Livelihood and Environmental Impacts of Payments for Forest Environmental Services: A Case Study in Vietnam

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Abstract: Payments for ecosystem services (PES) is widely employed in various settings; however, whether, and in what contexts, PES programs achieve their objectives by improving local livelihoods and conservation goals is still being debated. This paper aims to evaluate the impacts of payments for forest environmental services (PFES) policies on livelihoods and the environment using propensity score matching of data on 725 systematic randomly selected households in the buffer zones of seven protected areas (PAs) of Quang Nam and Thua Thien Hue provinces in Central Vietnam and data from the General Statistics Office and Landsat. The findings indicate that the PFES policy has some positive effects on economic and environmental issues for different groups. In terms of financial capital, the study found that poor households with PFES have slightly higher income than what they would have had they not participated in PFES. The difference in total income between poor households with and without PFES, however, was statistically insignificant, while the income of non-poor households with PFES was significantly higher than those without PFES. In addition, PFES households are likely to have more consumption expenditure for their daily living and better access to loans from various microfinance sources compared to those without PFES. The PFES policy has provided slight changes in the forest and forest cover and reduced natural forest loss between the pre-PFES and PFES periods. The findings of this study contribute to designing future PFES policies that can better distribute benefits to all household groups as well as harmonize social and natural capital.

Keywords: financial capital; natural capital; livelihood; payments for forest environmental services; propensity score matching

1. Introduction

Since the enactment of the first payments for ecosystem services (PES) schemes, the concept has become more popular in the global environmental development discourse. The growing policy, focusing on the value of ecosystem services, can be considered as both a promotion of ecosystem services [1] and a social movement for ecological management [2]. The crucial roles of ecosystem services (ES) were significantly reflected in the global Sustainable Development Goals (SDGs), of which at least seven out of 17 are closely related to ES. While PES schemes do not focus on improving livelihoods, there has been a growing concern about the impact on the livelihoods of participants (i.e., sellers) and nonparticipants of these schemes, especially in relation to poverty [3–6].

The impact of PES generally and payments for forest environment services (PFES) in particular on multiple objectives is an ongoing debate [7,8], and few studies have examined the synergies between impact on livelihood and PES [4,9–11]. By contrast, other studies have revealed that PES schemes have no impact or even a negative impact on livelihood outcomes [12–14]. Opponents view PES
as a neoliberal policy with negative indications for vulnerable and marginalized groups, for whom PES schemes are not well designed and property rights are not fully taken into account [4,15–19]. Similarly, quantitative empirical evidence verifying the correlation between PES and poverty reduction as the most common objective remains limited and mixed [20,21]. The extent to which the poor actually benefit from being involved in PES programs seems to be case-specific, with findings reporting both positive [4,22] and negative [23,24] effects; therefore, the controversy over PES and livelihood requires a cross-sectional evaluation with a full range of actors such as ES providers and direct users, time scales [3,16], and systematic evaluation [25,26].

The PFES policy was piloted in Vietnam from 2008 to 2010 based on Decision 380/QD-TTg, dated 10 April 2008, by the prime minister, with the majority of financial support from the United States Agency for International Development (USAID) through the technical support and implementation of Winrock International. After successfully piloting the PFES policy in the first two provinces, Lam Dong and Son La, the government of Vietnam (GoV) conducted an interim assessment and proposed institutionalizing the PFES policy for the whole country by issuing Decree 99/2010/ND-CP, by the prime minister of GoV, dated 24 September 2010. There are five types of forest environmental services (FES) indicated under Decree 99. However, only three types of PFES had been implemented at the time this study was conducted: Soil protection, restriction of erosion, and sedimentation of reservoirs, rivers and streams; regulation and maintenance of water sources for production and social life; and protection of natural landscape and conservation of biodiversity of ecosystems for tourism services.

The PFES policy was operated and managed by the Forest Protection and Development Fund at the central and provincial levels. After 10 years of implementation (2008–2018), one Vietnam Forest Protection and Development Fund (Central Fund) and 44 provincial Forest Protection and Development Funds (FPDFs) were established to manage the PFES policy [27]. After 10 years of operation, 387 hydropower companies, 150 clean water companies, and 76 tourism companies had signed contracts, paying VND 10,026.176 billion (equivalent to approximately US $442 million) into a PFES Trusted Fund of the Central and Provincial FPDFs. By the end of 2017, there were 450,108 ethnic minority households participating in and benefiting from the PFES policy, of which 196,380 were poor households [27], with income lower than VND 700,000 ($35) per person/month, and 72,834 were near-poor households, with income lower than VND 1,000,000 VND ($50) per person/month. This indicator was based on Decision 59/2015/QD-TTg of the prime minister of GoV on the new poverty line, promulgated on 19 November 2015.

The operational framework of the Vietnamese PFES policy is illustrated in Figure 1. Different from those in previous studies [21,28–30], this framework consists of six layouts of the PFES policy implementation process, from activities to outcomes.

- The first layout of the framework shows the related activities of FESs such as demand–supply transactions embedded in payments for using power and water from hydropower companies. This layout also indicates the enabling conditions such as regulations, capacity building, governing, monitoring, and evaluation, following Decree 99/2010/ND-CP on PFES policy implementation. These activities are being conducted by different FES stakeholders (indirect FES users) as inputs (layout 2) for water supply and hydropower, and by tourism companies (direct FES users) to operate their businesses.

- Based on the enabling conditions, including contract arrangements, these direct FES users collect FES payments and transfer 100% of those payments to the central and/or provincial Forest Protection and Development Funds (FPDFs) under Ministry of Agriculture and Rural Development (MARD) or Department of Agriculture and Rural Development (DARD). The collected FES payments, as intermediate outputs (layout 3), are managed by government trust fund managers. These managers are entitled to reserve up to 15% of the total payment (10% for administrative costs and 5% for forest protection in the case of natural disaster or drought).

- Through subcontracting arrangements with FES providers, trust fund managers (from central and provincial FPDFs) transfer the remaining 85% of the collected FES payment to FES providers...
who are individual household (HH) forest owners, organization forest owners (e.g., commune people’s committees, companies, forest management units, youth unions, etc.), and/or village, community, or household group forest owners. FES providers receive these FES payments, one of the short-term livelihood outcomes of the PFES policy (layout 4), to better manage, protect, and develop their respective forest areas, and to contribute to building financial capital for their families, enhancing natural capital and strengthening social capital.

- Consequently, it is expected that with FES payments, HH income (financial capital) of FES providers will be increased and forest environmental services (natural capital) will be enhanced. This is the expected medium-term outcome of the PFES policy (layout 5). As a result, the PFES policy would contribute to improved well-being, poverty reduction, social development, and a healthy environment as long-term outcomes (layout 6). Eventually, the healthier environment/nature will provide better ecosystem services for humans (including indirect and direct FES users from levels 1 to 6 of Figure 1) and other organisms.

Figure 1. Payments for forest environmental services (PFES) policy and its operational framework. HH, household; forest management Unit (FMU); Ministry of Agriculture and Rural Development (MARD); Department of Agriculture and Rural Development (DARD).
Although the PFES policy has been implemented in Vietnam as a whole and Quang Nam (QN) and Thua Thien Hue (TTH) provinces of Central Vietnam in particular for more than six years, there have been very few studies examining the impact of this policy on local livelihoods and the environment.

This paper aims to examine whether the PFES policy can enhance livelihood outcomes in terms of the financial and natural capital of local people in the buffer zones of protected areas (PAs) by addressing the following research questions: (1) What are the impacts of the existing PFES policy on financial and natural capital? (2) What are the implications for the design of PFES interventions? The paper contributes to filling the knowledge gap in the literature on PES and livelihood interaction by determining the impacts of the PFES policy on the two dimensions of financial and natural capital in the context of a developing country. Moreover, the evaluation method, and propensity score matching, is first applied in this paper to estimate the livelihood impacts of the PFES policy in Vietnam, which can then be generalized to other relevant studies on PES schemes and livelihood outcomes.

Additionally, the findings derive implications for policymakers, researchers, and local government officials in terms of implementing the PFES policy. The paper begins with an introduction, which is followed by a discussion of the literature on the causality between PFES and livelihood and environmental outcomes. The other four sections comprise the methodology, results, discussion, and conclusion.

2. Livelihood and Environmental Impacts of PES

Although robust evidence on financial and natural capital impacts of PES schemes is lacking in the literature [31], this study attempted to highlight the impact from existing studies, concluding that PES schemes have mixed effects on financial and natural capital (Table 1).

2.1. PES Schemes Have a Positive Impact on Financial Outcomes at the Household Level

Receiving payments, increasing household income, and diversifying economic activities and annual expenditure are the positive impacts of PES on financial capital [11,16,31–33]. The potential impacts of PES on financial capital improvement rest upon payments to households and/or community groups [11,34,35]. However, 90% of studies indicate that such payments contribute a small percentage (approximately 2–5%) to total income, and the remaining 10% show that they contribute up to 50% of household income, which confirms the highly variable nature of PES contributions to income [3,4,26]. In some cases, payments have been allocated to local communities or households, but most studies (approximately 85%) indicate that payment was made to small and medium landowners, which partly confirms the benefits of PES for poor household [26,36] and for livelihood improvement and poverty reduction [3,10,12,14,36–38]. The studies of Grieg-Gran, Porras, and Wunder [3] and Pagliola, Arcenas, and Platais [4] showed that a PES scheme can improve the security of land tenure and tree planting on marginal land, which then contributes to the increased household income. Pagliola, Arcenas, and Platais [4] and Molnar et al. [39] indicated that PES participants received payments for changing their land use or improving their land use practices so that they could enhance their household income. Similarly, Pagliola, Arcenas, and Platais [4] and Tacconi et al. [40] indicated that PES enhances the availability of non-timber forest products (NTFPs) and access to land for cultivation.

PES also contributes to household income by diversifying household economic activities [26]. Various studies have indicated that although PES payments are insufficient to enhance and diversify sources of household income, the PES scheme provides a number of revenue streams, including work in forest protection and other small forest services [16,41–43]. Moreover, Wunder [11] and Narloch, Pascual, and Drucker [34] argued that PES enhances accessibility to functioning markets and increases household wealth, which are important conditions for diversifying income-generating activities.

Estimations of the impacts of PES schemes on household expenditures and consumption were made by Hegde and Bull [16] and Ma et al. [44]. These studies confirmed that households that participate in PES schemes sustained more daily expenses than if they had not participated in such programs.
2.2. Natural Capital Impacts of PES

Landell-Mills and Porras [10] created a list of the positive and negative effects of PES schemes on natural capital, where the natural benefits were increased forest value, land tenure, soil fertility, biodiversity, and water resources. By contrast, PES schemes may cause potential risks in terms of natural capital, such as increased competition for resources, increased forest degradation, and loss of biodiversity. The benefits of PES have been revealed in many studies, such as increased land tenure security [31], financial gain, income stability, and diversification [4,6]. Furthermore, PES can improve health benefits by stabilizing sources of drinking water [6], sustaining cultural opportunities and social networks, strengthening institutions, and fostering economic growth [45]. Conversely, PES can also have a negative impact on livelihood. According to Pagiola, Arcenas, and Platais [4] and Wunder [11], the implementation of PES reduced resource-extractive activities, causing lower local production and increased prices and levels of market dependency, and may lead to social tensions from an unequal appropriation of benefits.

Table 1. Financial and natural capital impacts of payments for ecosystem services (PES).

| Authors                        | Case Studies                                      | Financial Capital                                      | Natural Capital                                      |
|--------------------------------|---------------------------------------------------|--------------------------------------------------------|------------------------------------------------------|
| Hegde and Bull [16]            | PES project in Mozambique                          | • Increasing cash income                                 | • Uncertain effect on forest use                      |
|                                |                                                   | • Incurring more consumption expenditure                |                                                       |
|                                |                                                   | • Payment for PES may be an extra income source for poor households |                                                       |
|                                |                                                   | • Increasing net farm income by reducing opportunity costs |                                                       |
|                                |                                                   | • Division of benefits with the landlord                |                                                       |
| Pagiola, Arcenas, and Platais [4] | Latin America                                 |                                                       | • Affecting land tenure and renting                   |
| Clements and Milner-Gulland [46] | PES and forest conservation in northern Cambodia | • Improving household well-being                        | • Reducing deforestation rates                        |
|                                |                                                   | • Changing the poverty rate                             | • Security of access to land and forest resources     |
| Zheng et al. [47]              | Paddy Land-to-Dry Land program in Beijing, China  | • Increasing income from agriculture production due to reduced input costs | • Protecting water quality and quantity for the only surface water reservoirs |
| Bremer, Farley, and Lopez-Carr [48] | Payments for ecosystem services in the Ecuadorean Andes | • Higher or more stable income                         | • Reduced burning/grazing                            |
|                                |                                                   |                                                       | • Improving agroforestry and conservation             |

3. Materials and Methods

3.1. Study Area

We used a dataset collected by the Centre for Rural Development in Central Vietnam (CRD) and its implementing partners, who were contracted by the USAID Green Annamites Project to conduct a livelihood assessment. A household survey that was part of this assessment was conducted in 25 villages within 12 selected communes located in the buffer zones of the seven PAs of Quang Nam (QN) and Thua Thien Hue (TTH) provinces of the Central Annamites Landscape: Song Thanh Nature Reserve (STNR), Ngoc Linh Nature Reserve (NLNR), Elephant Nature Reserve (ENR), and Quang Nam Sao La Nature Reserve (QN-SLNR) of Quang Nam province; and Phong Dien Nature Reserve (PDNR), TT Hue Sao La Nature Reserve (TTH-SLNR), and Back Ma National Park (BMNP) of Thua Thien Hue province (Figure 2). The Central Annamites region covers over 10,858 km² of core forest.
that is home to threatened species such as the red-shanked douc langur and Pseudoryx nghetinhensis (wwf.org.la/projects/ourlandscapes/). QN and TTH provinces, part of this landscape, make up the majority of the remaining 20% of healthy, natural forests. The forests in these two provinces are highly biodiverse in terms of their gene pools, species diversity, community structures, and ecosystem types, and are home to thousands of species. However, these forests are increasingly threatened by deforestation and forest degradation [49].

![Image of a map showing the locations of seven nature reserves and assessment.](image)

**Figure 2.** Locations of seven nature reserves and assessment.

The total area of the seven PAs is 452,284 ha, with 238,399 ha of the core zone and 213,885 ha of the buffer zone. The PFES scheme was implemented in these two provinces beginning in 2012. The total area of the seven PAs eligible for FES payment in 2016 was 134,913 ha, accounting for 30% of the PAs.

### 3.2. Data Collection and Analysis

#### 3.2.1. Sampling and Sample Size

The multiple-stage sampling method used in the present study consisted of cluster and stratified sampling, and systematic random sampling was used to address the sampling needs [50]. Specifically, cluster and stratified sampling methods were used to select the study communes, and systematic random sampling was applied to select the sampled households (HHs), indicated in Table 2.

For commune sampling, first, cluster sampling was used to select the communes from the districts where the PAs are located within QN and TTH provinces. The review of secondary data indicated that seven PAs (QN Saola, TTH Saola, Song Thanh, Ngoc Linh, Elephant, Phong Dien, and Bach Ma) are
mainly located within the territory of 10 districts. There are 58 communes in these districts, in close proximity to the PAs. Stratified sampling was then used to sample 12 of the 58 communes based on five selection criteria and the defined assessment scale of 100 points as follows: (i) High poverty rate = 30 points; (ii) low forest = 10 points; (iii) high population of ethnic minority = 10 points; (iv) large forest area covered by nature reserve = 30 points; and (v) high level of vulnerability = 20 points. The poverty rate and forest areas had higher point values compared to the others due to their weighting roles in this study.

Criteria for estimating the score for each commune were developed. Among the 58 communes, 12 with the highest scores were selected, accounting for 20.7% of the communes in the two target provinces. Two or three villages in each commune were selected for household interviews using stratified sampling. Three main criteria were applied for the selection of study villages: (1) They had a large area of natural forest; (2) they had representative features, for example, in terms of poverty rate and forest coverage; and (3) they were not next to each other. Of the 12 selected communes, 25 villages were selected.

The Slovin sampling formula was used to estimate the sample size for each commune: 
$$n = \frac{N}{N + (\frac{e^2}{2} + 1)}$$
where n is sample size, N is population size, and e is sampling error (i.e., one confidence level). With a confidence level of 95%, a population of 82,297, and 50,000 HHs in the buffer-zone communes of the seven PAs in QN and TTH provinces, a total sample size of 795 HHs was selected (Table 2). The sample size of the selected communes was prorated based on the probability proportion to the size (PPS) approach, in order to obtain a sample size that was proportional to the commune.

For HH sampling, based on the sample size of each village selected by using the PPS approach, a systematic random sampling method was used to sample the HHs. In order to select the HHs in a sample frame, an interval coefficient k for systematic selection was determined. This was estimated by dividing the total number of HHs in the sample frame by the sample size. A full list of the HHs in the sample frame was prepared. Subsequently, the initial household as a random integer from one to nine was selected before selecting other HHs (every ninth) in the next segments with an interval of k = 9. An approximate 10% contingency of HHs from the sample frame was selected and used in cases where the preselected HHs were unable to participate in the interview.

In order to obtain valid data, either the HH head or the main HH representative of working age (between 18 and 60 years) was approached to be interviewed, as he or she would likely have a better understanding of the household and livelihood issues, as well as adequate knowledge and experience. The respondents who were interviewed gave their full consent and were assured of the confidentiality of their responses. In addition, gender sensitivity was taken into account by applying a 50–50 ratio for sampling male and female respondents.

We designed a household survey questionnaire and consulted with different experts in the economic, forest/natural resources, and social fields. The experts provided comments for revising the questionnaire. The questionnaire consisted of eight parts covering 80 questions: (1) Demographic information; (2) socioeconomic profile; (3) livelihood assets and living conditions; (4) access to public services; (5) access to market and information; (6) access to sources of financial capital; (7) division of labor and decision-making; and (8) knowledge, practices, and vulnerability.

The final draft of the questionnaire was tested during three days in A Roang commune (THH province) with the participation of 10 testing households, and Tra Cang commune (QN province) with 12 testing households. All comments were collected, analyzed, and used for updating and finalizing the HH survey questionnaire prior to officially conducting the survey in the field. Seven questions relating to livelihood were updated to better capture the full picture of the PFES policy. A one-day training session on the survey tools and field procedures was organized for 10 enumerators and researchers. A comprehensive field household survey plan was also prepared and presented to the enumerators and researchers during the training. Field planning and logistic arrangements were discussed and finalized at the end of the training session before beginning the field survey. A checklist was developed and used to make sure that the whole process was thoroughly and systematically carried out.
Table 2. Selected communes and sample size for HH survey. PA, protected area.

| Nature Reserve/National Park | Date Established | Total Areas (Core and Buffer Zones) of PA (ha) | Areas Covered by PFES (ha) | No. of Communes in Buffer zones | Total HHs/Surveyed HHs | % Poor | % Ethnic | % Forest Cover | Surveyed Communes | Number of HHs | Surveyed Villages | Sample Size |
|------------------------------|-----------------|-----------------------------------------------|---------------------------|--------------------------------|------------------------|--------|----------|----------------|------------------|--------------|----------------|-------------|
| Bach Ma National Park (NP)   | July 1991       | 37,487                                        | 13,812                    | 15                             | 15,350/105             | 21.27  | 43.54    | 70.20          | A Ting           | 654          | Cho Nech       | 32          |
|                              |                 | 58,676                                        |                           |                                |                        |        |          |                | Thuong Lo        | 318          | Pa Zih         | 23          |
|                              |                 |                                               |                           |                                |                        |        |          |                | Cha Mang Dui     | 15           |                | 15          |
|                              |                 |                                               |                           |                                |                        |        |          |                | Pa Hy            | 37           |                | 35          |
|                              |                 |                                               |                           |                                |                        |        |          |                | Pa Ring          | 30           |                | 30          |
|                              |                 |                                               |                           |                                |                        |        |          |                | Dut 1            | 43           |                | 43          |
|                              |                 |                                               |                           |                                |                        |        |          |                | A Tia 2          | 40           |                | 40          |
|                              |                 |                                               |                           |                                |                        |        |          |                | Thua Thien Hue   | 26           |                | 26          |
| Phong Dien Nature Reserve (NR) | November 2002   | 41,508                                        | 14,000                    | 9                              | 8794/150               | 30.56  | 64.79    | 65.99          | Hong Ha          | 424          | Ka Lo          | 38          |
|                              |                 | 43,600                                        |                           |                                |                        |        |          |                | Hong Kim          | 526          | Karon Aho       | 35          |
|                              |                 |                                               |                           |                                |                        |        |          |                | Phuoc Dien Nature Reserve (SLNR) | October 2013 | 15,520 | 6889 | 4 | 2096/172 | 30 | 87.13 | 82 | A Roang | 627 | Village 3 | 35 |
|                              |                 |                                               |                           |                                |                        |        |          |                | Thuong Long       | 629          | Village 4       | 31          |
|                              |                 |                                               |                           |                                |                        |        |          |                | Village 8         | 33           |                | 33          |
|                              |                 |                                               |                           |                                |                        |        |          |                | Phuoc Xuan        | 293          | Lao Du          | 29          |
|                              |                 |                                               |                           |                                |                        |        |          |                | Village 58        | 16           |                | 16          |
|                              |                 |                                               |                           |                                |                        |        |          |                | Village 27        | 9            |                | 9           |
|                              |                 |                                               |                           |                                |                        |        |          |                | Village 124       | 47           |                | 47          |
|                              |                 |                                               |                           |                                |                        |        |          |                | Village 25        | 23           |                | 23          |
|                              |                 |                                               |                           |                                |                        |        |          |                | Village 3         | 37           |                | 37          |
|                              |                 |                                               |                           |                                |                        |        |          |                | Village 30        | 36           |                | 36          |
| Song Thanh National Reserve  | October 2000    | 54,897                                        | 46,213                    | 14                             | 7781/54                | 55.79  | 88.15    | 73.185         | Dac Pre           | 341          | Village 27      | 31          |
|                              |                 | 22,067                                        |                           |                                |                        |        |          |                | Phuoc Xuan        | 293          |                | 29          |
|                              |                 |                                               |                           |                                |                        |        |          |                | Village 58        | 16           |                | 16          |
|                              |                 |                                               |                           |                                |                        |        |          |                | Village 124       | 9            |                | 9           |
|                              |                 |                                               |                           |                                |                        |        |          |                | Village 124       | 47           |                | 47          |
|                              |                 |                                               |                           |                                |                        |        |          |                | Village 25        | 23           |                | 23          |
| Elephant National Reserve   | September 2017   | 18,977                                        | 5130                      | 6                              | 5736/163               | 43.5   | 48.78    | 76.78          | Phuoc Ninh        | 826          | Village 3       | 37          |
|                              |                 | 35,135                                        |                           |                                |                        |        |          |                | Que Lam           | 1097         | Village 4       | 36          |
|                              |                 |                                               |                           |                                |                        |        |          |                | Village 1         | 25           | Village 2       | 25          |
|                              |                 |                                               |                           |                                |                        |        |          |                | Village 2         | 27           |                | 27          |
| Ngoc Linh National Reserve  | November 2016   | 54,010                                        | 39,992                    | 6                              | 4379/125               | 63.5   | 91.97    | 60.83          | Tra Cang          | 869          | Village 3       | 37          |
|                              |                 | 2718                                           |                           |                                |                        |        |          |                | Tra Tap           | 617           | Village 4       | 36          |
|                              |                 |                                               |                           |                                |                        |        |          |                | Village 1         | 25           | Village 1       | 25          |
|                              |                 |                                               |                           |                                |                        |        |          |                | Village 2         | 27           |                | 27          |
| Total                       |                 | 238,399                                       | 134,913                   | 58                             | 46,214/795             | 43.44  | 73.94    | 73.03          | 12                | 7,220        | 25             | 795         |

* Note: There are no surveyed communes, villages, or HHs in this PA as Thua Thien Hue (TTH), Sao La Nature Reserve (SLNR), and Quang Nam Sao La Nature Reserve (QN-SLNR) are inter-provincially connected. (Source: Computed from [51]).
3.2.2. Data Quality Assurance

We applied six measures to mitigate fallacy and to ensure data quality and reliability: (1) A survey questionnaire was tested in the field and improved; (2) enumerators were trained on the survey tools and protocols and were deemed to be competent prior to the fieldwork; (3) survey responses were processed in a way that facilitated data entry and reduced errors; (4) HH questionnaires with significant errors were eliminated from the sample; and the content of the questionnaire was (5) reviewed by enumerators on the day of the interview and (6) supervised by the team leader. The team leader directly supervised the entire data collection process. Completed questionnaires were carefully filed before, during, and after data processing and analysis. Finally, the entered data were double-checked during the data cleaning process to ensure accuracy.

3.2.3. Outlier Checking

In order to check the data before conducting the analysis and interpretation, based on the economic status of the households assessed under the national multidimensional poverty line (MPL) of 2016–2020 (according to Decision 59/2015/QĐ-TTg dated 19 November 2015, promulgating MPL applied for the period 2016–2020), the survey dataset was divided into three sub-datasets representing poor, near poor (certified by commune people’s committees), and non-poor groups. In turn, these sub-datasets were subdivided into six groups of poor, near poor, and non-poor groups with and without PFES income.

The outlier analysis was carried out on these six sub-datasets to see if there were any abnormal data values in the datasets. In this study, any data value that was 1.5 times the lower bound or upper bound of the interquartile range (IQR) was considered an outlier (Tukey, 1977). In short, a data value \(x\) was considered an outlier if it was within the following ranges:

\[
x < (Q_1 - 1.5 \times IQR) \lor x > (Q_3 + 1.5 \times IQR)
\]

where \(Q_1\) is the first quartile and \(Q_3\) is the third quartile of the dataset. Table 3 summarizes the statistics related to the outliers of the datasets.

Table 3. Exploratory data analysis. IQR, interquartile range.

| Wealth Ranking | PFES/Without PFES | Number of Data Values | Q1         | Q2         | IQR          | Lower Bound | Upper Bound | Number of Outliers |
|----------------|-------------------|-----------------------|------------|------------|--------------|-------------|--------------|-------------------|
| Poor PFES      | 80                | 10,540,000            | 32,075,000 | 21,535,000 | -21,762,500 | 64,377,500  | 3            |
| Poor Without PFES | 255              | 8,206,500             | 31,950,000 | 23,743,500 | -27,408,750 | 67,565,250  | 13           |
| Near poor PFES | 37                | 15,900,000            | 60,400,000 | 44,500,000 | -50,850,000 | 127,150,000 | 1            |
| Near poor Without PFES | 118            | 14,000,025            | 43,260,000 | 29,259,976 | -29,889,939 | 87,149,963  | 6            |
| Non-poor PFES  | 81                | 26,200,000            | 84,200,000 | 56,000,000 | -60,800,000 | 171,200,000 | 5            |
| Non-poor Without PFES | 223           | 17,150,000            | 74,050,049 | 56,900,049 | -68,200,074 | 159,400,123 | 8            |

The tests showed that the data had outliers. Poor without PFES and non-poor without PFES groups had the most outliers. All of the outliers in the datasets were removed before conducting further analysis and interpretation (Table 4).

Table 4. Sample statistics of the six sub-datasets defined above after removing outliers.

| Wealth Ranking | PFES/Without PFES | Number of Data Values | Min          | Max          | Mean         | Standard Deviation |
|----------------|-------------------|-----------------------|--------------|--------------|---------------|-------------------|
| Poor PFES      | 77                | 2,470,098             | 59,280,000   | 20,943,477   | 14,030,345    | 14,030,345        |
| Poor Without PFES | 242              | 500,000               | 62,552,000   | 19,842,702   | 14,861,901    | 14,861,901        |
| Near poor PFES | 36                | 3,500,000             | 97,720,000   | 38,272,083   | 28,255,531    | 28,255,531        |
| Near poor Without PFES | 112         | 1,600,000             | 86,700,000   | 28,278,119   | 19,999,208    | 19,999,208        |
| Non-poor PFES  | 76                | 2,650,000             | 164,200,000  | 54,526,212   | 39,263,325    | 39,263,325        |
| Non-poor Without PFES | 215          | 400,000               | 144,500,000  | 45,988,760   | 35,858,670    | 35,858,670        |
3.2.4. Data Analysis

Although three household groups—poor, near poor, and non-poor—were involved in this data collection, there was not much difference between the poor and near-poor groups. Therefore, further statistical analysis combined poor and near-poor households into one group, named poor households. The resulting two groups, poor and non-poor households, had sample sizes of 446 and 279, respectively. We looked at households both with and without PFES in the poor and non-poor groups in order to compare the financial and natural outcomes of PFES participation with the outcomes that would have been obtained had the households not been involved in PFES. In order to estimate the mean impact of the PFES policy on the financial capital of households that did participate, we employed a matching technique to identify the average treatment effect on the treated (ATT), which was defined as

$$ATT = E(y_{1i} - y_{0i}|D_i = 1)$$

$$ATT = E(y_{1i}|D_i = 1) - E(y_{0i}|D_i = 1).$$

In this formula, $E(y_{1i} - y_{0i}|D_i = 1)$ indicates the impacts of the PFES policy, where $y_{1i}$ stands for financial indicators such as total income, expenditure, consumable items, income sources, and loan accessibility of household $i$ participating in PFES. Conversely, $y_{0i}$ is the financial indicator of households not participating in PFES, and the treatment indicator $D$ is equal to one if a sampled household is in the PFES group and zero otherwise. The challenge of the above formula was in estimating the financial impact of such policy on PFES households (D1) that no longer participate in PFES ($y_{0i}|D_i = 1$). In order to overcome this challenge, we constructed a suitable counterfactual from the pool of households without PFES. Accordingly, the estimation of ATT was simply treated without PFES households as the counterfactual and replacing ($y_{0i}|D_i = 1$) with ($y_{0i}|D_i = 0$). Therefore, the formula was changed as follows:

$$ATT = E(y_{1i}|D_i = 1) - E(y_{0i}|D_i = 1) = [E(y_{1i}|D_i = 1) - E(y_{0i}|D_i = 0)] - [E(y_{0i}|D_i = 1) - E(y_{0i}|D_i = 0)].$$

Matching techniques are generally based on comparisons of essential characteristics ($x$) between households with and without PFES. For this reason, if there are more $x$’s between groups of households, it will be challenging to find the same or sufficient characteristics ($x$) of households without PFES to compare with $x$’s of household with PFES in all dimensions.

The three matching methods for estimating the ATT in this paper are the nearest neighbor, radius, and kernel. The nearest neighbor, as analyzed by the algorithm, matched a household with PFES with a household without PFES that had the nearest propensity score. The radius matching method estimates ATT by comparing each unit with and without PFES within a predefined distance around the propensity score. In the kernel matching method, all comparison groups were compared with the weight average of the PFES households.

In order to determine who participates in the PFES policy, a regression analysis was conducted using a probit regression model. The identified independent variables were based on the stepwise logistic regression for all variables to see whether they affected the total income, income sources, expenditure, and loan accessibility of households participating in PFES. The dependent variable was binary (one for households with PFES and zero otherwise), while the independent variables consisted of household characteristics: (1) Gender of household head, with a dummy of one for male and zero for female, (2) age of household head, (3) a dummy for ethnicity, (4) level of education, (5) forestry area, (6) rice consumption, (7) water consumption, and (8) living area. The results indicated that the probit regression was statistically significant in a test of the joint null hypothesis in which the regression coefficient is prob $> \text{chi2} = 0.000$ (Table 5). All of the independent variables had a $P$-value $< 0.05$, which confirmed that these variables affected participation in PFES. However, the effect can be negative or positive.
Table 5. Probit regression outputs.

| PFES       | Non-Poor Households (N = 279) | Poor Households (N = 446) |
|------------|-------------------------------|---------------------------|
|            | Coef. | P > |z| Coef. | P > |z| |
| Age        | 0.007185 | 0.000 | -0.0066152 | 0.002 | |
| Ethnicity  | 0.0095029 | 0.003 | -0.366203 | 0.037 | |
| Education  | 0.1179336 | 0.001 | 0.1379293 | 0.000 | |
| Forest area| 0.0000110 | 0.005 | 0.0021009 | 0.003 | |
| Gender     | 0.0247456 | 0.000 | 0.0000111 | 0.000 | |
| Rice consumption | 0.0020609 | 0.010 | -0.00013708 | 0.005 | |
| Water consumption | -0.0035307 | 0.048 | -0.0097307 | 0.013 | |
| Area of living | 0.0000562 | 0.014 | 0.0000906 | 0.004 | |
| cons       | -1.382108 | 0.013 | -0.3291032 | 0.016 | |
| LR chi2(8) | 15.69 | | 31.42 | |
| Prob > chi² | 0.0000 | | 0.0000 | |
| Log likelihood | -160.23398 | | -240.95549 | |
| Pseudo R² | 0.0467 | | 0.0612 | |

4. Results

4.1. Characteristics of Sampled Households

Table 6 presents a summary of the key variables used in the propensity score matching analysis. There was no significant difference between PFES and without PFES, which can be used to run the propensity score matching without balancing.

Table 6. Descriptive analysis of sampled households.

| Variable                  | Non-Poor (N = 279) | Poor (N = 446) |
|---------------------------|--------------------|----------------|
| Sample size               | 198                | 81             |
| Age                       | 39.04              | 40.47          |
| Education                 | 4.37               | 5.33           |
| Family size               | 4.57               | 4.22           |
| Total income (million VND/year) | 72.8          | 62.9           |
| Total expenses (million VND/year) | 40.3          | 45.0           |
| Asset value (million VND/year) | 166.6           | 153.2          |
| Land for housing (m²)     | 565.61             | 642.51         |
| Forest income (million VND/year) | 6.0            | 8.5            |
| Agri-income (million VND/year) | 10.9           | 9.5            |

The descriptive data indicated that the 725 sampled households had members of quite similar ages (38 to 40 years), educational level (grade five), and family size (four to five people). However, the annual income of the non-poor households generally was twice that of the poor ones, due to higher income from forestry and agricultural activities. As a result of the higher overall income, non-poor households had higher yearly expenditures compared to poor households.

4.2. PFES and Financial Capital

The results of the PFES policy impacts on financial capital were evaluated by three main indicators: Total household income, sources of income, and accessibility to loans; and three other related indicators were total expenditures, consumable items, and days of food shortage. As mentioned above, the evaluation was conducted on two groups, poor and non-poor households, in order to see how participating in PFES impacted their financial capital. It was noted that in the case of non-poor households, the estimate of total annual household income was positive under the nearest neighbor matching method, with a significance at 10% (T-stat = 1.80 < 1.96), but was negative under the...
radius and kernel matching methods (Table 7). However, neither of these two matching methods was statistically significant concerning any evidence on the degree and direction of PFES impacts on the total overall household income. Similarly, for poor households, although the estimation of yearly household income was positive with the three matching methods, the T-stat was not statistically significant. While it did not show any significantly valid results, the consistency of the positive sign may be an indicator of the beneficial impact of PFES. In this case, it can be concluded that the income of poor households with PFES is higher than that of poor households without PFES; however, the difference may or may not be caused by participation in PFES.

Table 7. Matching estimates of PFES impacts on financial capital.

| Bias-Adjusted ATT | Nearest Neighbor | Radius Cal | Kernel |
|------------------|-----------------|------------|--------|
|                  | Difference      | T-Stat     | Difference | T-Stat     | Difference | T-Stat     |
| Non-poor         |                 |            |          |            |            |          |
| Total income (million VND) | 1.90 | 1.80 | -10.30 | -0.83 | -11.10 | -1.19 |
| Income sources   | 2.00 | 9.21 | 2.10 | 12.88 | 2.20 | 13.81 |
| Total expenditure (million VND) | 0.90 | 0.23 | -0.50 | -0.10 | 2.70 | 0.57 |
| Consumable items (million VND) | 0.90 | 0.23 | 1.10 | 0.38 | 2.90 | 1.03 |
| Days of food shortage (days) | 1.80 | 0.24 | 5.40 | 0.70 | 3.00 | 0.46 |
| Loan access (million VND) | -4.90 | -0.51 | -0.40 | -0.07 | 0.96 | 0.16 |
| Poor             |                 |            |          |            |            |          |
| Total income (million VND) | 1.00 | 0.29 | 0.90 | 0.31 | 0.40 | 0.14 |
| Income sources   | 1.60 | 9.91 | 1.70 | 13.85 | 1.60 | 14.17 |
| Total expenditure (million VND) | 2.30 | 0.50 | 4.60 | 1.10 | 3.90 | 0.96 |
| Consumable items (million VND) | 0.90 | 0.45 | 0.30 | 0.17 | -0.20 | -0.13 |
| Days of food shortage (days) | 0.90 | 0.12 | -5.90 | -1.13 | -0.40 | -0.06 |
| Loan access (million VND) | 3.50 | 2.02 | 2.80 | 0.92 | 1.70 | 0.58 |

The estimates of the income sources of poor and non-poor households were statistically significant under the three matching methods with T-stat > 2.58 (significant at 0.01). It can be concluded that participating in PFES creates more income sources for households. Changes in the natural conservation and management are likely to have repercussions for local labor. As mentioned by Landell-Mills and Porras [10], PES schemes have an impact on job creation, which then indirectly affects household income. The data analysis indicated that poor and non-poor households with PFES had more income sources on average than those without PFES, where ATT stood at 1.6 and two, respectively.

Expenditure was the second indicator for assessing the financial impact of PFES on the sampled households [16]. The study found that both poor and non-poor households that were involved in PFES had higher expenditures compared to those without PFES. However, the differences were not statistically significant. The nearest neighbor and kernel matching methods estimated that yearly total expenditure of non-poor households with PFES was higher than those without PFES, whereas the radius matching method indicated a negative relationship. Similarly, the three matching methods showed a positive relationship between the annual expenditure of poor households with and without PFES. However, the relationship between the PFES participation and household expense was not statistically significant under any of the three methods.

The estimation of consumable items was similar to the household total expenditure, with no statistical significance with the three matching methods. In this case, it can be concluded that participating in PFES supports non-poor and poor households with higher expenditures, more consumable items, and shorter duration of food shortage; however, the difference between households with and without PFES was not statistically significant. The estimates of the days of food shortage of poor households were negative and not statistically significant under two of the three matching methods, probably pointing to increased food security due to PFES participation. However, the difference between poor households with and without PFES was too small to reach significance.
Finally, the estimate of access loans from the credit policy of poor households with PFES was positive and statistically significant under the nearest neighbor matching method (T-stat > 2), while radius and kernel matching indicated a positive relationship but insignificant results. This provided evidence that poor households with PFES would have obtained more loans from different credit schemes than those without PFES.

4.3. PFES and Natural Capital

This study presents natural capital impacts of the PFES policy through two indicators: (i) Total forest areas, including forest cover; and (ii) forest loss, including forests that were cut and burned. The former was based on a dataset from the General Statistics Office (GSO) of Vietnam, Decision 1178/QD-BNN-TCLN dated 3 April 2018, the PFES Review Reports of 2018, and annual reports from the Forest Protection Sub-department and Forest Protection and Development Fund in QN and TTH provinces in 2018. The latter was based on data from the GSO data and Landsat image computation. To gather forest loss information, the authors took advantage of Landsat images downloaded from the Glovis website by the United States Geological Survey (USGS) (https://glovis.usgs.gov/). For forest cover from 2001 to 2012, the Landsat 5 Thematic Mapper (TM) was used, while forest cover from 2003 to 2017 was extracted from the Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) images. The study area, QN and TTH provinces of Vietnam, covers an area corresponding to the Landsat images of path 124, row 049 and path 125, row 049. Attempts were made to download cloud-free images. In cases where cloud-free images were not available, map algebra manipulation was employed to replace the cloud patches with corresponding patches from the nearest date images [52].

To extract the forest cover, we employed the unsupervised classification technique [53]. The classified images were then visually checked to avoid abnormal changes in the forest cover. The forest loss pixels for a certain period were then extracted by comparing the classified raster images. Forest loss was estimated for the natural forest areas within the intersections between watersheds and protected areas in the study sites. For each intersection, a zonal sum of the number of forest loss pixels was calculated and converted to hectares (30 m pixel size). All classification and map algebra operations were carried out using the ArcGIS 10.6 software by the Environmental Systems Research Institute (ESRI).

To measure the impact of PFES on the forest cover, the Landsat image computation technique was applied for protected areas overlapping hydropower watersheds areas. It is worth noting that the PAs have their own strict management procedures that helped to minimize site effects by other external factors that would have had an effect if other areas were selected. Meanwhile, forests in the hydropower watershed areas are eligible for FES payment. In addition, the authors applied a four- to five-year interval (e.g., 2004, 2008, 2012, and 2017) to compute the Landsat images to measure the forest cover change instead of computing every year due to short periods and not much change in the forest cover.

The data from the GSO indicated that the total forest areas of QN and TTH provinces increased significantly since the PFES policy was implemented in 2011 (see Figure 3). Specifically, the total forest area in the QN province significantly increased from 457,200 ha in 2008 to 680,300 ha in 2017, and in the TTH province increased slightly from 293,200 ha in 2008 to 311,900 ha in 2017 (Figure 3). The annual average forest area increased from 14,150 ha/year for the period 2008–2011 (pre-PFES) to 27,207 ha/year for the period 2012–2017 (during PFES) in QN. The total forest area eligible for FES payment in QN increased from 2500 ha in 2012 to 286,000 ha (or 42% of total forest area) in 2017.

Similarly, the average annual forest area in TTH increased from 375 ha/year for the period 2008–2011 (pre-PFES) to 2817 ha/year for the period 2012–2017 (during PFES). The total forest area eligible for FES payment in TTH increased from 115,200 ha in 2013 to 129,000 ha (or 41% of total forest area) in 2017. In other words, the average annual forest area during the PFES period increased by almost double and more than seven times compared to the increase of the pre-PFES period in QN and TTH, respectively. The increased total forest area and total forest area that received PFES money could have led to the increased forest cover. Obviously, the forest cover of TTH and QN gradually increased by 2.92% and 14% from 2008 to 2017, respectively. Although many other factors contributed
to the increased total forest area and forest cover, PFES policy could be seen as one of many factors contributing to this trend quantitatively.

In terms of forest loss due to fires, the data from GSO show that the average annual forest area that had fires declined from 2002 to 2016 in both provinces, although QN experienced an increase in 2014–2015 (Figure 4). Specifically, the average annual forest area that had fires declined slightly from 40.7 ha for the period 2002–2012 (when PFES service providers actually received the PFES money) to 35.3 ha for the period 2013–2016 (during PFES) in QN province. There was a similar trend in TTH, where the annual average forest area that had fires declined significantly from 52.2 ha in 2002–2012 to 12.0 ha in 2013–2016.

Inversely, Figure 4 shows that the average annual forest loss due to cutting increased from 2002 to 2016 in both provinces. Specifically, the average annual forest area that was cut increased significantly from 71.7 ha for the period 2002–2012 (pre-PFES) to 129.5 ha for 2013–2016 (during PFES) in QN,
and increased slightly from 18.4 to 21.7 ha for the same period in TTH. One of the main reasons for greater forest loss in QN may be due to the province needing land to building eight hydropower plants.

The data from the Landsat image computation indicated that natural forest area loss in eight hydropower watersheds of the buffer zones of six PAs of QN and TTH provinces increased in 2004 and 2012 (pre-PFES), and decreased in 2017 (Figure 5). The total natural forest area loss calculated from 2004, 2008, and 2012 is 988.3 ha, and from 2017 is 236.5 ha (Table 8).

**Figure 5.** Status of natural forest area loss in eight hydropower watersheds of QN and TTH over the period 2008–2017. (Source: Authors’ Landsat image computation.).

In general, the natural forest area loss of the studied watersheds decreased between the pre-PFES and PFES periods. Table 8 shows that the average natural forest area loss in eight watersheds of six PAs was 82.4 ha/year (or 10.3 ha/year/PA) for the pre-PFES period and 47.3 ha/year (or 5.9 ha/year/PA) during the PFES period. In other words, the average natural forest area loss decreased by almost half after the PFES policy was put into effect. Specifically, among these eight watersheds, Ta Trach and Song Bung had slightly increased the average natural forest area loss, from 8.4 ha and 11.8 ha to 10.2 ha and 14.2 ha, respectively. The consultation with the QN forest sub-department indicated that Song Bung watershed serves six hydropower plants. This could be the main reason that some of the natural forest was still cleared for the building of new hydropower plants after the PFES policy was put into effect.

**Table 8.** Natural forest area loss between pre-PFES and PFES policy periods in hydropower watersheds of QN and TTH provinces.

| Protected Area | Hydropower Watershed | Annual Forest Cover Loss (ha/Year) | Total Forest Cover Loss (ha) | Annual Forest Cover Loss (ha/Year) | Total Forest Cover Loss (ha) |
|----------------|----------------------|-----------------------------------|----------------------------|-----------------------------------|-----------------------------|
| Bach Ma NP     | Ta Trach             | 8.4                               | 101.1                      | 10.2                              | 50.9                        |
| TTH Phong Dien NR | Huong Dien        | 11.4                              | 137.1                      | 4.6                               | 23.1                        |
| TTH Sao La NR  | Binh Dien            | 13.3                              | 199.8                      | 0.7                               | 3.4                         |
| QN Sao La NR   | A Vuong              | 4.5                               | 54.6                       | 3.8                               | 19.2                        |
| QN Sao La NR   | Song Con 2           | 6.4                               | 76.7                       | 3.0                               | 15.0                        |
| QN Song Thanh NR | Dak Mi              | 4.5                               | 53.8                       | 1.4                               | 7.2                         |
| QN Song Thanh NR | Song Bung           | 11.8                              | 142.1                      | 14.2                              | 71.0                        |
| QN Elephant Species | Khe Dien       | 21.9                              | 263.3                      | 9.3                               | 46.6                        |

(Source: Authors’ Landsat image computation).
The reports from the QN forest protection sub-department indicated that the main reasons for forest loss were (i) ground clearance for hydropower and road development; and (ii) shifting cultivation by local people. Indeed, the results of the carbon baseline study conducted in QN and TTH by Hue University of Agriculture and Forestry showed that the main drivers of forest degradation are the construction of new roads and illegal logging [55].

The study also evaluated the collecting of non-timber forestry products (NTFPs) by households in seven PAs. The three matching methods indicated that there was a difference in the collection of NTFPs (e.g., firewood, fruits, bee honey, mushrooms, rattan, etc.) between households with and without PFES, as well as poor and non-poor households with PFES (Table 9). Specifically, the study shows that the estimation of PFES households collecting NTFPs had a statistically significant negative value. Table 9 shows that the estimation of poor households with PFES collecting NTFPs was negative with high significance. These findings mean that there were fewer households with PFES collecting NTFPs than households without PFES. This implies that the PFES policy may impact forest use according to the type of household. In other words, the PFES policy likely contributes to reducing the dependence of PFES households on forest resources, which would increase the quality of forests. In addition, the estimation of non-poor households with PFES collecting NTFPs is likely higher than that of non-poor households with PFES. However, this difference is not statistically significant.

Table 9. Estimation of non-timber forestry products (NTFPs) collected by households at PAs.

| Bias-Adjusted ATT | Nearest Neighbor | Radius | Kernel |
|-------------------|-----------------|--------|--------|
|                   | Difference | T-Stat | Difference | T-Stat | Difference | T-Stat |
| Households with PFES collecting NTFPs | -0.139175258 | -1.74 | -0.152409548 | -2.22 | -0.135613943 | -1.74 |
| Poor households with PFES collecting NTFPs | -0.25862069 | -2.44 | -0.254821238 | -3.01 | -0.16975548 | -1.92 |
| Non-poor households collecting NTFPs | 0.112903226 | 0.73 | 0.043587033 | 0.37 | 0.132384251 | 1.12 |

5. Discussion, Implications, and Limitations

This paper contributes to the understanding of the relationship between the PFES policy and livelihood outcomes in emerging countries and answers the research questions on the financial and natural impacts of the PFES policy and proposed implications for PFES scheme design. Although PES programs, as an instrument to improve natural conservation, are not targeted for poverty alleviation, their synergy with livelihood outcomes has been recognized. The rationale is that because of the high poverty rates in rural areas, where households mainly depend on natural resources for their income-generating activities, the PFES policy contributes to improving household income, expenditure, and natural resources in terms of sustaining livelihoods. In the case of the PFES policy at the buffer zones of seven PAs in Central Vietnam, communities in these areas are poor and are dependent on forest resources for their livelihoods, so the design of the PFES policy needs to include a better form of payment so they can improve their livelihood and natural resource management.

5.1. Financial Capital Impacts of PFES

The paper’s findings are consistent with other work [6,55–57] indicating that the PFES policy provides financial benefits for PFES households. For both poor and non-poor PFES households, the PFES money constitutes a considerable percentage of the household budget (approx. US $45 for non-poor PFES households and US $53 for poor PFES households), clearly exceeding the 4% yearly income of participating households [6,56,58]. This result confirms Engel, Pagiola, and Wunder’s [20] and Alston et al.’s [59] arguments on designing PES, wherein the PES policy can create economic hardship for poor communities that depend on forest resources for their income. Accordingly, PES needs
to distribute benefits equitably among various communities such as poor, non-poor, PES, and non-PES households in order to reduce related social conflicts.

The research findings of the present study partly answer the questions on the benefits of households being involved in PES and the dubious link between the PES money and reinvestment in natural conservation [20,60]. We found that, although the amount of this payment is quite “visible,” PFES households leveraged the payment for food and other consumable items in order to improve their standard of living [3,61,62]. Obviously, the PFES households in this study have had fewer days of food shortage than households without PFES, as they used their increased income to purchase consumables. This result is similar to those of Clements and Milner-Gulland [46], Alix-Garcia, Shapiro, and Sims [17], and Kwayu et al. [63], which indicated that households participating in PES were more food secure than households that did not participate. Alix-Garcia, Shapiro, and Sims [17] and Kwayu et al. [63] indicated that PES participation supported increased food consumption and the ability to meet household food needs. This suggests that participating in PFES enhances the standard of living of households in the buffer zones of the protected areas, and confirms that PFES households obtain financial benefits in terms of overall income, and use that income for other daily expenditures rather than reinvesting in natural conservation.

Beyond the direct effect of PFES on financial capital resulting from household income, it affects such capital through the diversification of household income sources. We found that participating in the PFES policy increases both overall household income and income sources, confirming the argument of the previous studies [14,64]. Those researchers showed that PES schemes create more off-farm jobs for participants compared to non-PES ones, while Locatelli et al. [38] specified the off-farm jobs as transportation, small business, and hired labor. Similarly, this study indicates that PFES households have 4.6 income sources, on average, while households without PFES have 2.8, as PFES households are more involved in off-farm jobs such as casual and hired labor from service contracts. We also considered accessing loans from banks as a dimension of financial capital, which was not mentioned in previous studies. The findings indicate that poor households with PFES accessed more loans from credit channels than those without PFES. Indeed, when poor people are involved in PFES, they have better and more diverse income sources, and accordingly they can be approved for loans at banks and other local credit schemes.

5.2. Natural Capital Impacts of PFES

To examine the natural capital impacts, the increase and loss of forest area were measured before and during the implementation of the PFES policy. Data from the Governmental Statistical Office (GSO) indicated that the total forest areas and percentage of forest cover increased between the pre-PFES policy and during the PFES policy in QN and TTH provinces. The findings confirm that an important perceived benefit from the PES scheme is enhanced natural capital by increasing the total forest area and forest cover [10,16,28,57,65,66]. The data from the Landsat image computation confirmed that the overall average natural forest loss in eight watersheds of six PAs declined after the PFES policy was implemented. However, more than 233 ha of natural forest was still lost during the five-year PFES period. This shows that although the PFES policy has a positive effect on slowing down natural forest loss, it still is not a panacea that will completely solve the forest loss problem. In addition, the PFES policy was launched in QN and TTH in 2012 and payment started in 2013, and this study was conducted in 2017 and 2018. A five-year period is not long enough to show a remarkable impact on natural capital by the PFES policy.

5.3. Implications

Based on the above findings, this study offers implications for minimizing the adverse impacts and maximizing the positive ones on financial and natural capital from the PFES policy. The first step is to design a payment mechanism for PFES so as not to exclude poor households. Local organizations, governments at the grassroots level, and nongovernment organizations (NGOs) can
support the organization of PFES participants and forums to discuss solutions that emerge during PFES implementation.

The design of PFES also needs to consider the objective of improving financial capital. Although the ultimate goal of the PFES policy is to create a sustainable financial scheme, sustainability will not be achieved unless service recipients’ expectations are met. The study indicates that payment from PFES schemes for forest owners living in the buffer zone of the studied protected areas is too small, and may not be enough to reinvest in their current production and daily expenses. In this case, the PFES payment should contribute to revolving development funds for villages, which could then be loaned among poor households rather than directly paid to them. To do this, local organizations and heads of villages and households would need to agree on the number of loans, loan procedures, and loan installments.

Most poor households in the studied areas are made up of young people, who have the ability to work but no land for cultivation. Accordingly, the design of PFES should include encouraging these households to take part in forest protection to receive more payment. It also needs to provide technical assistance or access to agricultural input and credit for poor households, so that they can increase their agricultural productivity and apply more sustainable land use practices.

When studying the impact of PFES on natural capital, it is suggested that one should consider its impact on different scales, because they have different levels of impact. Therefore, depending on the specific purpose of the policy intervention, the study should design and select the appropriate scale.

The modest income received from the PFES policy does not necessarily motivate local households to be active in protecting allocated forests. Therefore, we suggest combining the benefits of the PFES policy with other public and private incentive schemes, which would likely promote local household participation in forest protection. On the other hand, there should be a policy to penalize households that cannot protect their allocated forest as committed.

5.4. Limitations of the Study

It is difficult to evaluate the actual impact of the PFES policy and the complementarity of PFES. This is because QN and TTH are among the poorer provinces in Vietnam and have received quite a few state-subsidized programs, such as the Hunger Eradication and Poverty Reduction Program, the 30A or Poverty Alleviation Program, and the 661 or the Five Million Hectare Reforestation Program Forest Protection program. With the presence and interventions of many programs, the impact on forest quality and quantity is driven by the complementarity of these programs rather than just the PFES policy. An impact assessment of PFES needs to clarify the actual complement of PFES, therefore further studies at the hamlet and village level would increase the level of accuracy, especially regarding the change in natural capital.

Due to the lack of a baseline database, the before/without—after/with treatment—control method could not be applied. Therefore, the authors only used with and without PFES in this study to evaluate the changes in household income/livelihood and the quality and quantity of forests before and after the PFES policy. This is another limitation of the study.

The evaluation of natural capital impacts of the PFES policy has some limitations. First, the study focused on two provinces, QN and TTH, and the results cannot be generalized to the all provinces in Vietnam because of the different forestry conditions and duration of the PFES policy implementation. Accordingly, further studies are needed in other areas where the PFES policy has been rolled out. Second, given the five years of the PFES policy at the study sites, it is early to examine and provide a comprehensive conclusion about the natural capital impacts, as long-term monitoring and evaluation are needed to identify the contribution of the PFES policy to maintaining and developing ecosystems in general and natural capital in particular. Third, methods of measuring forest areas and forest cover vary, and different ones provide different results. For this reason, a standard method needs to be developed to provide a coherent result, so that the measuring of natural capital impact can be more accurate.
6. Conclusions

The PFES policy has been the subject of increasing examination. The paper’s analytical framework and method of data analysis (propensity score matching combining secondary data) provides insight into the implementation and effectiveness of the PFES policy and the measured outcomes in Central Vietnam. We identified a number of important issues related to outcomes of PFES in terms of financial and natural capital; the former comprises total household income, income sources, expenditure, and accessibility to loans from credit channels, while the latter emphasizes forest cover, area of forest, and forest cover loss.

Specifically, the study found that poor households with PFES have slightly higher income than what they would have had they not participated in PFES. However, this correlation is statistically insignificant, while the income of non-poor households with PFES was significantly higher than those without PFES. This finding shows that there is not enough convincing evidence to conclude that the PFES policy has a positive impact on the livelihoods of poor people.

Turning to natural capital, although it is early to reveal the impacts of PFES on natural capital, the study shows that the PFES policy could contribute to slight changes in increased forest area and forest cover and reduced natural forest loss between pre-PFES and PFES periods. However, the study also indicates that significant areas of natural forest still experienced loss during the PFES period. Despite the shortcomings in terms of the volume of benefits and benefit distribution from PFES, this policy will potentially enhance financial and natural capital, leading to improved livelihoods of local people and a healthier environment in the studied areas of QN and TTH provinces.

In attempting to examine whether the PFES policy is effective, the result is not straightforward. Since this paper employed case studies in two provinces, which have seven protected areas and their buffer zones, the result may not be generalizable to other regions or the whole country. Accordingly, another study with a larger sample of household surveys in different PAs or provinces is necessary. We suggest two research themes on the PFES policy and its impact on livelihood for the future: (1) Ensuring that the PFES policy provides sufficient contributions to the livelihoods of people who live in and around PAs generally, particularly the poorest, and (2) using payment from the PFES policy effectively to improve forest quality.

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References
1. Cortés-Arriagada, D.; Villegas-Escobar, N.; Ortega, D.E. Fe-doped graphene nanosheet as an adsorption platform of harmful gas molecules (CO, CO$_2$, SO$_2$ and H$_2$S), and the co-adsorption in O$_2$ environments. *Appl. Surf. Sci.* **2018**, *427*, 227–236. [CrossRef]
2. Norgaard, R.B. Ecosystem services: From eye-opening metaphor to complexity blinder. *Ecol. Econ.* **2010**, *69*, 1219–1227. [CrossRef]
3. Grieg-Gran, M.; Porras, I.; Wunder, S. How can market mechanisms for forest environmental services help the poor? Preliminary lessons from Latin America. *World Dev.* **2005**, *33*, 1511–1527. [CrossRef]
4. Pagiola, S.; Arcenas, A.; Platais, G. Can payments for environmental services help reduce poverty? An exploration of the issues and the evidence to date from Latin America. *World Dev.* **2005**, *33*, 237–253. [CrossRef]
5. Porras, I.T.; Grieg-Gran, M.; Neves, N. *All that Glitters: A Review of Payments for Watershed Services in Developing Countries*; IIED: London, UK, 2008.
6. Wunder, S.; Engel, S.; Pagiola, S. Taking stock: A comparative analysis of payments for environmental services programs in developed and developing countries. *Ecol. Econ.* 2008, 65, 834–852. [CrossRef]

7. Muradian, R.; Arsel, M.; Pellegrini, L.; Adaman, F.; Aguilar, B.; Agarwal, B.; Corbera, E.; Ezzine de Blas, D.; Farley, J.; Froger, G. Payments for ecosystem services and the fatal attraction of win-win solutions. *Conserv. Lett.* 2013, 6, 274–279. [CrossRef]

8. Wunder, S. When payments for environmental services will work for conservation. *Conserv. Lett.* 2013, 6, 230–237. [CrossRef]

9. Tallis, H.; Kareiva, P.; Marvier, M.; Chang, A. An ecosystem services framework to support both practical conservation and economic development. *Proc. Natl. Acad. Sci. USA* 2008, 105, 9457–9464. [CrossRef]

10. Landell-Mills, N.; Porras, I.T. Silver Bullet or Fools’ Gold? A Global Review of Markets for Forest Environmental Services and Their Impact on the Poor; IIED: London, UK, 2002.

11. Wunder, S. Payments for environmental services and the poor: Concepts and preliminary evidence. *Environ. Dev. Econ.* 2008, 13, 279–297. [CrossRef]

12. Li, F.; Wenhua, L.; Lin, Z.; Heqing, H.; Yunjie, W.; Naomi, I. Estimating eco-compensation requirements for forest ecosystem conservation: A case study in Hainan province, southern China. *Outlook Agric.* 2011, 40, 51–57.

13. Chen, X.; Lupi, F.; An, L.; Sheely, R.; Viña, A.; Liu, J. Agent-based modeling of the effects of social norms on enrollment in payments for ecosystem services. *Ecol. Model.* 2012, 229, 16–24. [CrossRef][PubMed]

14. Yin, R.; Liu, C.; Zhao, M.; Yao, S.; Liu, H. The implementation and impacts of China’s largest payment for ecosystem services program as revealed by longitudinal household data. *Land Policy* 2014, 40, 45–55. [CrossRef]

15. McAfee, K.; Shapiro, E.N. Payments for ecosystem services in Mexico: Nature, neoliberalism, social movements, and the state. *Ann. Am. Assoc. Geogr.* 2010, 100, 579–599. [CrossRef]

16. Hegde, R.; Bull, G.Q. Performance of an agro-forestry based Payments-for-Environmental-Services project in Mozambique: A household level analysis. *Ecol. Econ.* 2011, 71, 122–130. [CrossRef]

17. Alix-Garcia, J.M.; Shapiro, E.N.; Sims, K.R. Forest conservation and slippage: Evidence from Mexico’s national payments for ecosystem services program. *Land Econ.* 2012, 88, 613–638. [CrossRef]

18. Dempsey, J.; Robertson, M.M. Ecosystem services: Tensions, impurities, and points of engagement within neoliberalism. *Prog. Hum. Geogr.* 2012, 36, 758–779. [CrossRef]

19. Wunder, S. Revisiting the concept of payments for environmental services. *Ecol. Econ.* 2015, 117, 234–243. [CrossRef]

20. Engel, S.; Pagiola, S.; Wunder, S. Designing payments for environmental services in theory and practice: An overview of the issues. *Ecol. Econ.* 2008, 65, 663–674. [CrossRef]

21. Muradian, R.; Corbera, E.; Pascual, U.; Kosoy, N.; May, P.H. Reconciling theory and practice: An alternative conceptual framework for understanding payments for environmental services. *Ecol. Econ.* 2010, 69, 1202–1208. [CrossRef]

22. Corbera, E.; Soberanis, C.G.; Brown, K. Institutional dimensions of Payments for Ecosystem Services: An analysis of Mexico’s carbon forestry programme. *Ecol. Econ.* 2009, 68, 743–761. [CrossRef]

23. Kosoy, N.; Martinez-Tuna, M.; Muradian, R.; Martinez-Alier, J. Payments for environmental services in watersheds: Insights from a comparative study of three cases in Central America. *Ecol. Econ.* 2007, 61, 446–455. [CrossRef]

24. Kronenberg, J.; Hubacek, K. Could Payments for Ecosystem Services Create an Ecosystem Service Curse? *Ecol. Soc.* 2013, 18. [CrossRef]

25. Ezzine-de-Blas, D.; Wunder, S.; Ruiz-Pérez, M.; del Pilar Moreno-Sanchez, R. Global patterns in the implementation of payments for environmental services. *PLoS ONE* 2016, 11, e0149847. [CrossRef][PubMed]

26. Schomers, S.; Matzdorf, B. Payments for ecosystem services: A review and comparison of developing and industrialized countries. *Ecosyst. Serv.* 2013, 6, 16–30. [CrossRef]

27. VNFF 10-Year PFES Policy Review Report; Vietnam Forest Protection and Development Fund: Hanoi, Vietnam, 2018.

28. Mousquès, C.; George, A.; Sengsoulitchanb, P.; Latchachack, D.; Sengtheuanghoung, O.; Ribolzi, O.; Pierret, A. Relevance of payments for environmental services (PES) for watershed management in northern Lao PDR. *Lao J. Agric. For.* 2008, 17, 129–148.

29. Kerr, J.; Lapinski, M.; Liu, R.; Zhao, J. Long-term effects of payments for environmental services: Combining insights from Communication and Economics. *Sustainability* 2017, 9, 1627. [CrossRef]

30. Li, P.; Chen, M.-H.; Zou, Y.; Beattie, M.; He, L. Factors Affecting Inn Operators’ Willingness to Pay Resource Protection Fees: A Case of Erhai Lake in China. *Sustainability* 2018, 10, 4049. [CrossRef]
31. Lawlor, K.; Madeira, E.; Blockhus, J.; Ganz, D. Community Participation and Benefits in REDD+: A Review of Initial Outcomes and Lessons. *Forests* **2013**, *4*, 296–318. [CrossRef]

32. Wunder, S. Are direct payments for environmental services spelling doom for sustainable forest management in the tropics? *Ecol. Soc.* **2006**, *11*, 23. [CrossRef]

33. Liang, J.; Zhong, M.; Zeng, G.; Chen, G.; Hua, S.; Xue, I.; Yuan, Y.; Wu, H.; Gao, X. Risk management for optimal land use planning integrating ecosystem services values: A case study in Changsha, Middle China. *Sci. Total Environ.* **2017**, 579, 1675–1682. [CrossRef]

34. Narloch, U.L.F.; Pascual, U.; Drucker, A.G. Cost-effectiveness targeting under multiple conservation goals and equity considerations in the Andes. *Environ. Conserv.* **2011**, *38*, 417–425. [CrossRef]

35. Pascual, U.; Muradian, R.; Rodriguez, L.C.; Duraliapah, A. Exploring the links between equity and efficiency in payments for environmental services: A conceptual approach. *Ecol. Econ.* **2010**, *69*, 1237–1244. [CrossRef]

36. Miranda, M.; Porras, I.T.; Moreno, M.L. *The Social Impacts of Payments for Environmental Services in Costa Rica: A Quantitative Field Survey and Analysis of the Virilla Watershed*; IIEC: London, UK, 2003.

37. Locatelli, B.; Rojas, V.; Salinas, Z. Impacts of payments for environmental services on local development in northern Costa Rica: A fuzzy multi-criteria analysis. *For. Policy Econ.* **2008**, 10, 275–285. [CrossRef]

38. Tacconi, L. Redefining payments for environmental services. *Ecol. Econ.* **2012**, *73*, 29–36. [CrossRef]

39. Molnar, J.L.; Gamboa, R.L.; Revenga, C.; Spalding, M.D. Assessing the global threat of invasive species to marine biodiversity. *Front. Ecol. Environ.* **2008**, *6*, 485–492. [CrossRef]

40. Tacconi, L.; Mahanty, S.; Suich, H. *Assessing the Livelihood Impacts of Payments for Environmental Services: Implications for Avoided Deforestation*; Research Summary; Crawford School of Economics and Government: Canberra, Australia, 2009.

41. Ingram, J.C.; Wilkie, D.; Clements, T.; McNab, R.B.; Nelson, F.; Baur, E.H.; Sachedina, H.T.; Peterson, D.D.; Foley, C.A.H. Evidence of Payments for Ecosystem Services as a mechanism for supporting biodiversity conservation and rural livelihoods. *Ecosyst. Serv.* **2014**, *7*, 10–21. [CrossRef]

42. Blundo-Canto, G.; Bax, V.; Quintero, M.; Cruz-Garcia, G.S.; Groeneveld, R.A.; Perez-Marulanda, L. The different dimensions of livelihood impacts of Payments for Environmental Services (PES) schemes: A systematic review. *Ecol. Econ.* **2018**, *149*, 160–183. [CrossRef]

43. Tacconi, L.; Mahanty, S.; Suich, H. Forest payments for environmental services and livelihoods. In *Payments for Environmental Services, Forest Conservation and Climate Change livelihood in REED+*; Tacconi, L., Mahanty, S., Suich, H., Eds.; Edward Elgar: Northampton, MA, USA, 2010.

44. Ma, S.; Swinton, S.M.; Lupi, F.; Jolejole-Foreman, C. Farmers’ willingness to participate in payment-for-Environmental-Services programmes. *J. Agric. Econ.* **2012**, *63*, 604–626. [CrossRef]

45. Tacconi, L.; Mahanty, S.; Suich, H. The livelihood impacts of payments for environmental services and implications for REDD+. *Soc. Nat. Resour.* **2013**, *26*, 733–744. [CrossRef]

46. Clements, T.; Milner-Gulland, E. Impact of payments for environmental services and protected areas on local livelihoods and forest conservation in northern Cambodia. *Conserv. Biol.* **2015**, *29*, 78–87. [CrossRef]

47. Zheng, H.; Robinson, B.E.; Liang, Y.-C.; Polasky, S.; Ma, D.-C.; Wang, F.-C.; Ruckelshaus, M.; Ouyang, Z.-Y.; Daily, G.C. Benefits, costs, and livelihood implications of a regional payment for ecosystem service program. *Proc. Natl. Acad. Sci.* **2013**, *110*, 16681–16686. [CrossRef]

48. Bremer, L.L.; Farley, K.A.; Lopez-Carr, D. What factors influence participation in payment for ecosystem services programs? An evaluation of Ecuador’s Soc’Oparo program. *Land Use Policy* **2014**, *36*, 122–133. [CrossRef]

49. USAID Green Annamites. Thua Thien Hue Portal. Available online: https://thuathienhue.gov.vn/en-us/Investor/Investor-detail/tid/Truong-Son-Xanh-Green-Annamites-project-launched/newsid/4559E212-9BF7-43B7-B18C-AB8100511E1E/cid/A1B8E73D-A1A6-4843-A990-C4E40BC38B2 (accessed on 18 December 2018).

50. Babbie, E. *The Practice of Social Research*; Wadsworth: Belmont, CA, USA, 2010; p. 625.

51. USAID Green Annamites Project. *Livelihood Needs Assessment in Quang Nam and Thua Thien Hue Province*; CRD funded by USAID: Washington, DC, USA, 2017; p. 191.

52. Dana Tomlin, C. *Geographic Information Systems and Cartographic Modeling*; Englewoods Cliffs, Prentice-Hall: Upper Saddle River, NJ, USA, 1990; p. 249.

53. Campbell, J.B. *Introduction to Remote Sensing*; The Guilford Press: New York, NY, USA, 1987.

54. General Statistics Office of Vietnam. Available online: https://www.gso.gov.vn/Default_en.aspx?tabid=491 (accessed on 15 December 2018).
55. USAID Green Annamites Project. Final Report of Baseline Assessments for Low Emission Land Use Planning and to Support. Development of REDD+; CRD funded by USAID: Washington, DC, USA, 2018; p. 101.
56. Ezzine-de-Blas, D.; Corbera, E.; Lapeyre, R. Payments for environmental services and motivation crowding: Towards a conceptual framework. *Ecol. Econ.* 2019, 156, 434–443. [CrossRef]
57. Bremer, L.L.; Farley, K.A.; Lopez-Carr, D.; Romero, J. Conservation and livelihood outcomes of payment for ecosystem services in the Ecuadorian Andes: What is the potential for ‘win–win’? *Ecosyst. Serv.* 2014, 8, 148–165. [CrossRef]
58. Pham, T.V. Lessons and Experiences from Implementation of PFES in Vietnam. Presented at the ASFN Workshop Inle Lake, Shan State, Myanmar, 1–3 June 2015.
59. Alston, L.J.; Andersson, K.; Smith, S.M. Payment for Environmental Services: Hypotheses and Evidence. *Annu. Rev. Resour. Econ.* 2013, 5, 139–159. [CrossRef]
60. Wunder, S.; Albán, M. Decentralized payments for environmental services: The cases of Pimampiro and PROFAFOR in Ecuador. *Ecol. Econ.* 2008, 65, 685–698. [CrossRef]
61. De Man, M. Local Impacts and Effectiveness of Payments for Environmental Services in Costa Rica: The Case of Payments for Forest Hydrological Services in Costa Rica’s Aranjuez Watershed; Utretch University: Utrecht, The Netherlands, 2004.
62. Calvet-Mir, L.; Corbera, E.; Martin, A.; Fisher, J.; Gross-Camp, N. Payments for ecosystem services in the tropics: A closer look at effectiveness and equity. *Curr. Opin. Environ. Sustain.* 2015, 14, 150–162. [CrossRef]
63. Kwayu, E.J.; Paavola, J.; Sallu, S.M. The livelihood impacts of the Equitable Payments for Watershed Services (EPWS) Program in Morogoro, Tanzania. *Environ. Dev. Econ.* 2017, 22, 328–349. [CrossRef]
64. Trac, C.J.; Schmidt, A.H.; Harrell, S.; Hinckley, T.M. Environmental reviews and case studies: Is the returning farmland to forest program a success? Three case studies from Sichuan. *Environ. Pract.* 2013, 15, 350–366. [CrossRef]
65. Hansen, M.C.; Potapov, P.V.; Moore, R.; Hancher, M.; Turubanova, S.; Tyukavina, A.; Thau, D.; Stehman, S.; Goetz, S.; Loveland, T.R. High-resolution global maps of 21st-century forest cover change. *Science* 2013, 342, 850–853. [CrossRef]
66. Samii, C.; Lisiecki, M.; Kulkarni, P.; Paler, L.; Chavis, L. Effects of payment for environmental services (PES) on deforestation and poverty in low and middle income countries: A systematic review. *Campbell Syst. Rev.* 2014, 10, 1–95. [CrossRef]

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