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Article

Effect of payment for forest ecosystem services on forest conservation practices in Vietnam

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Abstract: Payment for forest ecosystem services (PFES) policy is a prevalent strategy designed to establish a marketplace where users compensate providers for forest ecosystem services. This research endeavours to scrutinise the impact of PFES on households' perceptions of forest values and their behaviour towards forest conservation, in conjunction with their socio-economic circumstances and their communal involvement in forest management. By incorporating the social-ecological system framework and the theory of human behaviours in environmental conservation, this study employs a structural equations model to analyse the factors influencing individuals' perceptions and behaviours towards forest conservation. The findings indicate that the payment of PFES significantly increases forest protection behaviour at the household level and has achieved partial success in activating community mechanisms to guide human behaviour towards forest conservation. Furthermore, it has effectively leveraged the role of state-led social organisations to alter local individuals' perceptions and behaviours towards forest protection.

Keywords: payment for forest ecosystem services; structural equations model; community-based forest management

1. Introduction

Forests, encompassing nearly one-third of the global land area FAO (2020), represent a crucial ecosystem on our planet. They offer a plethora of indispensable ecosystem services that contribute to human welfare, including the preservation of soil and water, biodiversity conservation, recreational services, and climate regulation (Millennium Ecosystem Assessment, 2005). Nevertheless, many of these forest ecosystem services are public goods, resulting in a lack of remuneration for the providers of these services. Consequently, they lack the economic incentives to safeguard the forest to sustain the provision of these services. Fortunately, since 1990, numerous measures have been implemented to decelerate the rate of global forest loss. For instance, a larger expanse of forests has been legally designated as protected areas. Globally, the extent of these protected areas has augmented by 191 million hectares since 1990, amounting to approximately 726 million hectares of forest in 2020 (FAO, 2020). In addition, other initiatives such as taxation and subsidisation (Pirard, 2012), and specifically, payment for ecosystem services (PES), have made significant contributions to forest conservation worldwide (Börner et al., 2017; Grima et al., 2016; Wunder et al., 2018).

Introduced in the 1990s, payment for ecosystem services (PES) has surfaced as a promising mechanism for the conservation of nature and the sustainable delivery of

ecosystem services (Wunder et al., 2018). The fundamental principle of PES is to establish an institutional marketplace where users can purchase ecosystem services from providers (Wunder, 2008). This mechanism is typically formulated and spearheaded by the government as an instrument for sustainable forest management (Roldan Muradian et al., 2010; Wunder et al., 2018). Essentially, PES involves a conditional payment system where users who derive benefits from forest ecosystem services are obligated to compensate service providers. Consequently, to receive payment, service providers are required to strive to maintain and/or enhance the provision of services (Wunder, 2015).

In Vietnam, the payment for forest ecosystem services (PFES) policy was formally instituted as a nationwide initiative in 2011. Over a decade of implementation has rendered Vietnam's PFES a subject of considerable interest in numerous studies. These studies primarily focus on the discrepancy between the theoretical underpinnings of PES and its practical application in the Vietnamese context (Duc et al., 2016), the effectiveness of forest conservation and the enhancement of local livelihoods (Do et al., 2018; McElwee, 2012; Pham Thu Thuy et al., 2013; Suhardiman et al., 2013), and operational issues in PFES such as transaction costs (Phan et al., 2017). These studies reveal that the PFES policy design approach in Vietnam is government-led, aimed at mobilising financial resources for forest conservation to alleviate the fiscal burden on the state budget. Recent research has centred on the distribution of benefits among stakeholders. Loft et al. (2017) found that fairness in benefit distribution is significantly influenced by the land use right management mechanism and transparency in the payment process. Additionally, Duong and de Groot (2018) analysed the risks associated with distributing benefits from the PFES policy, revealing that the policy exacerbates income inequality. To address the inequality issues of PFES, Chu et al. (2019) investigated the challenges in balancing the efficiency and equity of Vietnam's PFES policy, developing an optimal model to ensure both the policy's effectiveness and equitable distribution among policy stakeholders. From a different viewpoint, To and Dressler (2019) suggested that the PFES policy does not have a clear impact on forest conservation or local livelihoods.

In Vietnam, comprehensive studies examining the influence of policies on local people's perceptions, attitudes towards forest values, and forest conservation actions are lacking. This research issue is pivotal as it aids in understanding how the policy impacts and what aspects of it can instigate changes in attitudes about forest values and forest owners' conservation behaviours, thereby enhancing the effectiveness of policies in grassroots-level forest protection. Moreover, while numerous studies have demonstrated the interactions of the policy with the specific socio-economic conditions of the forest owners and the characteristics of the local community governance regime in other contexts (Salzman et al., 2018; Wunder et al., 2018), no study has concentrated on this issue in the context of PFES research in Vietnam. Consequently, these interactions warrant analysis. The findings from research on these issues are beneficial for proposing policy implications to foster flexibility and augment the suitability of policy design, particularly in the local contexts of the Northwest region, Vietnam.

Consequently, the objective of this research is to scrutinise the attributes of the

payment for forest ecosystem services policy and its execution in Vietnam's Northwest region and to explore how these policy characteristics shape the attitudes, knowledge, and forest conservation behaviours of local forest owners. Simultaneously, it seeks to comprehend the interplay of the policy with the demographic and socio-economic traits of local households, as well as the role of communities and state-led organisations in policy implementation and forest management.

2. Theoretical foundation

2.1. PFES and quasi-PFES programs

Over the past decade, PFES has surfaced as a mechanism that holds significant promise for forest conservation and the enhancement of forest ecosystem services delivery (Wunder et al., 2018). Presently, there are two primary methodologies in the design and execution of PFES programs and policies. Initially, PFES are typically constructed based on a market mechanism to incentivise forest owners to supply ecosystem services from their forests. In this approach, a national government assumes a role in establishing a mechanism that enables service users and environmental service providers to engage in voluntary transactions akin to market transactions (Wunder, 2015). Alternatively, given the challenges in applying the ideal PFES in reality (Muradian, Arsel, et al., 2013; Muradian, Corbera, et al., 2010), a second approach known as quasi-PFES has been proposed. In this form, a government formulates a PFES policy to mobilise resources to fund forest preservation programs. The government can utilise a blend of market and non-market tools (e.g., environmental tax or mandatory transaction) to implement the PFES policy (Wunder et al., 2018). In essence, both PFES and quasi-PFES are financial transactions that aim to transfer a portion of the value that users derive from the conservation and restoration of forest ecosystems to forest owners, who sustain and enhance the provision of forest ecosystem services. For these payment schemes to function effectively, the payment must be greater than or at least equal to the opportunity costs of forest owners in undertaking forest conservation actions, but not exceed the willingness to pay (benefit) of the users derived from the conservation of the forest ecosystem services.

Vietnam has been at the forefront of executing payment for forest services (PFES) in Asia. The PFES program in Vietnam is designed with multifaceted objectives: i) safeguarding forests, ii) enhancing livelihoods and alleviating poverty, and iii) promoting equitable income distribution (Loft et al., 2017; Thuy, Chau, et al., 2020). Over a decade of implementation has seen PFES compensating for three categories of forest ecosystem services: i) services that protect the soil and mitigate soil erosion and sedimentation, ii) services that regulate water, and iii) services that preserve natural landscapes and maintain the biodiversity of forest ecosystems for tourism and recreational purposes. The consumers of these services contribute to the forest ecosystem services through an environmental fee, which is incorporated into the price of goods produced using resources provided by forest ecosystems. In the current PFES framework in Vietnam, payments are made through three primary entities: i) hydroelectric power plants, ii) potable water companies, and iii) eco-

tourism enterprises. These entities, which directly utilise forest ecosystem services in their production processes, are tasked with collecting environmental fees from the end users. Subsequently, the fees are indirectly remitted to the providers of forest ecosystem services. The transaction is facilitated by the Forest Protection and Development Fund, a state-established entity tasked with the operation of the PFES program. Presently, the primary financial resource for the PFES program is derived from hydroelectric power plants, which typically contribute over 97% of the total funds collected. These funds are then distributed by the Forest Protection and Development Fund to individuals and organisations that offer forest ecosystem services through forest conservation. Within the framework of this PFES program, the service providers who are eligible for payments encompass organisations, households, individuals, and communities who either own forests or are accountable for their protection.

2.2. Social-ecological system

The social-ecological system (SES) formulated by Ostrom (2009) and McGinnis and Ostrom (2014) serves as a theoretical structure for scrutinising the decision-making processes of stakeholders within an SES. This structure elucidates the interactions that occur internally and externally among humans (users, the governance system, and their respective interactions) and the environment (resource system, resource unit, and their respective interactions). This research framework helps predict SES outcomes by analysing these interactions in specific social, economic, and political contexts, which in turn can infer the effect of these outcomes to humans.

2.3. The theory of human behaviours in environmental preservation

Several theories, including the behavioural change model, the environmentally responsible behaviour model, and the theory of planned behaviour seek to elucidate human behaviours in relation to environmental conservation (Ajzen and Fishbein, 2000; Maleksaeidi and Keshavarz, 2019). These theories propose that intentions towards environmental preservation are influenced by social norms, individual attributes encompassing demographic and socioeconomic variables, and notably, psychological elements such as perceptions, attitudes, and beliefs pertaining to the environment. These intentions, in turn, significantly shape actual behaviours. The theories contend that it is feasible to anticipate and foster environmental preservation behaviours through education that alters individuals' awareness and attitudes towards the natural environment and instigates pro-environment mechanisms (Akintunde, 2017; Hanna, 1995).

2.4. Conceptual framework of the study

Utilising the aforementioned theoretical underpinnings, this study conceptualises the interplay between forest governance, community-based forest management, and household demographics. The aim is to assess the impact of the PFES policy on local households' understanding of forest values, their knowledge of PFES implementation, and ultimately, their behaviours towards forest protection

within the socio-economic context of Vietnam (**Figure 1**).

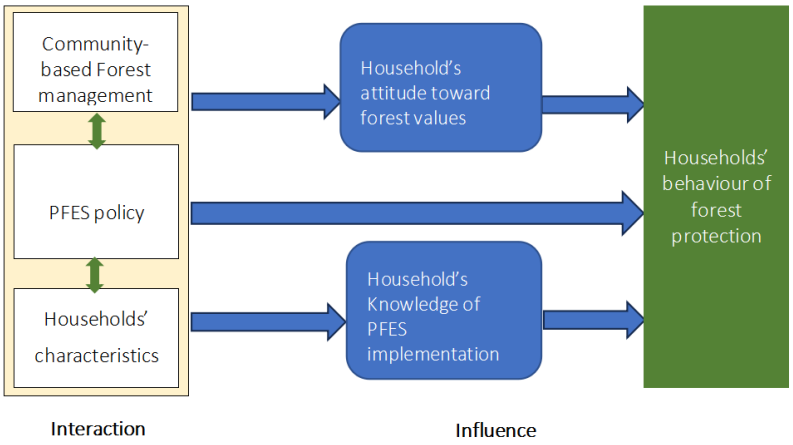

Figure 1. The conceptual framework to evaluate the influence of PFES policy on forest protection behaviour.

3. Data and methods

3.1. Research site

This research was carried out in Dien Bien, Son La, and Hoa Binh provinces in the Northwest region of Vietnam (see **Figure 2**), all of which have substantial forest coverage (42.66%, 45.40%, and 51.54% respectively) and their poverty rates surpass the national rate (GSO, 2021; MARD, 2021). More specifically, Dien Bien stands out with the poverty rate at 36.74%, with an average income of 900 USD/year. Hoa Binh, despite having the highest income per capita among the three (1403 USD/year), exhibits a poverty rate of 9.09%, which is nearly double the national average. These provinces are also home to a significant proportion of ethnic minorities (83.7% in Son La, 82.7% in Dien Bien, and 75% in Hoa Binh) (CEMA and GSO, 2020). A notable aspect of this region is the high-income contribution from agriculture and forestry, exceeding the national average of 11.20% (27.58% in Dien Bien, 33.37% in Son La, and 16.11% in Hoa Binh) (refer to **Table 1** for a summary of the study site's general features).

Table 1. Study site's overall features (GSO, 2021; CEMA and GSO, 2020).

Province	Total area (ha)	Forest cover rate (%)	Population (1.000 people)	Ethnic minority population rate (%)	Poverty rate (%)	Annual income (USD per capita)	Contribution of agriculture and forestry to total income (%)
The whole country	33,123.6	42.10	97,582.7	14.7	4.8	3450	11.20
Dien Bien	951.4	42.66	613.5	82.6	36.74	900.1	27.58
Son La	1412.3	45.40	1270.6	83.7	30.53	904.2	33.37
Hoa Binh	459.1	51.54	861.2	74.3	9.09	1402.7	16.11

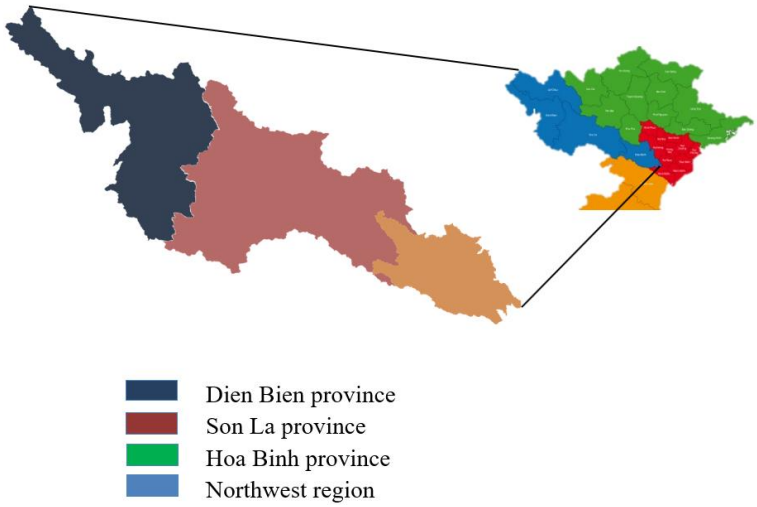

Figure 2. Study sites (**Google**, n.d.-a, b, c, d).

3.2. Sampling and data collection techniques

Preliminary data was gathered via household surveys in the study areas. A two-stage sampling method was employed. Firstly, 20 villages were selected from 6 representative districts across the three surveyed provinces. Secondly, 15 to 20 households participating in the PFES program were randomly selected from each village, resulting in a total of 330 households being drawn. Of these, 318 observations were suitable for modelling, with 12 excluded due to unreasonable outliers and missing variable values.

A semi-structured questionnaire was employed in the household survey. It aimed to gather data on households' understanding, and attitudes related to forest values, PFES implementation, and forest protection behaviours. It also sought information on the community's involvement in managing PFES payments, the policy's impact on households, and their views on its fairness and transparency. Additionally, it collected socio-economic and demographic data such as ethnicity, age, gender, education, land resources, and income.

3.3. Models and variables

3.3.1. Model specification

Based on the theoretical framework in **Figure 1**, this study investigates how the PFES policy, community-based forest management, and socio-economic characteristics of local households influence their perception, knowledge of PFES, and forest protection behaviours. The aim is to quantify the direct and indirect effects of these variables on forest protection behaviour. The structural equation model (SEM) is utilised for its ability to merge multiple regression analysis and factor analysis, enabling the determination of both direct and indirect effects of variables on forest protection behaviour (Rezaei-Moghaddam et al., 2020).

The model is written as follows:

$$B_i = \beta_0 + P_i\beta_1 + K_i\beta_2 + X_i\beta_3 + C_i\beta_4 + Z_i\beta_5 + \varepsilon_i \quad (1)$$

$$P_i = \Omega_0 + X_i\Omega_1 + C_i\Omega_2 + Z_i\Omega_3 + \mu_i \quad (2)$$

$$K_i = \theta_0 + X_i\theta_1 + C_i\theta_2 + Z_i\theta_3 + \alpha_i \quad (3)$$

where, B_i, P_i, and K_i represent the behaviour, perception, and knowledge of farmer household i, respectively, related to forest protection, PFES implementation and forest values, X_i represents the characteristics of the household, C_i the community involvement in forest management and PFES implementation and Z_i represents the PFES policy feature, and ε_i, μ_i, and α_i are the error terms.

Forest protection behaviour is quantified by the frequency of daily excursions households undertake for forest conservation activities, encompassing forest patrols, fire prevention, and surveillance of unlawful harvesting. The perception of forest values among households is evaluated based on the direct and indirect advantages derived from forests. Concurrently, the comprehension of PFES implementation among households is gauged by the forest owners' grasp of the policy implementation in their communities.

3.3.2. Variable selection

In this study, we denote the dependent variables as the following:

P—Perception towards the values of forests,

K—Knowledge of PFES implementation, and

B—Household pro-forest protection behaviour.

The independent variables including X_i, C_i and Z_i are described in **Table 2**. Particularly, based on the theoretical foundations of PES, theories of human behaviour in ecological conservation, and the theoretical framework of SES, we select independent variables for the model, particularly:

The characteristics of the household (X_i) are delineated based on the sustainable livelihoods framework (Ashley and Carney, 1999), encompassing human, social, financial, physical, and natural capital. Human capital is denoted by factors such as age (Age), gender (Gender), level of education (Education), ethnicity of the household head (ethnicity), size of the household (HH_size), and labour within the household (Labour). Social capital is indicated by the count of socio-political groups (Social_Network) in which household members are involved. The household's non-agricultural income and economic status signify financial capital. Agricultural land owned by the household represents natural capital. These variables have been widely utilised in prior studies to investigate their influence on participation in a PES program (Adhikari and Agrawal, 2013).

Community-based PFES implementation (C_i) serves as an indicator of community-level forest governance. The capacity for self-governance within a community is a key determinant of sustainable forest conservation (Ostrom, 2005). These elements are further detailed into the forest area managed by communities (Community_Forest), and the proportion of forest area under community management (Rate_Community_Forest). We also establish several variables to denote community participation in PFES payment implementation (Community_Involvement), and community-based forest management, which includes local households' perception of the efficacy of community monitoring, punitive and reward mechanisms (CFM_Enforment_Effectiveness), and the size of the community (Village_Size). These variables are postulated to influence individuals' engagement in forest protection activities within the PFES program framework (Brownson et al., 2019).

Table 2. Description of the model variables.

Variable name	Variable description with connections to the variables from the SES framework (McGinnis and Ostrom, 2014; Ostrom, 2009)
Dependent variables	
P	*P*—Perception towards the values of forests
K	*K*—Knowledge of PFES implementation
B	*B*—Household pro-forest protection behaviour
Independent variables	
Household's characteristics (X_i)—Actors (A2)	
Gender	Gender of household head (female = 0, male = 1)
Age	Age of HH
Ethnicity	Ethnicity of HH head
Education	Education level of HH
HH_size	Number of household members
Labour	Number of labourers in households
Eco_Condition	Economic condition of household
Nonfarm_Income	Whether households have nonfarm income or not
Land_Shortage	Shortage of agricultural land for cultivation
Social_Network	Social network connections of household
Community-based PFES management (C_i)—Community's governance system (GS4, GS5, GS6, GS8)	
Rate_Community_Forest	Percentage of forests managed by the community, at the community level
Community_Forest	Forest areas managed by the community
Village_Size	The number of households in the community
Community_Involvement	If households received the PFES payment via community payment (yes = 1 if fully received via community payment or partly received via community payment, otherwise = 0, fully received via direct household payment).
CFM_Enforcement_Effectiveness	The sense of people regarding the community punishment and reward regime
PFES characteristics (Z_i)—National governance system (GS5, GS8)	
Aver_PFES_Payment	Yearly PFES payment (2018–2020) received by a household
Receive_Full	Fully received yearly PFES payment
Equivalence_of_PFES_Payment	Equivalence of PFES payment compared to households' efforts in forest protection activities
Participate_PFES_Communication	Participation of HH in the PFES communication meetings
Fairness	Attitude toward fairness of PFES implementation
Demand for Transparency	Attitude toward transparency of PFES implementation

Actors (A2): Socioeconomic attributes, GS4: Property-rights systems, GS5: Operational-choice rules, GS6: Collective-choice rules, GS8: Monitoring and sanctioning rules (McGinnis and Ostrom, 2014; Ostrom, 2009).

Features of PFES implementation (Z_i) encompass variables like the annual PFES payment received by a household (Aver_PFES_payment), involvement in PFES communication meetings (Participate_PFES_Communication), and the household's receipt of the full yearly PFES payment (Receive_Full). These variables

are integral to the PFES program, which is predicated on the economic theory that fiscal incentives will motivate individuals to conserve forests (Wunder et al., 2018). Additionally, the fairness and transparency aspects of PFES are gauged through households' attitudes towards equity and the demand for transparency of PFES payment execution at the community level and the payment amount relative to households' forest protection efforts (Equivalence_of_PFES_Payment). These variables influence individuals' perceptions of forest protection value and their understanding of PFES implementation (Loft et al., 2017; Secco et al., 2014).

3.3.3. Research hypotheses

This study, based on its theoretical framework and SEM Equations (1)–(3), aims to test several hypotheses. Firstly, it posits that households' forest protection behaviour is positively influenced by their understanding of PFES implementation and their attitudes towards forest ecosystem values. Our study also examines how different factors, such as designed features of the payment for forest environmental services (PFES), community-based forest management, community involvement in PFES implementation, state-led social networks, and sociological characteristics of households, might affect people's decisions to protect forests.

Secondly, through Equations (2) and (3), the study aims to examine if variables associated with PFES attributes, community forest management mechanisms, and household socio-economic characteristics positively influence households' comprehension of PFES and their perception of forest ecosystem services' values. An exception is the Demand for Transparency variable, which is hypothesised to have a negative effect. The hypothesis is that the greater the demand for transparency in PFES implementation, the less favourable the attitude towards the policy.

The specific research hypotheses in each equation are summarised in **Table 3**.

Table 3. Summary of research hypotheses.

Explanatory Variables	**Dependent variables**		
	B (Household pro-forest protection behaviour)	**P (Perception towards the values of forests)**	**K (Knowledge of PFES implementation)**
P: Perception towards forest values	+		
K: Knowledge of PFES implementation	+		
Gender			+
Age			+
Education			+
Ethnicity		+	
HH_size	+		
Labour	+		
Eco_Condition	+	+	
Nonfarm_Income	-	+	+
Land_Shortage	-		
Social_Network	+	+	+

Table 3. (*Continued*).

Explanatory Variables	Dependent variables				
	B (Household pro-forest protection behaviour)	P (Perception towards the values of forests)	K (Knowledge of PFES implementation)		
Village_Size			+		
Rate_Community_Forest			+	+	+
Community_Forest			+	+	+
Community_Involvement				+	+
CFM_Enforcement Effectiveness			+		
Aver_PFES_Payment			+		
Receive_Full			+		+
Equivalence_of_PFES_Payment			+		
Participate_PFES_Communication				+	+
Fairness				+	+
Demand for Transparency				-	

"+" indicates that explanatory variable *X* improves dependent variable, while "-" means that explanatory variable *X* reduces dependent variable.

3.3.4. Techniques for running SEM model

In this SEM model, we concurrently model the dependent variables, namely the perception of forest value (*P*), knowledge of PFES implementation (*K*) and behaviour of forest protection (*B*). Given their endogenous nature, we employ the three-stage least squares (3SLS) method, which is apt for simultaneous equation models. 3SLS, superior to single equation methods like Indirect Least Squares (ILS) and two-stage least squares (2SLS), estimates parameters of all equations simultaneously, accounting for the correlation between endogenous dependent variables and Equation (1)'s error terms, thereby generating more efficient parameter estimates (Zellner and Theil, 1962).

To enhance and validate the model's fit, we employed several measures. Firstly, standard errors clustered at the village level were used to account for regional differences in the study sites. We also conducted VIF tests to check for multicollinearity among independent variables, with results rejecting the null hypothesis (**Table A1** in Appendix). For simultaneity issues, we performed the Hansen-Sargan test, the Breusch-Pagan Lagrange Multiplier Test, and the Likelihood Ratio (LR) Test and Wald Test, which confirmed the validity of overidentifying restrictions, the dependency of the three equations, and overall system homoscedasticity respectively (**Table A2**).

4. Results and discussions

4.1. Results

4.1.1. PFES implementation

Under Vietnam's PFES program legal framework, forest owners or those allocated land for forest conservation, including individuals, households, and communities, are eligible for payment for forest ecosystem services. The state-

established Forest Protection and Development Fund (PFES Fund) regulates transactions between these service providers and users, collecting payments from users and transferring them to the providers.

In the study area, PFES policy implementation at the community level involves three payment forms, varying by community participation in receiving, managing, and utilising payments. In Dien Bien, where most forests are community-managed, payments are made to groups or communities rather than individuals. In contrast, in Hoa Binh and Son La, payments are made either directly to individual providers or to communities who then distribute to individual providers. This variation reflects differing levels of community involvement in PFES implementation. According to Duong and de Groot (2018), some communities, despite direct payment, voluntarily establish a community fund, contributing 10% to 50% of the received amount for forest protection activities or equal distribution among all households.

4.1.2. The socioeconomic characteristics of households

Table 4's descriptive statistics depict the characteristics of farmer households in the study site. On average, households consist of nearly 5 members and 3 workers, predominantly from ethnic minorities like Tay, Muong, H'Mong, Dao, and Thai. The majority are poor or near-poor (average poverty score of 2.81/5). Agriculture is the main income source, yet 48% lack agricultural land and the average forest area eligible for PFES payment per household is only about 0.73 ha. Non-farm income is limited, with 58% of households having additional income from this source. Socially, about 63% of households participate in at least one social organisation.

Table 4. Descriptive statistics of the variables representing the household's characteristics.

Variable	Measurement unit	Mean	Standard deviation	Min	Max
Gender	1 if the head is male; 0 if otherwise	0.88	0.32	0	1
Age	In years	48.09	12.21	20	76
Education	Education level of HH, 0: Never go to school, 1: Primary school, 2: Secondary school, 3: High school, 4: College and higher	1.61	0.98	0	4
Ethnicity	0 if the HH is H'Mong/Dao; 1 if the head is Tay/Muong/Thai group; 2 if the head is other ethnic groups	0.22	0.41	0	1
HH_size	Number of HH member	4.76	1.74	1	11
Labour	Number of HH labour	2.86	1.22	0	8
Eco_Condition	1 if the household is poor; 2 if the household is near-poor; 3 if the household is moderate; 4 if the household is in good condition; 5 if the household is wealthy	2.82	0.85	1	5
Nonfarm_Income	1 if the household has income from non-farm activities; 0 if otherwise	0.58	0.50	0	1
Land_Shortage	1 if the household lacks agricultural land; 0 if otherwise	0.48	0.50	0	1
Social_Network	HH's total memberships of social-political organisations	0.63	0.56	0	3.5

Table 5 outlines community involvement in forest management and PFES implementation. Results indicate substantial community participation in forest management, with communities managing an average of 53% of forests, equating to an average area of 178 ha. The remaining forests are managed by households and individuals. In terms of PFES payment implementation, the rate of community involvement is approximately 39%.

Table 5. Descriptive statistics of the variables representing the community's involvement in forest management and PFES implementation.

Variable	Measurement unit	Mean	Standard deviation	Min	Max
Community_Forest	Hectare	177.82	187.49	0	720.27
Rate_Community_Forest	Percentage	52.78	35.78	0	100
Community_Involvement	Percentage	38.99	48.85	0	100
Village_Size	Households	164.98	92.39	71	400
CFM's Enforcement Effectiveness	Percentage	82.08	38.41	0	100

Table 6. Descriptive statistics of the variables representing the PFES characteristics.

Variable	Measurement unit	Mean	Standard deviation	Min	Max
Aver_PFES_Payment	Mil. VND	1.30	4.57	0	50.46
Receive_Full	1 if the household fully received the PFES payment; 0 if otherwise	1.00	0.06	0	1
Equivalence_of_PFES Payment	5—level Likert scale; 1 if the household strongly disagrees that PFES payment is matched with their forest protection effort; 5 if the household strongly agrees that PFES payment is matched with their forest protection effort	2.34	0.71	1	4
Participate_PFES_Communication	1 if the household participated in PFES implementation meetings; 0 if otherwise	0.73	0.47	0	1
Fairness	5—level Likert scale; 1 if the household strongly disagrees that PFES should pay all forest owners equally; 5 if the household strongly agrees that PFES should pay all forest owners equally.	3.76	1.24	1	5
Demand for transparency	5—level Likert scale; 1 if the household strongly disagrees that PFES payment needs to be checked and monitored by the people; 5 if the household strongly agrees that PFES payment needs to be checked and monitored by the people.	3.60	1.23	1	5

Table 6 presents the characteristics of the PFES policy. On average, a household received 1.3 million VND annually from PFES between 2018 and 2020, accounting for about 1.8% of local household income. Survey results also show that there is quite a large dispersion in the distribution of money from PFES with a standard deviation of 4.57 mil VND. The results also show that the average payment paid directly to households is smaller than those that is transferred via local communities but the differences are not statistically significant (See **Table A3** in Appendices). Additionally, most households received the full annual PFES amount. However, the payment for forest ecosystem services is deemed low relative to the effort expended on forest protection (average score of 2.34 on a scale of 1 to 5). Besides, local households do not appreciate the appropriateness of the PFES payment compared to their efforts to protect forests and have a higher demand for transparency in the distribution of this money.

Table 7 presents the policy outcomes, including enhanced perception of forest values, knowledge of PFES, and forest protection behaviour. Generally, forests are

perceived as valuable resources, with a measured value of 13.37 on a scale of 5 to 15. Knowledge of PFES implementation scores above average at 2.50 on a scale of 0 to 3. Forest protection behaviour, gauged by the annual working days spent on activities like patrolling and fire prevention, indicates active participation, with an average of nearly 68 days.

Table 7. Descriptive statistics of variables denoting households' perception of forest values, PFES knowledge, and forest protection behaviours.

Variable	Variable name	Measurement unit	Mean	Standard deviation	Min	Max
P	Perception towards forest values	A total score is calculated from five questions; for each question, score 1 if the household has a negative opinion, score 3 if the household has a positive opinion (see Appendix **Table A4** for the questions)	13.37	1.60	9	15
K	Knowledge of PFES implementation	Total score from three questions; 1 if the household has a correct answer, 0 if the household has an incorrect answer, and if the household answered not sure (see Appendix **Table A5** for the questions)	2.50	0.85	0	3
B	Household pro-forest protection behaviour	Number of forest protection daily trips of the household in a year	67.99	83.14	1	365

4.1.3. SEM models' results

To assess PFES's impact on households' forest protection behaviour, we scrutinise the SEM models' primary results, initially concentrating on model 1 (the main model), followed by model 2 (the supplementary model and use interactions between community involvement variables and a dummy variable of Dien Bien province where community forest management is a dominant forest management scheme) (see **Table 8**).

Table 8. Determinants of the households' perception, knowledge of forest values, PFES and their forest protection behaviours.

Variables	Model 1			Model 2		
	(*B*)	(*P*)	(*K*)	(*B*)	(*P*)	(*K*)
Perception towards forest values (*P*)	0.790**			0.776*		
	(0.396)			(0.472)		
Knowledge of PFES implementation (*K*)	0.102			0.064		
	(0.307)			(0.288)		
Gender			0.022			0.092
			(0.163)			(0.152)
Age			0.007*			0.010**
			(0.004)			(0.004)
Education			0.152*			0.160*
			(0.094)			(0.091)
Ethnicity		−0.128			−0.072	
		(0.174)			(0.186)	

Table 8. (*Continued*).

Variables	Model 1			Model 2		
	(*B*)	(*P*)	(*K*)	(*B*)	(*P*)	(*K*)
HH_size	−0.006			−0.003		
	(0.038)			(0.038)		
Labour	0.123			0.121		
	(0.106)			(0.107)		
Eco_Condition	0.017	0.053		0.054	0.020	
	(0.181)	(0.169)		(0.173)	(0.165)	
Nonfarm_Income	−0.326	−0.060	0.148*	−0.332*	−0.040	0.184**
	(0.215)	(0.225)	(0.083)	(0.194)	(0.231)	(0.085)
Land_Shortage	0.085			0.085		
	(0.128)			(0.130)		
Social_Network	0.079	0.328*	−0.096	0.115	0.320*	0.045
	(0.264)	(0.187)	(0.105)	(0.279)	(0.186)	(0.113)
Village_Size	0.001			0.001		
	(0.001)			(0.001)		
Rate_Community_Forest	0.004	−0.004	0.004*	0.010	−0.009*	−0.005
	(0.003)	(0.003)	(0.002)	(0.007)	(0.005)	(0.004)
Rate_Community_Forest_DB				−0.008*	0.008*	0.011***
				(0.004)	(0.004)	(0.003)
Community_Forest	−0.000	0.000	−0.000	−0.002	0.002	0.001
	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)	(0.000)
Community_Forest_DB				0.003*	−0.003**	−0.001
				(0.002)	(0.001)	(0.000)
Community_Involvement		−0.211	0.292**		−0.203	0.498***
		(0.245)	(0.142)		(0.257)	(0.106)
CFM_Enforcement Effectiveness	0.574***			0.573***		
	(0.140)			(0.145)		
Aver_PFES_Payment	0.027**			0.029**		
	(0.012)			(0.015)		
Receive_Full	1.366		1.481***	1.443		1.347***
	(1.462)		(0.182)	(1.496)		(0.122)
Equivalence_of_PFES_Payment	−0.107			−0.104		
	(0.107)			(0.112)		
Participate_PFES_Communication		0.142	0.234*		0.148	0.163
		(0.143)	(0.120)		(0.134)	(0.125)
Fairness		0.032	−0.015		0.031	−0.001
		(0.048)	(0.053)		(0.049)	(0.053)
Demand for Transparency		−0.183***			−0.183**	
		(0.071)			(0.083)	

Table 8. (*Continued*).

Variables	Model 1			Model 2		
	(*B*)	(*P*)	(*K*)	(*B*)	(*P*)	(*K*)
Cons.	−9.400*	13.738***	−0.003	−9.390	13.810***	−0.143
	(5.693)	(0.776)	(0.350)	(6.817)	(0.753)	(0.342)
Number of observations	318			318		
Log likelihood	-1.5×10^3			-1.4×10^3		
Wald chi2	87.27	21.51	53.73	83.68	27.18	75.88
Prob > chi2	0.000	0.018	0.000	0.000	0.007	0.000
R-squared	−0.898	0.061	0.144	−0.845	0.077	0.192

Simultaneous equations model: estimation via three-stage least squares (3SLS) with the use of robust standard errors clustered at the village level; the standard error in parenthesis. * significant at 10%; ** significant at 5%; *** significant at 1%. Model 2 is run using the interaction between communitForest, Rate_Community_Forest and the province dummy of Dien Bien, whereas model 1 does not use these interaction variables.

Model 1's findings

In terms of factors influencing households' forest protection behaviour (*B*), the model results indicate that:

- Perception of forest values (*P*) directly and significantly influences households' forest protection behaviour (*B*).
- Both the average PFES payments and the effectiveness of CFM's enforcement mechanism positively impact forest protection behaviour, indicating that economic incentives from PFES policy and effective CFM enforcement motivate forest protection.
- Other variables, including socio-economic factors and knowledge about PFES implementation (*K*), were not statistically significant.

In terms of factors influencing households' perception of forest values (K), the model identifies two significant variables: Demand for Transparency (negative effect) and social network (positive effect). Greater transparency demand in PFES payment implementation correlates with lower attitudes towards forest value. This suggests that enhanced transparency can boost policy trust, thereby improving attitudes towards forest protection goals. The positive effect of social networks implies that well-connected households have more access to information about forest values and protection benefits, thereby enhancing their perception of forest value. The findings align seamlessly with the theoretical expectations (Bendtsen et al., 2021; Carter et al., 2018).

The research results show that age, education, non-agricultural income, PFES communication participation, community forest rate, community involvement, and full PFES receipt as significant contributors to PFES implementation understanding. Diverse income households, active in policy dialogues and in regions with substantial community-managed forests, demonstrate superior PFES policy comprehension. Full payment, policy dialogue participation, and community-based payment emerge as the most potent factors. These insights validate the initial hypothesis and affirm previous studies.

Model 2's findings

Beyond model 1, we implemented model 2 to delve deeper into the impact of forest allocation to communities on local attitudes, knowledge, and forest conservation practices. This model incorporates interaction variables, including the extent of community forests, the proportion of community forest area, and a dummy variable for Dien Bien province. The rationale is that in Dien Bien, the majority of the forestland is community-managed to minimize transaction expenses associated with PFES and general forest protection policies.

Model 2's results underscore the complex impact of community-based forest management. Specifically, while community-managed forest area positively affects conservation behavior, a larger proportion negatively impacts it. This suggests that the effects of community forest management are multifaceted, requiring consideration of other factors like community involvement and CFM enforcement efficacy.

Predominantly, the explanatory variables with significant effects validate the research hypotheses, with the exception of the community forest rate's impact on forest protection behaviour, which contradicts the hypothesis. This variable's influence necessitates meticulous consideration in conjunction with other variables in community forest management. Furthermore, certain variables, such as PFES implementation knowledge (*K*) and socio-economic household characteristics (e.g., household size, labour, economic conditions, non-agricultural income, and land shortage), were hypothesised to positively influence forest protection behaviour, but the model results lacked statistical significance.

4.1.4. Robustness check

In order to validate the reported findings, we conducted a robustness test using the bootstrap method with 1000 iterations and a cluster option at the village level in STATA. The outcomes, displayed in **Table A6**, corroborate the initial results of models 1 and 2, affirming the reliability of the results presented in **Table 8**.

4.2. Discussions

This research is designed to assess the impact of PFES on household forest conservation practices. Consequently, our discourse is centred on evaluating the efficacy of policy measures intended to foster forest conservation. Based on the findings, it's plausible to assert that the PFES implemented in the Northwest region constitutes a forest conservation mechanism grounded in a quasi-PES strategy. This PES policy employs a blend of economic incentives (economic payment) and non-economic mechanisms, encompassing community participation and state-influenced approaches, to encourage local households to safeguard forests that is similar to the findings of several previous studies (McElwee et al., 2014; Wunder et al., 2018). Our discussion focuses on the impact of these policy aspects on changing people's knowledge, attitudes and behaviours toward forest protection.

Firstly, in terms of economic incentives, it is indeed the case that at the household level, the policy has engendered a change in people's behaviour through small but statistically significant economic incentives. However, given that the low payment contributes to only 1.8% of households' income and is not proportionate to

the efforts exerted in forest protection, the influence of PFES payment is less pronounced than that of CFM's enforcement effectiveness and the local populace's perception of forest values. Consequently, it is reasonable to contend that despite the government's efforts to augment the payment level for forest protection (Nguyen, Ha, et al., 2020), this adjustment remains minimal (Nguyen, Ancev, et al., 2020) and has not transitioned the policy approach towards a market mechanism as advocated by Wunder (2015).

Secondly, with respect to non-economic mechanisms, the PFES policy employs community institutions and state-led social networks to bolster its effectiveness in fostering forest protection attitudes and behaviours among locals, compensating for the minimal economic incentive from modest payments. The integration of community mechanisms into the PFES policy is predicated on the theory that the promotion of community institutions will positively impact forest protection (Gibson et al., 2005). Nonetheless, community governance is not a universal solution, and its efficacy is contingent upon the local context and its interaction with the specific PES program (McGinnis and Ostrom, 2014; Ostrom, 2007). The research indicates that the PFES policy has achieved partial success in engaging communities in enhancing locals' attitudes towards forest values, their understanding of PFES implementation, and their forest protection behaviour if it can stimulate community forest management mechanism because simply assigning forests to the community for management and transferring PFES payments to households via local communities will not effectively improve people's awareness of forest value or their forest protection behaviour.

The interesting finding of this article as previously argued by Ostrom (2005) is the importance of community self-governance capacity in community-based forest management. When community self-governance regimes of monitoring, reward, and punishment mechanisms in forest management are effectively activated, community participation in PFES implementation and forest management does yield positive results. Research results show that the effectiveness of the community-based forest management mechanism (CFM_Enforcement Effectiveness) has a strong, positive and statistically significant influence on the forest protection behaviour of local people. This aligns with the recent findings of Duc et al. (2021) arguing that PFES can enhance people's attitudes towards forest values through community mechanisms and active community participation in PFES implementation. Stable PFES policy financing can stimulate community participation in policy implementation and the development of community-based reward and punishment regulations. These community mechanisms enhance people's awareness of the values of forests. Nilsson et al. (2016) make similar arguments, asserting that the community mechanism has been effective in monitoring forest behaviour and strictly addressing violations of community regulations. The study's results indicate that merely allocating forests to the community for management and implementing payment for forest ecosystem services through the community does not clearly improve people's attitudes about forest values or promote changes in people's forest protection behaviour. Improvements are only achieved when the PFES policy can establish a community forest management mechanism with an effective monitoring, reward, and punishment system.

In terms of the efficacy of social networks, the policy's notable achievement lies in its utilisation of state-led social organisations to enhance people's understanding of forest values. PFES conducts communication activities via these social associations. In underprivileged regions like Vietnam's Northwest, local households maintain strong ties with state-led social organisations, such as Women, Farmers, and Youth Unions, which play a crucial role in facilitating people's access to resources for agricultural production and economic development, including credit and advanced production techniques. Consequently, through the communication activities of these organisations, people's awareness of forest values can be elevated, and this enhancement is anticipated to guide their behaviour towards the objective of forest protection under the PFES policy. This outcome corroborates To and Dressler's (2019) argument that PFES serves as a tool for the state, via its social organisations, to retain control over the forestry sector in general, and to accomplish the goal of forest protection in particular (To and Dressler, 2019).

5. Conclusions and recommendations

The study findings indicate that the implementation of PFES in Vietnam's Northwest region, through engagement with local household social networks, has enhanced local individuals' understanding of forest values and, ultimately, their forest conservation behaviours. This policy has also generated economic incentives to modify people's behaviour. Moreover, this policy also achieved certain successes in promoting community-based forest management in implementing PFES. This success does not come by simply handing over forests to the community to manage and making payments through the community. The important factor that brings success, argued by Ostrom, is that the policy can stimulate and promote the self-governance capacity of local communities, particularly by putting the community's enforcement mechanism into practice.

The study suggests that PFES policy needs enhancement to adequately and transparently compensate for forest protection efforts and provide greater economic benefits to locals. This would strengthen economic incentives for forest protection and support livelihoods and economic development for disadvantaged ethnic minorities. For effective community-based forest management, more efforts are needed to develop and promote its monitoring, reward, and punishment regulations.

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Appendix

Table A1. Multicollinearity test for structural equations model.

Variable	Model 1		Model 2	
	VIF	**1/VIF**	**VIF**	**1/VIF**
Gender	1.13	0.88	1.15	0.87
Age	1.48	0.68	1.49	0.67
Education	1.23	0.81	1.23	0.81
Ethnicity	1.80	0.56	2.05	0.49
HH_size	1.73	0.58	1.74	0.57
Labour	1.94	0.52	1.98	0.51
Eco.Condition	1.34	0.75	1.34	0.75
Nonfarm_Inc.	1.12	0.89	1.12	0.89
Land_shortage	1.17	0.85	1.19	0.84
Social_Network	1.51	0.66	1.59	0.63
Rate_Community_Forest	2.26	0.44	7.77	0.13
Rate_Community_Forest_DB			9.31	0.11
CommunityForest	2.22	0.45	5.76	0.17
CommunityForest_DB			4.07	0.25
Aver_PFES_payment	1.32	0.76	1.40	0.71
Receive_full	1.05	0.95	1.06	0.94
Equivalence_of_PFES payment	1.20	0.83	1.23	0.81
Participate_PFES_Communication	1.22	0.82	1.23	0.81
Fairness	1.11	0.90	1.12	0.89
Transparency	1.21	0.83	1.21	0.83
Community_involvement_D	1.18	0.85	1.55	0.65
Enforcement_effectiveness	1.22	0.82	1.24	0.81
VillageSize	1.85	0.54	2.06	0.49
Mean	**1.44**		**2.34**	

Table A2. Tests for structural equations model 1 & model 2.

Model	Test	$chi^2(3)$	Prob. > chi^2
(1)	Tests of overidentifying restrictions (Hansen-Sargan test)	2.9178	0.4044
	Tests of independent equations (Breusch-Pagan Lagrange Multiplier Test)	146.6154	0.0000
	Tests of Overall System Heteroscedasticity (Likelihood Ratio LR Test)	5.9214	0.1155
	Tests of Overall System Heteroscedasticity (Wald Test)	5.5402	0.1363
(2)	Tests of overidentifying restrictions (Hansen-Sargan test)	5.8820	0.1175
	Tests of independent equations (Breusch-Pagan Lagrange Multiplier Test)	11.5024	0.0093
	Tests of Overall System Heteroscedasticity (Likelihood Ratio LR Test)	5.7502	0.1244
	Tests of Overall System Heteroscedasticity (Wald Test)	5.5850	0.1336

Table A3. Average annual PFES payment by two forms of payment.

Aver_PFES_Payment (Mil. VND)	Direct payment to households (1)	Indirect payment via community involvement (2)	Difference (2)-(1)
Mean	1.004	1.774	0.77^{ns}
Standard deviation	3.458	5.882	
Min	0.000	0.000	
Max	46.284	50.459	

Note: ns—in-significant at 10% level.

Table A4. Questions for calculating variable *Y*1.

No.	Content	Household's answer			Point
		Agree	Not sure	Disagree	
1	The forest needs to be strictly protected and should not be exploited (Agree means 3 points; disagree means 1 point; not sure means 2 points)				
2	Forests are an important source of income for local people, so people have to be allowed to harvest firewood, timber and forest products (Agree means 1 point; disagree means 3 points; not sure means 2 points)				
3	Community forests are owned by the community, so anyone can exploit them (Agree means 1 point; disagree means 3 points; not sure means 2 points)				
4	Forest should not be exploited because protecting the forest will bring greater benefits to my family (e.g., non-timber forest products exploitation, tourism development, etc.) (Agree means 3 points; disagree means 1 point; not sure means 2 points)				
5	Forest protection is very important because forests protect soil, water resources (Agree means 3 points; disagree means 1 point; not sure means 2 points)				

Table A5. Questions to calculate variable *Y*2.

No.	Condition for receiving PFES payment	Household's answer			Point
		Yes (1)	No (0)	Not sure (0)	
1	Household's forest needs to be in the eligible forest area for PFES payment (Yes is the correct answer)				
2	Household's forest needs to be covered (Yes is the correct answer)				
3	Forest protection results need to be checked by authorities (Yes is the correct answer)				

Table A6. Determinants of the households' perception, knowledge of forest values, PFES and their forest protection behaviours using bootstrap.

Variables	Model 1			Model 2		
	*Y*3 (*B*)	*Y*1 (*P*)	*Y*2 (*K*)	*Y*3 (*B*)	*Y*1 (*P*)	*Y*2 (*K*)
Perception towards forest values (*Y*1)	0.790**			0.776*		
	(0.358)			(0.461)		
Knowledge of PFES implementation (*Y*2)	0.102			0.064		
	(0.286)			(0.205)		
Gender			0.022			0.092
			(0.145)			(0.131)
Age			0.007*			0.010**
			(0.004)			(0.004)

Table A6. (*Continued*).

Variables	Model 1			Model 2		
	***Y3* (*B*)**	***Y1* (*P*)**	***Y2* (*K*)**	***Y3* (*B*)**	***Y1* (*P*)**	***Y2* (*K*)**
Education			0.152**			0.160*
			(0.072)			(0.093)
Ethnicity		−0.128			−0.072	
		(0.136)			(0.173)	
HH_size	−0.006			−0.003		
	(0.041)			(0.041)		
Labour	0.123			0.121		
	(0.101)			(0.102)		
Eco_Condition	0.017	0.053		0.054	0.020	
	(0.154)	(0.137)		(0.154)	(0.146)	
Nonfarm_Income	−0.326	−0.060	0.148*	−0.332*	−0.040	0.184**
	(0.202)	(0.204)	(0.078)	(0.181)	(0.214)	(0.076)
Land_Shortage	0.085			0.085		
	(0.112)			(0.123)		
Social_Network	0.079	0.328*	−0.096	0.115	0.320*	0.045
	(0.225)	(0.175)	(0.097)	(0.216)	(0.179)	(0.108)
Village_Size	0.001			0.001		
	(0.001)			(0.001)		
Rate_Community_Forest	0.004	−0.004	0.004*	0.010	−0.009*	−0.005
	(0.003)	(0.003)	(0.002)	(0.007)	(0.005)	(0.004)
Rate_Community_Forest_DB				−0.008*	0.008*	0.011***
				(0.004)	(0.004)	(0.003)
Community_Forest	−0.000	0.000	−0.000	−0.002	0.002	0.001
	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)	(0.000)
Community_Forest_DB				0.003*	−0.003**	−0.001
				(0.002)	(0.001)	(0.000)
Community_Involvement		−0.211	0.292**		−0.203	0.498***
		(0.223)	(0.138)		(0.243)	(0.110)
CFM_Enforcement Effectiveness	0.574***			0.573***		
	(0.146)			(0.149)		
Aver_PFES_Payment	0.027**			0.029**		
	(0.011)			(0.014)		
Receive_Full	1.366		1.481***	1.443		1.347***
	(1.354)		(0.191)	(1.347)		(0.132)
Equivalence_of_PFES_Payment	−0.107			−0.104		
	(0.103)			(0.101)		
Participate_PFES_Communication		0.142	0.234*		0.148	0.163
		(0.123)	(0.123)		(0.126)	(0.118)
Fairness		0.032	−0.015		0.031	−0.001
		(0.036)	(0.041)		(0.037)	(0.045)

Table A6. (*Continued*).

Variables	Model 1			Model 2		
	***Y3* (*B*)**	***Y1* (*P*)**	***Y2* (*K*)**	***Y3* (*B*)**	***Y1* (*P*)**	***Y2* (*K*)**
Transparency		−0.183***			−0.183**	
		(0.068)			(0.087)	
Cons.	−9.400*	13.738***	−0.003	−9.390	13.810***	−0.143
	(5.435)	(0.723)	(0.215)	(6.176)	(0.638)	(0.254)
Number of observations	318			318		
Log likelihood	-1.5×10^3			-1.4×10^3		
Wald chi2	67.52			62.79		
Prob > chi2	0.000			0.000		
R-squared	−0.898	0.061	0.144	−0.845	0.077	0.192

Simultaneous equations model: estimation via three-stage least squares (3SLS) with the use of robust standard error bootstrapped with 1000 replications and clustered at the village level in parenthesis. * significant at 10%; ** significant at 5%; *** significant at 1%. Model 2 is run using the interaction between communitForest, Rate_Community_Forest and the province dummy of Dien Bien, whereas model 1 does not use these interaction variables.