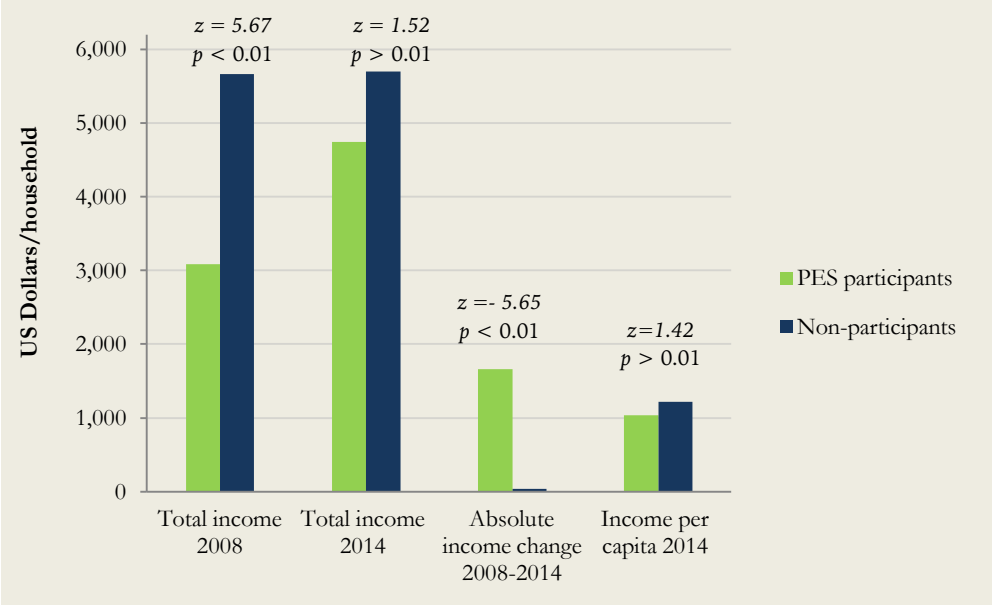

Figure 5.2 Comparison of changes in income of PES participants and non-participants.

Zooming in on agricultural production, the main source of livelihood for a majority of the inhabitants in the study area, gross agricultural revenues of non-participating households are 1.3 times higher in 2014 than that of their participating counterparts. However, this difference proves to be statistically insignificant. Agricultural production costs, on the other hand, including the purchase of seeds, fertilizer, chemicals and the hiring of labor, are significantly higher for non-participants (1.8 times), resulting in PES participants enjoying slightly higher net agricultural revenues (US$ 1,905 per household) than non-participants (US$ 1,789 per household), but the difference is not statistically significant.

Change in livelihoods. Changes in the relative share of different livelihoods (agriculture, forestry and hired labour) are found to differ significantly between participants and non-participants (see Annex E). The average share of agricultural income is consistently higher for non-participants, both before and during PES. Between 2008 and 2014, the share of agricultural income of PES participants decreased by only 2%, and this change is not statistically significant. In contrast, non-participating households show a significant 6% increase in their share of agricultural income. Before the introduction of PES, the share of forestry income was similar for participating and non-participating households (4.0% and 3.4%, respectively). After PES implementation, this share is 21% for participating households and virtually zero for non-participating households. For both groups, the share

of hired labor income has declined significantly, but much more so for PES participants (15%) than for non-participants (3%). Finally, other sources of income (e.g. family-run businesses, salaries, and pensions) are observed to be consistently and significantly higher for non-participants than for participants.

Change in income inequality. The magnitude of income inequality between PES participants and non-participants was assessed by calculating the Gini coefficients for the two groups. The current (2014) income distribution is more equal among PES participants than non-participants. The same finding is reported in a study by (Li *et al.*, 2011) related to one of the largest PES schemes in the world in China. Before the implementation of PES, the Gini coefficient was slightly higher for participants (0.472) than non-participants (0.442), implying a more skewed (unequal) income distribution in the sample of participants. This changed considerably after PES implementation and the Gini coefficient for households taking part in the PES scheme is 0.380, 6 years after the introduction of PES. This implies a 20% reduction in income inequality. The result for the non-participants shows a much lower decrease in income inequality of 3%, from 0.442 in 2008 to 0.427 in 2014.

Determinants of changes in household income levels. A treatment effects model was estimated to account for possible endogeneity between the decision to participate in the PES scheme and household income and simultaneously investigate the factors that determine (i) farmers' likelihood to participate in PES and (ii) household income change. The robustness of the treatment effects model was tested by comparing the results for the *relative* income change with those obtained from the same model estimated for the *absolute* change in income in Table 5.1. The effects appear to be exactly the same and hence robust. The estimated models are furthermore highly significant as can be seen from the outcome of the Wald test. The outcome of λ (the product of the correlation between the two error terms ρ and the standard error of the OLS regression σ) confirms the existence of a significant correlation between (i) and (ii) at the 1% level and hence the relevance of using the treatment effects model.

Table 5.1 Results of the treatment effects model

Explanatory variable	Relative income change		Absolute income change	
	Coefficient estimate	Std. error	Coefficient estimate	Std. error
Outcome model *(dependent variable: change in household income)*				
Intercept	-0.533***	0.205	-97.035***	33.874
Ethnicity (=1if Kinh)	0.014	0.066	1.896	11.021
Years living in area (=1 if > 20 years)	-0.175	0.116	-17.673	19.614
Years in PES scheme	0.039*	0.024	6.433*	3.834
Number of working family members	0.034*	0.021	6.993**	3.279
Number of dependent family members	0.027	0.024	2.179	3.963
Agricultural land size (ha)	0.041**	0.021	9.124***	3.339
Main crop type (=1 if coffee)	-0.001	0.062	0.222	9.632
PES participation (=1 if yes)	0.814***	0.204	116.269***	33.874
Selection model *(dependent variable: PES participation)*				
Intercept	1.431***	0.456	1.431***	0.456
Ethnicity (=1 if Kinh)	0.056	0.230	0.056	0.230
Years living in area (=1 if > 20 years)	0.333	0.336	0.333	0.336
Age (years)	-0.013*	0.008	-0.013*	0.008
Distance to forest (km)	-0.016**	0.007	-0.016**	0.007

Number of dependent family members	0.021	0.066	0.021	0.066
Pre-PES income level (US$/household)	-0.004***	0.001	-0.004***	0.001
Pre-PES forestry activities (=1 if yes)	-0.349*	0.196	-0.349*	0.196
Model statistical summary				
Wald χ^2	37.73		33.94	
Prob>χ^2	0.0001		0.0004	
λ	-0.392***		-75.054***	
ϱ	-0.840		-0.948	
σ	0.466		79.151	
N	264		264	

*, **, *** statistically significant at 10%, 5% and 1% respectively.

The selection model shows that respondent age, distance to the forest, pre-PES income and pre-PES forestry activities have a statistically significant effect on a farmer's decision to participate in PES. A negative relationship is observed for all these explanatory variables. Older respondents are less likely to participate in the PES scheme than younger respondents. In line with prior expectations and comparable to the findings reported in (Chen *et al.*, 2009), increasing distance significantly decreases the likelihood of PES participation. Similarly, households involved in forestry programs before are found to be less likely to participate in PES, possibly because of the low payment rates received in the past. Families who earned less money prior to PES implementation, and hence had lower opportunity costs, tend to be more motivated to participate in the scheme as a means of acquiring additional income.

With regards to the change in household income, a significant positive effect is detected for the following variables: PES participation, the number of years a farmer is in the PES scheme (since not all respondents have been participating since the beginning), the number of working family members, and agricultural land size. Most findings are in line with prior expectations. Household participation in PES has a significant positive influence on the change in household income whilst controlling for other explanatory factors. A positive relationship is also detected for the number of years a farmer participates in the PES scheme: the longer the farmer participates, the more absolute and relative income changes. Similarly, an increase in agricultural land size or the amount of family labour helps to raise household income. No significant relationships are found in the two regression models for the number of dependent family members, the number of years that farmers have been living in the study area, whether or not households belong to the Kinh majority or a minority group, and main crop type. Control was also included for the 4 villages where the survey was carried out, but none of the dummy variables were statistically significant, most probably due to the fact that the selected villages are very much alike, and are therefore not included in the model presented in Table 5.1.

5.5 CONCLUSIONS AND DISCUSSION

This is the first study to examine the impacts of Vietnam's PES scheme on both local forest quality and the livelihoods of participating households. Changes in forest tree-cover and household income levels and their distribution are measured before and after PES implementation. Earth observations to assess forest ecosystem impacts were used over a period of 15 years, while changes in income were measured over a period of 7 years across PES participants and non-participants as a control group. The study reveals that between the pre-PES period and the period since PES was introduced in the study area, a statistically significant increase in average percentage tree-cover was observed while the absolute and relative changes in income proved to be significantly higher for participating households than non-participating households. The average income level of participating households has increased by 45% since the introduction of PES in Vietnam. After PES, also a more pronounced improvement in income distribution can be observed among those participating in PES compared to those not participating in the PES scheme.

Equally important, this study shows furthermore that whilst controlling for other relevant socio-economic trends and characteristics, changes in income levels are driven significantly by the number of years families participated in the PES scheme. The positive impact on income increases the longer households participate. As such, we were able to isolate the impact of PES participation on income change and conclude that this has been a significant factor behind income growth. The contribution of forestry income in particular has increased significantly since 2009 as a result of PES participation, nowadays ranking as the second most important income source after agriculture. Although generating the largest share of household income, income flows from agriculture are less stable. Agricultural income depends on various exogenous factors, including weather conditions, changes in the price of inputs such as fertilizer and pesticides, and changes in market selling prices. Farmers in the study area reported to be generally poorly informed about market conditions and to have limited negotiating power with traders. In contrast, the periodic PES payment is stable and helps families to pay their children's tuition fees, daily living expenses and outstanding loans. However, an important concern relates to the longer term financial viability of the PES scheme in view of the fact that the contracts between forest owners and farmers are renewed annually, with payments largely depending on the involvement of and overall coordination by the FPDF. Combined with the legal constraints on protected forested land conversion, this introduces some degree of uncertainty about future income security.

Finally, a few limitations of this study should be mentioned. First, because our research focuses on the district of Lam Dong, some caution should be exercised in generalizing the results. The sample is considered representative for the district and province, but not necessarily for the country as a whole. Further research in other areas where PES has been rolled out in Vietnam is needed. Second, it should be borne in mind that the data used for the livelihood analysis are based on self-reported information obtained from farmers during the field survey. This may have introduced a degree of unreliability and possibly strategic reporting bias. The self-reported information cannot be verified, since there are no statistical records of household incomes in the study area. Third, due to measuring difficulties and time constraints, we were unable to assess other potential factors of influence on the observed impacts. These include, for example, the role of social coherence on PES participation. Last but not least, it could be argued that the 250m spatial resolution of the MODIS images employed in this study for the environmental impact assessment is perhaps somewhat coarse for an accurate reflection of the scale at which the human-induced land-use changes occur in this specific local case study.

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