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RESEARCH ARTICLE

Impact of payments for forest environmental services on households' livelihood: a case study in the Central Highlands of Vietnam

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Abstract

Payments for environmental services have been popularly used in environmental management and an increasing number of studies assesses their contribution to local livelihoods. This study employs propensity score matching with a dataset of 404 indigenous households in the Central Highlands of Vietnam to evaluate the effect of payments for forest environmental services (PFES) on their livelihoods. Participating in PFES increased households' employment and income from activities related to natural forests. Income from PFES allowed households to enhance productive investment and promote income from cultivation activities. All of this, in turn, increased their annual income, job satisfaction, living expenditures, and reduced the amount of any loan. Additionally, PFES enhanced opportunities to participate in training courses and traditional community activities. This confirms that PFES is not only a good initiative for forest management but also a livelihood policy for communities.

Keywords: impact; indigenous household; livelihood; payments for ecosystem services; payments for environmental services; PES; Vietnam

JEL classification: Q23; Q51; Q58

1. Introduction

Payments for environmental services (PES) have been identified as an important tool in the design of environmental policies (Pesche *et al.*, 2012). They are considered an innovative strategy; in fact, they have drawn significant attention from academics and policy-makers in many countries around the world (Bulte *et al.*, 2008). The fundamental approach of PES is to create incentives and benefits for households or communities to improve environmental services (ES) by compensating their effort for providing ES (Mayrand and Paquin, 2004; Van Noordwijk *et al.*, 2007). Moreover, PES can correct

market failures, especially in the context of undervalued ES (Engel *et al.*, 2008; Scullion *et al.*, 2011).

PES may also be more beneficial to the government when dealing with conservation issues than other approaches such as command-and-control, environmental taxes or subsidies, which often require a huge amount of resources to implement (Landell-Mills and Porras, 2002; Wunder *et al.*, 2008). Specifically, PES programs have delivered additional environmental outcomes (Clements and Milner-Gulland, 2014), enhanced provision of ES (Jack *et al.*, 2007), and created positive incentives to promote environmental conservation as well as reinforced existing policies (Jack *et al.*, 2007; Vonada *et al.*, 2011).

As a result, PES programs have been considered: (i) a potential way of generating conservation funding; (ii) a sustainable approach to conservation that connects ES users and providers and brings benefit to both; (iii) an efficient approach for conserving ES when the benefit from ES is higher than the cost of providing ES; and (iv) a means of improving rural livelihoods (Ferraro and Kiss, 2002; Wunder, 2005). How each PES program affects livelihood outcomes can vary, depending on institutional characteristics; therefore, PES can positively or negatively impact livelihood indicators (Liu and Kontoleon, 2018). Generally, the positive effects of PES on livelihood have been found to be more prominent, although existing literature shows some negative or null impacts (Blundo-Canto *et al.*, 2018).

In Vietnam, deforestation and the conversion of forests to other purposes, especially agriculture, led to a sharp decrease in forest area, and the government has designed some policies in an effort to conserve forests since 1990 (Pham *et al.*, 2021). According to Sunderlin and Huynh (2005), PES, though unofficial, have been expressed through some prior programs (such as programs 327, 556 or 611) when the government paid households to plant and protect forests.[1] These programs relied heavily on government funds to offer cash incentives for participants to conserve forests. According to Nguyen and Gilmour (1999), Sunderlin and Huynh (2005) and Nguyen *et al.* (2015), after about three to five years of implementing these programs, the national budget for these programs became inadequate to maintain and promote households' efforts for forest protection as well as expand forest-protected areas.

After that, other policies have been issued to build the foundation for payments for forest environmental services (PFES). For example, the 2004 revised Law on Forest Protection and Development recognized the important role of forests in providing ES such as carbon sequestration, water regulation, soil erosion reduction, climate change, biodiversity conservation or landscape beauty, or Decision No. 18 on the 2006–2020 Forestry Development Strategy set out needs for assessing the financial value of forest environmental services (FES) (Vietnam Forests and Deltas Program, 2015). This change has

[1]In Vietnam, Program 327 on reforestation in bare hills and mountains, coastal mudflats and the water surface was introduced in 1992. This program aimed at replanting forest trees, protecting forests, improving land use, enhancing living standards, and supporting sedentarization. In 1995, Program 556 was issued to adjust Program 327. According to this program, the support that did not relate to natural forests, the protection and special-use forests, such as plantations of industrial crops or resettlement, was discontinued. Program 661 on five-million-hectare reforestation was introduced in 1998. The primary purposes of this program were to use bare hill lands effectively, create more jobs for forest workers, increase income for people living in mountainous rural areas, and provide raw timber materials for paper production (Government of the Socialist Republic of Vietnam, 1992, 1995, 1998).

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allowed studies to be conducted to build a financial mechanism and provide information for policymakers to explore the PFES background as well as the challenges in PFES implementation. As a result, the PFES scheme was designed and piloted from 2008 to 2010 and has been implemented nationwide since 2011, with its primary aim to conserve the environment, reduce poverty, as well as improve livelihood and welfare (Pham *et al*., 2021).

Some research has assessed the design, mechanism, and implementation of PFES in Vietnam (Pham *et al*., 2013; Nguyen and Vuong, 2016). Generally, the PFES policy is run by the state, through Forest Protection and Development Funds (FPDFs), rather than by ES users and ES providers in voluntary transactions (Pham *et al*., 2013; Vietnam Forests and Deltas Program, 2015; Nguyen and Vuong, 2016). FPDFs serve as a bridge connecting ES users and providers. They sign the contract, collect the payments from users and release payments to providers (Pham *et al*., 2013; Phan *et al*., 2017; Duong and De Groot, 2020). 85 per cent of the total payment collected is released to ES providers, and the remaining 15 per cent is used by the FPDFs to cover operations and build a reserve fund. ES providers can be households, groups of households, communities, or organizations which all protect the forest via an agreement (Pham *et al*., 2021). For example, if households are forest owners and the forest is in FES paid areas, they can register to participate in PFES.

The result of forest protection, which is assessed annually through forest inventory, is an important criterion to secure participation and benefits of ES providers in the next year. In most cases, households are not forest owners but can also participate in PFES by contracting with existing ES providers (i.e., forest owners or commune people's committees) to protect the forest and receive 90 per cent of the payment paid for these ES providers. This allows the households to not only benefit from the ES payment but also to gain from different activities associated with the forest. In Vietnam, state-owned forestry enterprises were also forest owners. After the process of restructuring and privatizing these state-owned enterprises, unallocated forests and forest land, returned by state-owned forestry enterprises, were temporarily assigned to respective commune people's committees for management purposes. So far, although a part of these forest areas has been transferred to local communities at the village levels, households and individuals as forest owners (To and Tran, 2014), others are still being managed by commune people's committees. Therefore, according to Vietnam's forestry law, although the commune people's committee is not the forest owner, they are allocated forests to manage and receive PFES payment if the forest is in FES-designated areas. This means that ES providers can be commune people's committees. On the other hand, ES users can be water supply facilities, hydropower plants, and tourism companies. These ES users must pay a fixed unit price, part of which can be passed on to the end-users (Pham *et al*., 2015, 2021).

Studies have shown that the major achievements of the PFES policy in Vietnam have been the establishment of a national program, collection of revenue, and recruitment of a huge number of households to participate in policy implementation. As of 2020, the PFES program has expanded rapidly and covered 45 out of 63 provinces with 6,812,867 hectares of PFES forests (accounting for nearly 46.42 per cent of total forest area in the whole country). The PFES program has also benefited over 170,089 households and 8,067 communities who are forest owners, as well as 43,945 households and 5,878 communities which contracted to protect forests for forest owners (Vietnam Forests and Deltas Program, 2021). The PFES program also appears to be more sustainable than prior

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conservation programs. Instead of using the state budget, in the PFES program, beneficiaries have to pay for the use of FES. This has helped reduce financial pressure on the government's budget, therefore allowing for expanded implementation of PFES nationwide. Moreover, PFES has been determined to be more flexible because the government can adjust the FES unit price for its users to promote forest conservation. Additionally, without getting into an agreement with the local government, small-scale households can join this market as a FES supplier by collaborating with the existing FES providers (Pham *et al.*, 2021).

However, there is little evidence on the contribution of this policy to tackling both environmental and socioeconomic objectives, especially regarding its impacts on livelihoods (Nguyen and Vuong, 2016). To address this gap, this study uses propensity score matching to evaluate how the PFES policy has affected the livelihoods in the Central Highlands, a multicultural area in Vietnam. Households and communities participating in the PFES scheme in this region are mostly indigenous minorities, who often live close to the forest area and whose livelihood activities can play significant roles in forest protection efforts and management. Pham *et al.* (2021) evidenced that PFES positively and significantly affected income sources, total income and income per labor.

In this study, we focus on broader and different angles of household livelihoods. We use seven livelihood resource indicators covering human capital, natural capital, financial capital, physical capital and social capital. In addition, we examine 17 livelihood outcome indicators, for example, income from livelihood activities, living expenditure, households' perception of improvement in welfare, land use and community livelihood (see more detail in the figure in section 3.3). Thus, the contribution of this study is to evidence the effectiveness of PFES via different and comprehensive dimensions of livelihoods, with a focus on indigenous households as ES providers.

2. Livelihood impacts of PES

A number of previous studies have demonstrated the effects of PES programs worldwide (Tacconi *et al.*, 2013; Alix-Garcia and Wolff, 2014; Ingrama *et al.*, 2014; Samii *et al.*, 2014; Borner *et al.*, 2017; Blundo-Canto *et al.*, 2018; Liu and Kontoleon, 2018). PES schemes, especially in developing countries, often have dual goals: one for conservation and the other for improvement of economic and social outcomes (Borner *et al.*, 2017). PES have often been discussed as not only an economic instrument promoting an increase in economic efficiency and social surplus (Farley and Costanza, 2010), but also as a lever for livelihood improvement as well as rural development (Angelsen and Wunder, 2003; Pascual *et al.*, 2010). How they affect livelihood depends on the institutional characteristics of each PES program such as payments, voluntary participation, transaction cost, or access to alternative income sources (Liu and Kontoleon, 2018); therefore, each PES program can have a different impact on a livelihood indicator.

Although PES programs tend to exhibit positive impacts on livelihoods (see table A1 in the online appendix), a few studies showed negative consequences of PES (see Leimona *et al.*, 2010; Hegde and Bull, 2011; Zheng *et al.*, 2013 for some detail; or Blundo-Canto *et al.*, 2018, for a systematic review). PES may reduce crop production due to land-use restrictions or the number of income sources due to decreasing forest production. Furthermore, previous studies have used different methods, from descriptive statistics or mean difference tests to propensity score matching (PSM) or difference-in-difference (DID), to infer causal impacts of PES on livelihood outcomes,

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depending on the data availability, i.e., DID suits well for the case of having ex-ante data of PES and non-PES.

Many previous studies assessing the effects of PES on livelihoods have evidenced an increase in household income. Pham *et al.* (2021) synthesized PES-relevant studies (i.e., Miranda *et al.*, 2003; Uchida *et al.*, 2007; Locatelli *et al.*, 2008; Corbera *et al.*, 2009; Hegde and Bull, 2011; Scullion *et al.*, 2011; Bremer *et al.*, 2014; Clements and Milner-Gulland, 2014; Yin *et al.*, 2014; Kwayu *et al.*, 2017; Beauchamp *et al.*, 2018; Do and NaRanong, 2019) on the impact of PES on income and showed that PES payment directly or indirectly affects the income of participants. The direct effect comes from PES payment while the indirect effect can be explained by enhancing production investment, improving knowledge and production capacity, diversifying livelihood activities (Pham *et al.*, 2021), increasing job options (Wunder, 2006) and accessing non-timber forest products (Pagiola *et al.*, 2005). Although PES payment varies greatly among programs (Pham *et al.*, 2021), it has been found to be often less volatile than other sources (e.g., cultivation and breeding) due to changes in market and weather conditions (Pagiola *et al.*, 2005). That is, PES schemes can enhance income stability for the participant households.

There is some proof that PES programs positively affect the expenditure and physical resources of participating households. PES payment allows households to invest more in housing or in buying furniture or other assets (Uchida *et al.*, 2007; Kwayu *et al.*, 2017; Jones *et al.*, 2019). Research conducted by Kwayu *et al.* (2017) and Do and NaRanong (2019) showed that PES programs had positive impacts on household spending, especially on food consumption. Similarly, Hegde and Bull (2011) confirmed that households had higher daily expenditures when participating in the PES programs.

The literature also shows that PES programs can positively impact the knowledge of households. PES schemes help to improve environmental knowledge and awareness (Miranda *et al.*, 2003; Locatelli *et al.*, 2008; Alix-Garcia *et al.*, 2018; Jones *et al.*, 2020) and knowledge of forest management and agricultural production (Kwayu *et al.*, 2017). This knowledge leads to an increase in sustainability (Bremer *et al.*, 2014): for example, prevention of soil erosion (Clements and Milner-Gulland, 2014) and water availability (Zheng *et al.*, 2013). Additionally, PES programs can widen experience in resource management and enhance benefit sharing among households in communities (Ingrama *et al.*, 2014).

There is some evidence that the implementation of PES programs may also improve social connections. Research conducted by Wang *et al.* (2017) showed that PES have facilitated the strengthening of connections among local authorities and the formation of cooperative organizations in agricultural production. Similarly, Kwayu *et al.* (2017) showed that PES were able to expand the internal and external networks, fostering trust among participants; moreover, Pagiola *et al.* (2005) reported that PES encouraged stakeholders to work together in a participatory environment to strengthen relationships.

Additionally, PES may help in upgrading infrastructure. In many PES programs, collective funds established from a proportion of PES income are used to invest in community infrastructure (Tacconi *et al.*, 2013; Molina Murillo *et al.*, 2014). For example, income from PES contributed to investment in the local electricity grid in China's Wolong Nature Reserve (Yang *et al.*, 2013) and road protection and improvement in western Fujian Province, China (Wang *et al.*, 2017). Moreover, PES can secure land use rights for participating households as their land will be certificated by the state agency,

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thus providing more formal land protection rights (Bremer *et al.*, 2014; Wang *et al.*, 2017) and improved access to farmland (Pagiola *et al.*, 2005).

Lastly, the literature also points out that PES programs can have positive impacts on the poor, by alleviating poverty as well as promoting rural development. Payments are often received by small- and medium-sized landowners. In this way, PES may assist poor people (Bulte *et al.*, 2008; Milder *et al.*, 2010; Schomers and Matzdorf, 2013) and reduce poverty (Landell-Mills and Porras, 2002; Wunder, 2005; Milder *et al.*, 2010; Lawlor *et al.*, 2013; Schomers and Matzdorf, 2013).

3. Methodology

3.1. Study areas

The Central Highlands is located in the middle of Vietnam with many protected forest areas. It has five provinces (see figure A1 in the online appendix) and all of them have implemented the PFES program. The forest area in this region accounts for nearly one-fifth of the total 14.1 million ha of the country's forest area. The forest covered by PFES includes more than 63 per cent of the total forest area in this region (Nguyen and Vuong, 2016; Pham *et al.*, 2021). For the present study, data on households' livelihood was collected at 31 villages in nine communes of four districts in Kon Tum and Dak Lak provinces (table 1).[2]

3.2. Data collection

In this study, communes and villages with similar socioeconomic conditions were selected using clustered sampling and, within those, systematic random sampling was conducted to select 404 indigenous households. The survey was carried out between August and December 2019. The sample was then divided into two groups: the treated group (including 204 households with PFES) and the control group (including 200 households without PFES) (table 1).[3] The interview was carried out by local enumerators who are proficient in both Vietnamese and the indigenous language. The purpose of the study, the questionnaires (in Vietnamese), the procedures, and the survey plan were explained to the enumerators in a training session before they commenced the survey. Average time to convey and capture information in an interview was about 2.5 h. The households were allowed to participate voluntarily, and confidentiality of their answers was guaranteed.

The same questionnaire was administered to treatment and control groups (see the questionnaire in online appendix B). The questionnaire consisted of five parts: (1) general information; (2) information about household head and household situation; (3) livelihood information; (4) attitude toward forest conservation; and (5) opinions of and feedback from households about the PFES program.[4]

[2]Pham *et al.* (2021) also used a subset of this dataset and the PSM techniques; hence readers are referred to this study for more details on the research site and the sampling procedure. Additionally, the profile of the respondents in this study can be similar to Pham *et al.* (2021), as the PSM requires socio-economic indicators to generate the propensity scores that produced the two comparable matched groups.

[3]All 404 observations were used in this study, while Pham *et al.* (2021) used only 400 households as some indicators used in the later study are unavailable.

[4]Pham *et al.* (2021) also used the information synthesized from a part of the third section and all of the fourth section to evaluate the impact of PFES on household income and attitude toward forest conservation.

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Table 1. Study areas and sample size for household survey

Province	Forest areas (1000 ha)	% forest cover	Areas covered by PFES (1000 ha)	% PFES forest	Study areas	No. of communes	No. of surveyed communes	No. of households with PFES in surveyed commune	Sample size		No. of surveyed villages
									PFES	Non-PFES	
Dak Lak	526.5	62.3	240.6	45.7	Krong Bong	14	2	523	52	48	5
					MDrak	13	3	144	50	52	18
Kon Tum	617.9	39.2	363.1	58.8	Dak Ha	11	2	706	51	50	4
					Kon Ray	7	2	155	51	50	4
Total	1,144.4	47.2	603.7	52.8	4	45	9	1.528	204	200	31

Note: Computed from the secondary data obtained from FPDF of Dak Lak and Kon Tum.

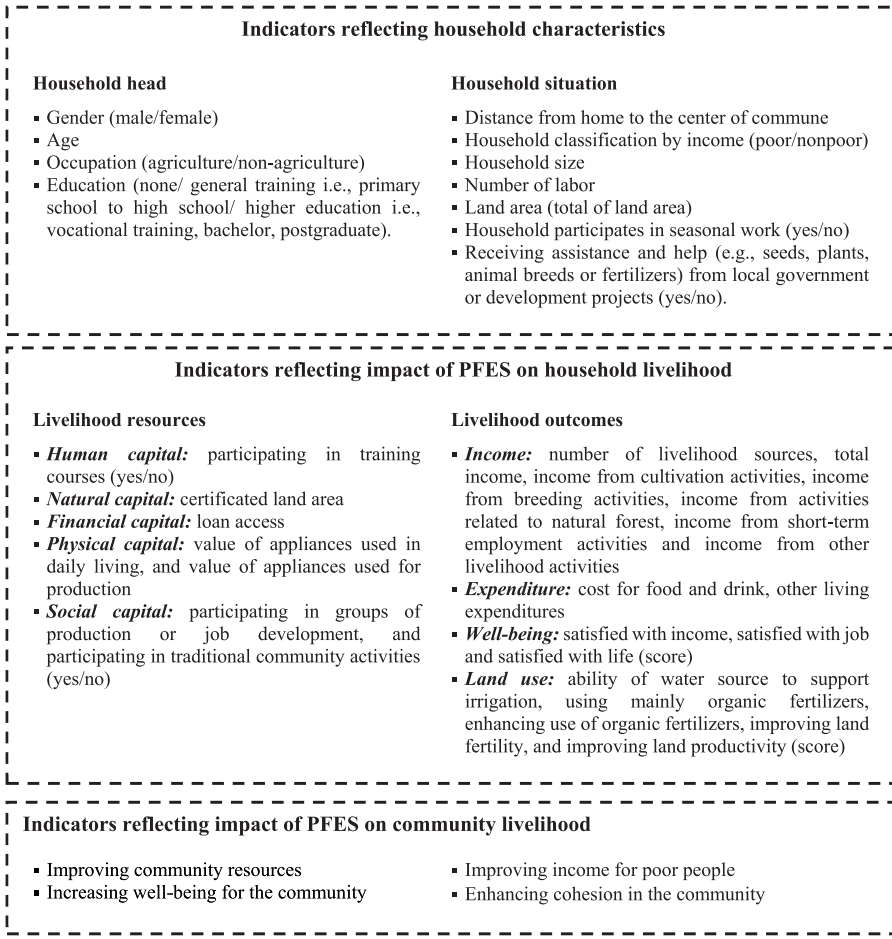

Figure 1. Description of variables used in this study.

3.3. Description of variables

Based on the sustainable livelihood approach of the Department for International Development (DFID, 2001), this study evaluates the impact of PFES on: (1) seven indicators of livelihood resources reflecting human capital, natural capital, financial capital, physical capital and social capital; and (2) 17 indicators of livelihood outcomes such as living expenditure, households' perception of improvement in welfare or land use (see figure 1). Household pecuniary indicators were measured by income from livelihood activities (i.e., value-added in the year after subtracting intermediate cost), costs for food and drink, and other living expenditures. Variables measuring perceptions (of welfare change or land use) were measured using Likert scales (Liddell and Kruschke, 2018). To

In this study, we have focused mainly on all of the information from the third section to assess the effect of PFES on different aspects of household livelihood.

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ensure time consistency, the relevant data to calculate these indicators was obtained for the year 2018.

In total, this study used 24 indicators to measure different aspects of household livelihood. In addition to households' livelihood, this study assessed the perception regarding impact of the PFES program on key aspects of community livelihoods, i.e., community resources, well-being for the community, income for poor people and cohesion in the community (figure 1).

3.4. Descriptive statistics

Table 2 describes the livelihood data of the households with and without PFES. Significant differences were noted between the gender and age of PFES and non-PFES household heads, the number of family members and productive land area in the two types of households. The PFES heads tend to be male, younger, and had more family members and productive land area than the non-PFES heads. Interestingly, there were no significant differences in terms of occupation, education level, or poverty level between those who joined the PFES program and those who did not. The same was also true for the number of employees, the distance to the commune, the participation in seasonal work, and the assistance from local government or development projects.

For livelihood resources, significant differences were noted between the PFES and non-PFES households' participation in a training course, and participation in traditional community services, all of which were larger/higher for the PFES households. Although both values of the appliances used in daily living and the appliances used in production of the PFES households were higher and the loan accesses lower than for the non-PFES, the differences were not statistically significant. Also, even though the PFES households participated in job development more than the non-PFES households, the difference remains insignificant.

In terms of household income and expenditure, the PFES households had significantly larger livelihood sources, income from cultivation, income from the forest, total income, food cost, and other living expenses compared to the non-PFES households. It should be noted that although the PFES households had lower income from livestock breeding, from short-term employment and from others than the non-PFES households, the differences were not statistically significant.

The well-being and land use indicators showed that the PFES households were significantly more satisfied with their income than the non-PFES households. However, the remaining indicators showed no statistical difference between the two groups.

With regard to the opinion on PFES impacts on community livelihoods, it can be observed that participating households perceived PFES effects on communities' livelihood positively. To be specific, the average scores for all four indicators were significantly higher than the medium score, with a statistical significance of 0.1 per cent.

3.5. Empirical model of propensity scores

The difference in observable characteristics between treated and comparison groups before the intervention can lead to bias in the estimation of program impact (White and Raitzer, 2017). Therefore, this study used PSM to control for these differences. In using PSM, selection into the program is based on observable characteristics, and the drawback of PSM relies on the degree to which observed characteristics drive program participation (Wendimu *et al.*, 2016; White and Raitzer, 2017). If selection bias from

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Table 2. Descriptive statistics

Variable	PFES ($n = 204$)	Non-PFES ($n = 200$)	p value
Household characteristics			
Age of the household head (years)	42.23	44.70	0.0495
Male-headed household (%)	91.67	84.50	0.0383
Occupation of household heads	94.12	96.00	0.5204
Household heads with no education (%)	12.25	14.00	0.7098
Household heads with general training (%)	80.39	78.00	0.6385
Household heads with higher education (%)	7.35	8.00	0.9542
Distance from home to the center of commune (km)	3.19	3.09	0.4795
Poor households (%)	41.67	44.50	0.6351
Number of family members (person)	5.13	4.70	0.0108
Number of employees (person)	3.08	2.92	0.2900
Productive land area (ha)	1.89	1.59	0.0384
Households participate in seasonal work (%)	63.24	68.50	0.3122
Households receive assistance (%)	34.80	27.50	0.1397
Livelihood resource			
Certificated land area (ha)	0.45	0.48	0.6904
Value of appliances used in daily living (million Vietnamese Dong – VND)	30.26	26.76	0.1959
Value of appliances used for production (million VND)	14.29	14.22	0.9813
Loan access (million VND)	27.03	30.49	0.2176
Households participating in training courses (%)	52.94	36.50	0.0013
Households participating in groups of production or job development (%)	4.90	4.00	0.8429
Households participating in traditional community activities (%)	56.86	36.50	<0.001
Income and expenditure			
Number of livelihood sources	3.11	2.81	<0.001
Total income (million VND)	52.19	41.12	0.0046
Income from cultivation (million VND)	24.4	18.02	0.0104
Income from livestock breeding (million VND)	2.76	3.54	0.2875
Income from activities related to natural forest (million VND)	10.31	1.93	<0.001
Income from short-term employment (million VND)	8.41	9.92	0.3058
Income from others (million VND)	6.31	7.70	0.5243

(*Continued.*)

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Table 2. *Continued.*

Variable	PFES ($n = 204$)	Non-PFES ($n = 200$)	p value
Cost for food and drink (million VND)	0.07	0.06	0.0022
Other living expenditures (million VND)	1.51	1.12	0.0024
Well-being			
Satisfied with income (score)	3.34	3.12	0.0310
Satisfied with job (score)	3.11	2.96	0.1314
Satisfied with life (score)	3.55	3.44	0.2385
Land use			
The ability of water source to support irrigation (score)	2.62	2.57	0.6295
Using mainly organic fertilizers (score)	1.75	1.68	0.2764
Enhancing to use organic fertilizers (score)	2.45	2.29	0.0950
Improved land fertility (score)	2.25	2.14	0.1682
Improved land productivity (score)	2.42	2.27	0.1007
Participating household's opinion about PFES impact on community livelihoods			
PFES helps improve community resources (score)	3.74	–	<0.001
PFES helps increase well-being for the community (score)	3.83	–	<0.001
PFES helps improve income for poor people (score)	3.89	–	<0.001
PFES enhances cohesion in the community (score)	4.07	–	<0.001

Notes: *t*-tests (prop.test for proportion) were used to test for mean values between households with and without PFES. In the case of indicators reflecting only PFES households' opinion about impacts on community livelihoods, this study uses t-tests to test for the mean score in comparison with 3 (medium score in Likert scale with five levels).

unobserved characteristics is negligible, then PSM will provide a good comparison. On the contrary, if selection is influenced by unobservable characteristics, impact estimates can be biased. However, PSM remains a common technique to evaluate program impact, and it is mentioned and used in many quasi-experimental studies, for which baseline data are not available (Khandker *et al.*, 2010; Wendimu *et al.*, 2016; White and Raitzer, 2017), especially in evaluating impacts of PES programs (Hegde and Bull, 2011; Kwayu *et al.*, 2017; Do and NaRanong, 2019).

Let Y_1 denote the outcome (i.e., livelihood indicators such as income or expenditure) for a household that participated in PFES and Y_0 the outcome of a household that did not participate; P denotes participation in PFES. If the household participates, $P = 1$, and if the household does not, $P = 0$. $\times$ represents a vector of observed characteristics of the household that may influence participation in the PFES program. According to Heckman *et al.* (1997), the average effect of program participation (ATT) on the outcome can be calculated as follows:

$$ATT = E(Y_1|X,\ \mathrm{P} = 1) - E(Y_0|X,\ \ \mathrm{P} = 1). \quad (1)$$

As there is no information regarding the outcome for households without PFES in the survey if they participate in PFES (i.e., $E(Y_0|X,\ \ \mathrm{P} = 1$ is unobserved), one cannot calculate ATT. To solve this problem, Rosenbaum and Rubin (1983) suggested substituting

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the expected outcome $E(\bar{Y}_0|X,\ \mathrm{P}=0)$ for the unobserved outcomes $E(Y_0|X,\ \mathrm{P}=1)$:

$$ATT = E(Y_1|X,\ \mathrm{P}=1) - E(\bar{Y}_0|X,\ \mathrm{P}=0). \quad (2)$$

Here, $E(\bar{Y}_0|X,\ \mathrm{P}=0)$ is the average predicted outcome for observations under the counterfactual condition.

PSM creates a counterfactual that is as similar as possible to the treated group in terms of observed characteristics (Khandker *et al.*, 2010) through applying the participation probability model in PFES conditional on observed characteristics X, to estimate a propensity score (i.e., probabilities of participation) as a statistical comparison group.

In this study, the use of PSM to estimate the causal effect of participation in PFES on the livelihood involved: (i) identifying the variables for the selection model, (ii) choosing the matching algorithms, (iii) testing the covariate balance, and (iv) estimating the PFES effect based on the matched data set. A regression analysis was then run based on the binary logistics model. In this model, the dependent variable is the participation in the PFES program (1 for households participating in PFES and 0 for households nonparticipating in PFES). According to Caliendo and Kopeinig (2008), the selection model should include the variables that simultaneously affect the participation decision and the outcome variables. Thus, based on similar studies synthesized from the literature (e.g., Lokina and John, 2016; Kwayu *et al.*, 2017; Do and NaRanong, 2019) and local knowledge acquired through discussions with government officers and village heads, five independent variables were chosen for the selection model for this study. These include age, gender of household head, household size, participating in seasonal works, and receiving assistance.

The result of the participation model shows that this model was statistically significant (see table A2 in the online appendix). Four factors significantly affected participation in PFES. Specifically, male-headed household and household size positively affected PFES participation, while age of household head and having seasonal work negatively contributed to program participation. Meanwhile, receiving assistance from private or state organizations positively affected program participation, although this variable was statistically significant only at the 10 per cent level.

In the PSM, one can use different matching techniques such as optimal matching, nearest-neighbor matching, greedy matching, genetic matching, or full matching. According to Caliendo and Kopeinig (2008), the choice of the matching technique relies upon the trade-off between variance and bias. This study used the nearest neighbor with a caliper (also called caliper matching), which can lead to a reduction in bias and closer matches and an improvement in the performance of matching (Austin, 2014; Lunt, 2014). This method is similar to the nearest neighbor matching, but it adds the restriction that only the closest neighbor from the control group with the propensity score within a certain radius (caliper) is used to match treatment individuals. Additionally, results estimated by using neighbor matching without caliper and full matching are presented as comparative information. As shown below, the results of the three matching algorithms are generally robust.[5] Estimates of the PFES impact on livelihood, which are presented in the next section, were calculated using the ordinary least squares (OLS) regression model

[5]Using caliper matching leads to the most improvement after matching. This improvement is statistically significant when using the caliper matching and nearest-neighbor matching without caliper. However, it is statistically insignificant when using the full matching (see table A3 in the online appendix).

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with a dummy variable for PFES participation as an explanatory variable for program impact.

4. Results

The estimated results indicate that participation in the PFES program had statistically significant effects on some household livelihood indicators. In general, these impacts were clearer and more prominent in relation to income and expenditure for living than for the indicators reflecting livelihood resources, welfare, and land use (table 3).

In terms of livelihood resource indicators, the rates of households participating in training courses and traditional community activities were two indicators that were statistically significant with p-value < 0.05 under all the three matching techniques. PFES was able to bring about positive impacts on livelihood resources by creating more chances for households to improve their knowledge and to join community activities. On the contrary, there was no conclusive evidence regarding PFES influence on the certificated land area. Although the difference between households with and without PFES was positive for the value of appliances used in daily living and negative for the value of appliances used for production, these differences were not statistically significant (p-value > 0.05). Similarly, we did not see a significant difference between the two groups in the proportion of households participating in production groups. Meanwhile, the size of loans of participating households was significantly smaller than that of non-participating households with p-value < 0.05 under caliper matching and neighbor-nearest matching.

Additionally, it can be considered that the PFES policy significantly affected some indicators related to household income and living expenditure. The work of Pham *et al*. (2021) shows that under caliper matching the PFES program created more income sources and increased the annual income of the households participating in PFES. This study reinforced this conclusion when showing that two indicators were still statistically significant with a p-value < 0.05 under full matching and neighbor-nearest matching. Additionally, this study pointed that the differences in income from activities related to natural forest and cultivation activities between households with and without PFES were statistically significant at 5 per cent under three matching techniques. Conversely, although the average income from breeding activities, short-term employment activities, and other activities of non-participating households was greater than that of households who participated in PFES, these differences were statistically insignificant. The increase in the household income led to a rise in living expenditure. These study results showed that the differences in the estimated household expenses for food and drink and the cost of living between households with and without PFES were positive with a statistical significance of 5 per cent under three matching techniques.

With regard to well-being and land use issues, in general, PFES households had more positive opinions and assessments than non-PFES households in all indicators related to welfare and land use. However, we were able to note significant differences in average scores only in the indicators related to income (under three matching techniques) and job assessment (under only caliper matching) between the two household groups. This means that there was evidence to conclude that PFES significantly and positively affected the perception of households regarding income and job issues. Meanwhile, the average score of other indicators reflecting well-being (e.g., feeling satisfied with current life) and aspects related to land use (e.g., the ability of water source to meet the irrigation needs;

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Table 3. Estimated impacts of PFES on livelihood

Indicators	Estimate *(Std. Error)*		
	Caliper matching	Nearest-neighbor matching	Full Matching
Livelihood resources			
Certificated land area (ha)	−0.0499 (*0.0915*)	−0.0168 (*0.0914*)	−0.0459 (*0.0857*)
Value of appliances used in daily living (million VND)	5.3995 (*2.8388*)	4.9660 (*2.8509*)	3.2648 (*2.6549*)
Value of appliances used for production (million VND)	−0.1757 (*2.9550*)	−0.0450 (*2.9708*)	−1.4759 (*2.6315*)
Loan access (million VND)	−6.5220 (*3.0186*)	−6.8395 (*3.0268*)	−4.1544 (*2.8941*)
Households participating in training courses	0.1944 (*0.0525*)	0.1820 (*0.0530*)	0.1556 (*0.0498*)
Households participating in groups of production or job development	0.0088 (*0.0231*)	0.0060 (*0.0239*)	−0.0000 (*0.0213*)
Households participating in traditional community activities	0.2139 (*0.0524*)	0.1873 (*0.0529*)	0.1712 (*0.0496*)
Income and expenditure for living			
Number of livelihood sources	0.3300 (*0.0756*)	0.3381 (*0.0770*)	0.3286 (*0.0719*)
Total income of household (million VND)	11.7639 (*4.3007*)	12.3560 (*4.3264*)	10.1539 (*4.0016*)
Income from cultivation activities (million VND)	5.5110 (*2.7436*)	6.0350 (*2.7732*)	5.1601 (*2.4772*)
Income from livestock breeding activities (million VND)	−0.7495 (*0.8016*)	−0.7617 (*0.8069*)	−0.8059 (*0.7566*)
Income from activities related to natural forest (million VND)	8.2401 (*0.7257*)	8.2781 (*0.7264*)	8.3868 (*0.6924*)
Income from short-term employment activities (million VND)	−0.9761 (*1.5467*)	−0.9034 (*1.5564*)	−0.9934 (*1.3803*)
Income from other activities (million VND)	−0.2616 (*2.3499*)	−0.2920 (*2.3632*)	−1.5936 (*2.2296*)
Cost for food and drinking of households (million VND per day)	0.0116 (*0.0040*)	0.0120 (*0.0041*)	0.0090 (*0.0038*)
Other living expenditures of households (million VND per month)	0.5030 (*0.1411*)	0.4956 (*0.1427*)	0.4013 (*0.1327*)
Well-being			
Feeling satisfied with the family's income (score)	0.2450 (*0.1103*)	0.2628 (*0.1104*)	0.2291 (*0.1040*)
Family members had an appropriate job (score)	0.2147 (*0.1034*)	0.1832 (*0.1044*)	0.1286 (*0.0980*)
Feeling satisfied with current life (score)	0.1554 (*0.1006*)	0.1349 (*0.1013*)	0.1146 (*0.0953*)

(*Continued.*)

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Table 3. *Continued.*

Indicators	Estimate *(Std. Error)*		
	Caliper matching	Nearest-neighbor matching	Full Matching
Land use			
The ability of water source support irrigation (score)	0.0901 (*0.1198*)	0.0741 (*0.1206*)	0.0298 (*0.1120*)
Organic fertilizers were mainly used in agricultural production (score)	0.0909 (*0.0714*)	0.1017 (*0.0719*)	0.1016 (*0.0718*)
Enhancing the use of organic fertilizer to replace chemical fertilizers (score)	0.1716 (*0.1019*)	0.1281 (*0.1036*)	0.1672 (*0.0968*)
Soil fertility was increasingly improved (score)	0.1518 (*0.0806*)	0.1317 (*0.0826*)	0.1284 (*0.0791*)
Land productivity was increasingly improved (score)	0.0847 (*0.0972*)	0.1400 (*0.0968*)	0.1222 (*0.0916*)

Notes: Standard errors in parentheses. The caliper used in this study equals 0.1 (for the caliper matching); the ratio of 1:1; the treated observations dropped after caliper matching, nearest-neighbor matching and full matching were 32, 0 and 4 respectively. Impacts of PFES (ATT) are estimated by using OLS. The results using the Bonferroni correction were presented in table A4 in the online appendix.

using mainly organic fertilizers in agricultural production; enhancing use of organic fertilizer to replace chemical fertilizers, improving soil fertility or land production) were not statistically significant at the 5 per cent level.

5. Discussion

As there was no retrospective data about households before implementing PFES, PSM was used to evaluate the PFES impact on livelihood. This limits the efficacy of findings; however, this research has provided evidence to support the effect of PES programs on livelihood in a developing country and conveys a picture of the PFES policy in Vietnam. As per our results, PFES had positive impacts on some aspects of the livelihoods of indigenous households and communities.

PFES brought financial benefits to participating households. This is because PFES helped households diversify livelihood activities and improve income streams. Pham *et al.* (2021) used the caliper matching to demonstrate the effect of PFES on income sources and the household income in the Central Highlands of Vietnam. The study stated that the Central Highlands is a poor region, and the livelihood activities of households depend mainly upon the agricultural sector, which is often highly seasonal. Therefore when participating in PFES, the households can diversify their income and improve employment in the forestry sector. Moreover, when households and communities participate in PFES, they are paid for forest protection efforts. Thus, a direct financial stream has been created and this helps households increase investment in agricultural production and enhance crop yields and income. In this study, we used the caliper, nearest-neighbor without a caliper and full matching technique to support this conclusion, but also to evaluate the effect of PFES on the range of livelihood indicators.

By evaluating the effect of PFES on income from other livelihood activities, this study provided information explaining the increase in the total income of households.

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To be specific, the increase in the total income of participating households could be attributed mainly to increased income from activities related to natural forest and cultivation activities. This is because while the impact of PFES on income from breeding, short-term employment and other livelihood activities was relatively small and was not statistically significant, there is evidence showing the positive effect of PFES on income from activities related to natural forest and cultivation activities. The analysis showed that the income from forest-related activities of households with PFES was about 10.31 million VND (accounting for 19.75 per cent of total income), which was much larger compared to non-participating households (about 1.93 million VND and 4.7 per cent respectively). Income from activities related to natural forest includes income from forest protection (i.e., PFES payment) and income from forest products (i.e., non-timber products from the forest such as firewood, bamboo shoots, or vegetable), therefore, PFES payment can contribute to income from activities related to natural forest. This result confirmed the results of Wunder (2008) and Tacconi *et al.* (2013) on the impact of PES in improving financial capital based payments. Similarly, the income from the cultivation of households with PFES was about 24.4 million VND, while this income for households without PFES was only 18.02 million VND. This difference could be partly explained by the difference in productive land area, while the other important part of the difference came from the change in crop productivity. The average income from cultivation per unit area of the participating households was about 12.91 million VND/ha (24.4/1.89), which was deemed higher than that for the households without PFES (18.02/1.59 = 11.33). Most interviewed households reported that payment from PFES enabled households to invest more in cultivating activities, especially buying fertilizers and pesticides. The result is in line with Pham *et al.* (2021), showing that PES can help households increase production investment, and then improve production capacity. Meanwhile, Uchida *et al.* (2007) showed PES had a significant and positive effect on income from breeding, while this study has no statistical evidence on this aspect.

These findings also partly answered questions about the relationship between participation in PFES and the improvement of living standards of households. Unlike the conclusion of the studies of Uchida *et al.* (2007), Kwayu *et al.* (2017), and Jones *et al.* (2019), on the positive impact of PES on household assets, our research results were not statistically significant for confirming this relationship. However, this study presented similarities with the research results of Kwayu *et al.* (2017) and Do and NaRanong (2019) in view of the positive effect of PES on household spending, especially on food and drinking consumption. To be specific, the households with PFES had significantly higher expenditure for food, drinks, and other living expenses than households without PFES. Similar to Do and NaRanong (2019), this study showed significant impacts of PFES on the size of loans. However, while Do and NaRanong (2019) argued that PFES has given poor households access to loans, we highlighted that PFES decreased the amount of loans for participating households. Therefore, it can be concluded that participation in the PFES program improved the living standards of participating households through their use of their additional income to purchase consumption goods and to reduce the amount of loans.

Another significant impact of this study is that we were able to determine that PES has an impact on social capital through increasing community connectivity. This is because when households participate in PFES, they have more opportunities to participate in community groups to conduct forest patrolling activities and have more connections with local authorities in the process of program participation and implementation. The

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study results show that in the group with PFES, the rate of households participating in traditional community activities was about 56.9 per cent, while this figure for non-participating households was only 36.5 per cent. These results were also mentioned in some previous studies such as those by Pagiola *et al.* (2005), Kwayu *et al.* (2017) and Wang *et al.* (2017). However, we did not find any significant connection between participation in PFES and formation of cooperative organizations in production as in the research result of Kwayu *et al.* (2017).

The research results were consistent to some findings from other works (Miranda *et al.*, 2003; Locatelli *et al.*, 2008) when pointing out that PFES increased the opportunity to access knowledge and raised awareness for participating households. In the PFES program, households with PFES can participate in training in the process of policy implementation, therefore, they can expand their understanding and knowledge. The analysis results indicate that the proportion of PFES households participating in training courses was nearly 53 per cent, whereas, for non-participating households, it was only 36.5 per cent.

Although many studies such as those by Bremer *et al.* (2014), Wang *et al.* (2017), and Jones *et al.* (2020) mentioned the positive impact of PES on land use rights for participating households; our study did not find clear results on this relationship. The analysis results show that the land area with certification for households with PFES was smaller than for the non-participating households. However, the negative difference was not statistically significant.

The next issue that this study examined was the evaluation of the surveyed households about the change in land use or satisfaction with certain aspects reflecting the livelihood of households. Comparison between households with and without PFES shows that the differences between the two groups in the average score measuring satisfaction with income and job are statistically significant. This further clarifies and reinforces the positive impact of PFES on household income. With respect to other indicators mentioned (e.g., satisfaction with current life, the ability of water sources to support irrigation, change in fertilizer use in crop production, change in soil fertility, and land productivity), although the participating households had greater score for positive assessments than the non-participating households, the differences were not enough to reach significant conclusions about the PFES impact on these indicators.

Finally, this study drew similar conclusions with some research on the positive effects of PES on community livelihoods such as increasing income for the poor (Miranda *et al.*, 2003; Schomers and Matzdorf, 2013), improving livelihoods and reducing poverty (Landell-Mills and Porras, 2002; Grieg-Gran *et al.*, 2005; Milder *et al.*, 2010; Lawlor *et al.*, 2013), strengthening social connection (Pagiola *et al.*, 2005; Kwayu *et al.*, 2017; Alix-Garcia *et al.*, 2018), and enhancing investment in community infrastructure (Tacconi *et al.*, 2013; Yang *et al.*, 2013; Molina Murillo *et al.*, 2014; Wang *et al.*, 2017). These study results show that nearly 42 per cent of the households with PFES were poor. In addition, all households participating in PFES had positive assessments, which were statistically significant, about the policy's impacts on poor people's income, and resources, connectivity and on the welfare of communities. In the surveyed areas, especially where the forest is protected by community and commune people's committees, a part of the PFES income is utilized for community infrastructure construction such as a lighting system in Krong Bong district in Dak Lak province and the transportation systems and building community houses in Dak Ha district in Kon Tum province. In particular, there were

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two surveyed communities (village 7 and village 13, Dak Pxi commune, Dak Ha district, Kon Tum province) in which female cooperative groups were established in the community to protect forests. These groups used a part of the money from PFES to assist poor members of the community in improving their livelihoods. These cooperative groups have been judged a sound model of PFES implementation by communes and the provincial government.

6. Conclusions and limitations

This study uses the surveyed data and PSM techniques to evaluate the impacts of PFES on the livelihood of the households in the Central Highlands of Vietnam. This study shows that PFES has positively and significantly affected several aspects of household livelihoods. Study result points out the impact on the household's income streams, including income from activities related to natural forest and cultivation activities as well as increasing satisfaction with the generated income and job creation. Moreover, the result indicates that the PFES policy positively and significantly contributed to the living standard of households by increasing consumption of provisions and other requisites for living and decreasing the amount of loans. Third, this study evidences that PFES increased the opportunity for participation in training courses and enhanced traditional community activities for participating households as well as benefited community livelihoods by improving income for the poor and increasing community resources, cohesion, and welfare.

Additionally, although the study shows that participating households have a slightly higher asset value than non-participating households, and have a more positive assessment on land use and well-being indicators, these differences between the two groups are not statistically significant. Similarly, there is no conclusive proof to indicate negative impacts of PFES on the certificated land area, income from animal husbandry, and income from seasonal work of participating households.

Assessment of the impact of PFES in this study on livelihoods has several limitations. The first drawback is that due to data limitation, this study only used data after implementing PFES and compared the difference in livelihood indicators of households with and without PFES to reflect the impact of PFES. Second, this study relies only on four districts in two provinces with different forest conditions and payment norms. Therefore, it is necessary for further research agenda, based on larger samples of households in more provinces, to evaluate the impact of PFES on the livelihoods of the households in the Central Highlands of Vietnam.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S1355770X22000146

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