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Ecosystem Services in Mountainous Area: A Case Study of Nghe an, Vietnam

Hoang Phan Hai Yen, Nguyen Thi Viet Ha, Binh Thai Pham[1*]; Indra Prakash[2], Lai Van Manh[3], Nguyen Thi Thuy Dung[4], Phan Bui Quoc Manh[5], Tran Thi Tuyen[6*]

Department of Geography, School of Social Sciences Education, Vinh University, 460000, Vietnam
[1]University of Transport Technology, Hanoi 100000, Vietnam.
[2]Department of Science & Technology, Bhaskarcharya Institute for Space Applications and Geo-Informatics (BISAG), Government of Gujarat, Gandhinagar, India
[3]Institute of Strategy and Policy on Natural Resources and Environment, Hanoi, Vietnam
[4]Education for Nature of Vietnam (ENV) - 17T5 Hoang Dao Thuy street, Thanh Xuan, Hanoi;
[5]Nghe An Center Natural Resource and Environment of Monitoring, No. 4, Duy Tan street, Hung Phuc ward, Vinh city, Nghe An province, 460000, Vietnam
[6]Department of Resource and Environment Management, School of Agriculture and Resources Vinh University, 460000, Vietnam
**E-mail: binhpt@utt.edu.vn; ttt.dhv@gmail.com*

Abstract: A study was carried out in the mountainous Western area of Nghe An province, Vietnam, which is a forested area inhabited by ethnic minorities for payment for forest environment services with focus on watershed protection and carbon sequestration services. Remote sensing - GIS methods were used to map forest area for biomass assessment. In addition, the method of determining the level of payment for forest environmental services was used to calculate the Pu Hoat natural reserve. The study shows that there is great potential for the development of forest ecosystem services in the study area, which can contribute significantly to improve the livelihoods of indigenous people besides protecting/enriching forest capital. A number of practical solutions to improve the good implementation of forest environmental services have been proposed for the study area, which can also be applied in other areas. This research has highlighted the practical benefits of the Forest (environmental) Payment Service (FPS) and pointed out the shortcomings that need to be addressed.

Keywords: Forest Payment Service (FPS), Carbon absorption capacity, Nghe an province, Vietnam

A payment for Ecosystem or Environmental Services (PES) is an innovative approach for the nature conservation. Ecosystem services are the benefits that humans derive from natural systems. PES encourages the maintenance of natural ecosystems through environmentally friendly practices. People seek many services from ecosystems of forests and thus perceive the condition of an ecosystem in relation to its ability to provide desired services (Burkhard et al 2012). Ecosystem services include provisioning services obtained directly from the ecosystem such as food provision, regulating services such as water regulation, habitat, air quality, and water quality, and cultural services, which the people obtain through tourism, aesthetic values, spiritual enrichment, and sense of place (Perrings et al 2011, Wainger et al 2011). The ecosystem services approach is useful for decision-making in conservation and natural resource management because it assigns value to nature by translating ecosystem properties into human needs (Castro et al 2013). This is a rather complex issue, including ecosystems, natural resources, economic, social and human values in space, so the integration of both natural and social science perspectives is needed (Helfenstein and Kienast 2013). Ecosystem services provide a valuable framework for analyzing and acting on the linkages between people and their environment (Gomiero et al 2003). PES is becoming increasingly popular in recent years as a market-based approach to conserve and manage ecosystems that uses economic incentives to improve the livelihoods of environmental-service providers.

In developing countries like Vietnam, poverty households control much of the ecologically sensitive land, so the potentials to gain benefit from PES is eligible at the household or community level, in different forms (Pagiola et al 2005, 2008, Phuc et al 2012). The potential for PES to alleviate rural poverty by 2030 in developing countries was quantified, which indicated that markets for biodiversity conservation could benefit 10-15 million, carbon markets could benefit 25-50 million, markets for watershed protection could benefit 80-100 million, and markets for landscape beauty and recreation could benefit 5-8 million (Wunder and Dung 2005, Milder et al 2010). In Vietnam, pilot project of PES schemes has been implemented in Vietnam with partial success associated with some problems such as insecure land tenure, high transaction costs, and potential risk for livelihood of households (Chiramba et al 2011, Turner and Pham 2015). These issues are also challenges of the

mountains of Nghe An, province of Vietnam that selected as study area. Our present research aim is to address the questions of how is the service potential to pay for forest environment? how has the locality made payment?, how do people perceive and assess this issue?, what solutions can be applied to make PES better? and answer to these questions requires detailed information of Land Cover (LC), which may change with the population growth and area development. The, vegetation may differ in pools of carbon capacity and their sequestration rate with time (Vitousek et al 1997; Gomiero et al 2000, Chauhan et al 2016, Sharma et al 2016). LC change leads to the change of forest function. Thus, it is required to update forest status and accordingly change the value of payment for forest environmental services for unit areas. This will encourage upland farmers to protect and plant more forests.

MATERIAL AND METHODS

Methodology adopted in this study mainly include generation of land cover map of the study area, determination of carbon absorption capacity and ethnographic interviews.

Study area: This study was conducted for the Western Nghe An province, located in the middle of Vietnam (Fig. 1), where has steeply sloping terrain, upstream of rivers and diverse tropical forest ecosystems. Same as tropical forest areas in Vietnam (about 15 per cent of the Vietnamese population and 30 per cent of the country's poorest people) (Nguyen and Masuda 2015), there are mainly inhabited by ethnic minorities (Thai). The livelihoods of local people depend mainly on forests. In Nghe An, more than 80 per cent of Thai ethnic depends on the agricultural production and rely on traditional agriculture. Que Phong district is located in the high mountains of Nghe An province, belong to Pu Hoat Nature Reserve. The steep sloping terrain and large flow are favorable conditions for this district to build four hydroelectric plants. The majority living by practicing their own traditional knowledge of agriculture by protecting biodiversity in the buffer zone of Pu Hoat Nature Reserve. This knowledge has led to the creation of a strong relationship between the local culture and natural resources, which has helped in managing and protecting biodiversity in this area. People from ethnic minorities are normally subsistence farmers depending on the natural resources (Brandon 2014). When the land they cleared belongs to the managed. Traditional land use rights of these peoples are not guaranteed they clear land in the Pu Hoat nature reserve.

Generation of land cover (LC) map: The LC map was generated from Landsat 8 images of the United States Geological Survey (USGS) using remote sensing method (Dorren et al 2003, Dwivedi et al 2005). Normalized Difference Vegetation Index (NDVI) was applied for the development of LC map by using the formula *NDVI = (NIR – VIS)/ (NIR + VIS)* (Afirah Taufik et al 2019, Xu et al 2014).

NDVI values at a point (position) on the image ranges from (-1) to (+1). Areas of barren rock, sand, or snow usually show very low NDVI values (0.1 or less). Sparse vegetation (shrubs and grasslands) may result in moderate NDVI values (approximately 0.2 to 0.5). High NDVI values (approximately 0.6 to 0.9) correspond to dense vegetation. Higher values of NDVI indicate stronger photosynthetic especially in temperate and tropical forests or crops at their peak growth stage. The NDVI values can be used in the identification of vegetation including forest types. Maps of the study area were generated using NDVI indices, Google Earth Images and GPS survey data in GIS environment (Vieira et al 2012).

Determination of carbon absorption capacity*:* The carbon absorption assessment and commercial value of carbon accumulated can be evaluated by determining biomass of forests. In this study, we used the remote sensing method in conjunction with field survey for mapping biomass to determine the carbon absorption capacity of forest vegetation, which would be useful for carbon trade. In the study area, we selected 09 Typical Standard Cells (TSC), of 9 m x 9m dimension representing forest types (Table 3, 4 and Fig. 5). In each TSC, species name, density, spacing between trees, height, Diameter at Breast Height (DBH) and basal area of the tree were measured. This information was verified and improved by field survey and interviewing forest owners (Questionnaire in standard format). In order to determine the value of biomass, measurement values of TSC were converted by the formula Y = 0:11 * r * D1.32 + c;

Where: D1 is tree biomass (kg tree^{-1}); r is wood density (for forests re-afforested naturally: r =0.5g cm^{-3}); c is the extrapolation factor (for forests re-afforested naturally: c = 0.62).

The amount of carbon absorption was calculated as:

WC (ton C ha^{-1}) = 0.46 *Mass.

The value of carbon trading: C (USD) = WC * 5 (USD).

Ethnographic interviews: Socio-economic ecosystem service survey of forest area was conducted at six case sites located in Pu Hoat area. Each survey site corresponds to six different villages. The survey was conducted in different villages (the Na Sai, Pa Com village in Hanh Dich commune, Que Phong district; the Phuong Tien, Dan village in Tien Phong commune, Que Phong district; the Muong Phu, Muong Phiet villages in Thong Thu commune, Que Phong district) to ensure the reliability of the data collection for the analysis (Fig. 4). In total 300 persons were interviewed through questionnaires. The population samples were

selected to cover a wide range of ecosystem service beneficiaries such as local inhabitants and environmental technical experts. In each village, 50 representative households (16.67%) were surveyed under the guidance of local officials. After doing survey in the field, data were analyzed to judge perceptions of ecosystem services to explored status of payments for forest environment services in western Nghe An including advantages and disadvantages; the level of willingness of the payer to pay, and the level of satisfaction of the beneficiary .

RESULTS AND DISCUSSIONS

Land cover (LC) map: Generation of LC map (Fig. 4) of the study area was done to analyse and evaluate status of the vegetation and carbon sequestration in this area. The NDVI of the area was determined using ENVI 5.0 software as shown in Table 1. Results showed that the NDVI index for the different classes of vegetation in the study area is generally high (0.1 to >0.7; NDVI mean = 0.280330), which represent dense vegetation.

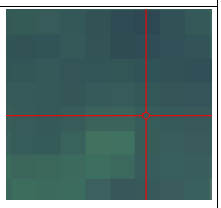
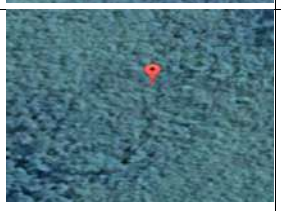
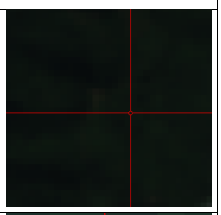
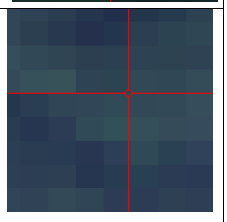
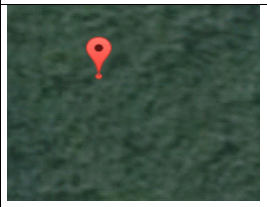
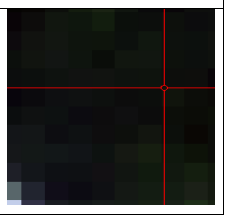
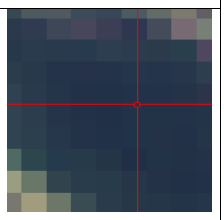
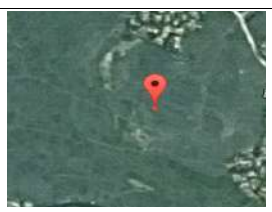
Potential of Carbon Storage and Sequestration

Value of biomass and commercial carbon: The location of the standard plots was selected, representing forest types. Coordinates of locations were determined from Google Earth Images, and verified by GPS survey, besides layout of roads and traffic conditions (Table 2). The result of field survey shows that most of vacant forest in the research area comprises of barren land, shrubs interspersed with trees (trees regenerate 10% coverage). The quality of poor natural tropical forest is low, trees are small: the diameter of average tree^{-1} ranges from 9.71 to 10.41cm, the sum of horizontal section (area) of trees ranges from 4.13 to 4.52 m^2, the destiny ranges from 451 to 510 tree ha^{-1} and the average height ranges from 9.59 to 10.52 m. The native forest regeneration is of large trees with complex species. The average diameter of trees is greater than 10 cm, whereas, the average height ranges from 10.5 to 12.65 m of rich and medium natural tropical forest.

Table 1. NDVI index of forest area

Order	NDVI	Objects	Area (ha)
1	< 0.1	Vacant land; Other land cover	696
2	0.1 – 0.3	Agricultural crop	127
3	0.3 – 0.5	Native forest regeneration; Poor natural tropical forest; Planted forest	31189
4	0.5 – 0.7	Young forest restoration; Tropical mixed forest	31181
5	> 0.7	Rich nature forests, Medium nature forests	44791
Sum			107984

Table 2. Position of standard plots

Coordinates (GPS-ArcGIS)	Location in Google Map	Sample interpretation key
19°33'33.10"N105°3' 28.26"E		
		
19°25'24.15"N104°5 3'8.35"E		
19°35'59.88" 105°1'2.57"E		
19°24'49.03"N 104°49'4.67"E		
19°33'39.32"N10 5°4'25.08"E		
19°33'15.91"N 105°12'40.20"E		
19°34'43.59"N 105°2'10.01"E		

The average of biomass determined at each TSC is 79.418 (ton ha^{-1}). Total biomass of naturally re-afforested forest area in Que Phong district is 10587497.916 ton. The quantity of Carbon accumulated in biomass of naturally re-afforested forest area in Que Phong district is 2812985.5 ton. The commercial value of forest carbon cover in Que Phong district is C = 14064927.8 USD (Tables 3, 4).

Potential of payment for forest ecosystem services: The study area was divided into three types of forest (special use forest, protection forest and planted forest) and there were two types of allocation schemes, in which special use forest and protection forest are grouped into one type. The division ensures feasibility and scientifically determining the coefficient 'K', which is required to determine the relative value of different forest areas based on an average of four factors: forest type (KLR) (protection category/special use/production); quality of forest (KCLR) (rich/moderate/poor/secondary); origin of forest (KNGR) (natural forest/planted forest); and human impact (KTĐ) (near road or residential areas,/remote forest area) (Chiramba et al 2011). The national pilot policy on PFES provided guidance for applying a coefficient (the 'K coefficient') to determine the relative value of different forest areas based on an average of four factors, that is coefficient K= (KLR+KCLR+KNGR+KTD). Currently, in Nghe An province, only four hydroelectric plants built earlier were the sole payer for local forest services (Table 5). Vietnam Government stipulates that the level of payment for environmental services applied to hydropower generation facilities is 0.001585 USD/kWh (Decree No. 147/2016/ND-CP dated 2 November 2016, https://thuvienphapluat.vn/van-ban/tai-nguyen-moi-truong). For the total area 139723.08 ha, the total amount collected from the ecosystem services is 1965954.75 USD. The average payment per hectare of forest (P) at Pu Hoat Nature Reserve is 14.07 USD (Table 5).

The amounts of money, which service users (hydropower plants), have to pay for forest protection and management of the region**:** The amount of money that Pu Hoat nature reserve received is 1207488.41 USD. Population in the Western Nghe An currently is estimated to be 1109.052 people. Had this payment been made, local people would had the opportunity to receive more money. The amount of additional money would be 567498.35 USD (Table 6). Similarly, each year from 2018 to 2020, amount at Pu Hoat NR to be received for services would be 1208184.77 USD, 1208741.85 USD and 1211062.99 USD, respectively.

Actual benefit of local people from forest environmental services: In Nghe An only payments was made for watershed protection services. In this case, estimated value for people services which they would have received for one ha of forest is VND 287,621.34. However, in reality, the payment value is much lower than the estimation (in Pu Hoat NR is now VND 197,000 ha^{-1} $year^{-1}$). Moreover, Western Nghe An forests, still had great potential for the CO^2 absorption service. Results of the natural forest area (for protection forests) analysis indicated that in Que Phong district each hectare of forest was worth 4,961,000 VND. Had both services been implemented (watershed protection and carbon sequestration), the income for the protection of forest would had increased significantly. This will improve livelihood of people, and thus they will be motivated to protect and develop forests.

Local perception of ecosystem services of tropical forests: Survey of the study area revealed that most people were aware about payments for the ecosystem services

Table 3. The results of trees density and size analysis in the TSC

	Density N/0,81 ha (1 tree)	$D_{1,3}$ (cm)	H_{vn} (m)	Basal area G (m^2 ha^{-1})
TSC1	458	10.03	11.55	5.06
TSC2	451	9.82	10.43	4.52
TSC3	510	10.15	10.32	5.99
TSC4	405	10.07	12.77	5.14
TSC5	335	12.20	11.93	6.12
TSC6	370	11.82	12.65	5.63
TSC7	385	10.41	10.52	4.13
TSC8	459	9.71	9.59	4.25
TSC9	258	8.3	11.31	4.14

Table 4. Results of biomass determined at the sample plots

TT	TSC1	TSC2	TSC3	TSC4	TSC5	TSC6	TSC7	TSC8	TSC9
Biomass	83.55	71.22	85.13	82.34	93.39	102.67	68.91	65.16	37.14

Table 5. The amount of money the hydropower plants have to pay

Payer	Calculation unit	Production	Unit price	Total amount
Hydropower plant Sao Va	KWh	13450,00	0.001585	21318.25
Hydropower plant Ban Coc	KWh	80000000	0.001585	126800
Hydropower plant Hua Na	KWh	716900000	0.001585	1136286.5
Hydropower plant Cua Dat	KWh	430000000	0.001585	681550
Total				1965954.75

Fig. 1. The location of study area

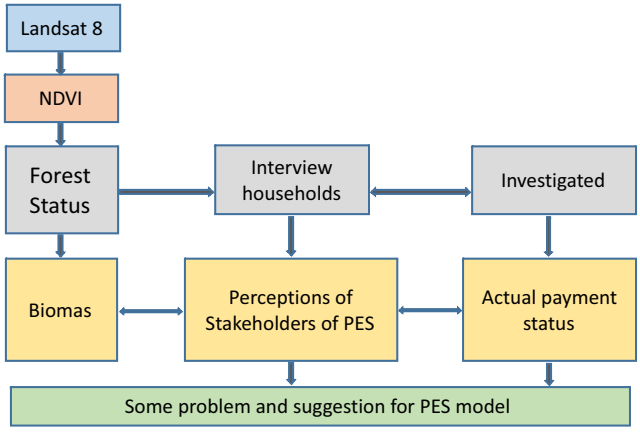


Fig. 2. Flow chart of study

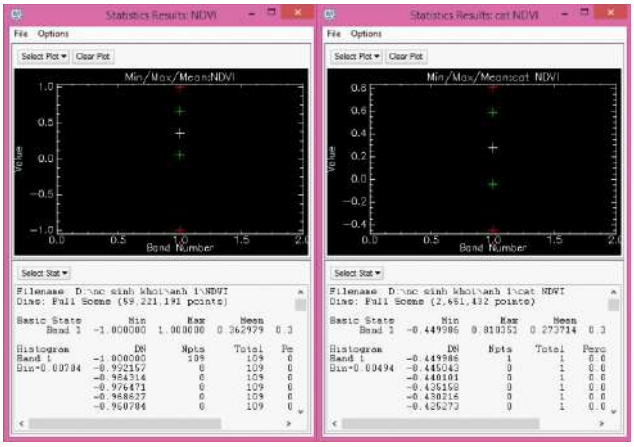
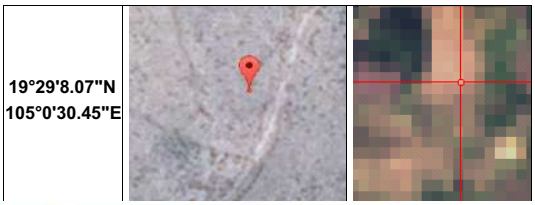


Fig. 3. The statistics of NDVI

Fig. 4. Forest map developed from NDVI index



MAP OF VEGETATION AND SAMPLING LOCATIONS IN QUE PHONG DISTRICT

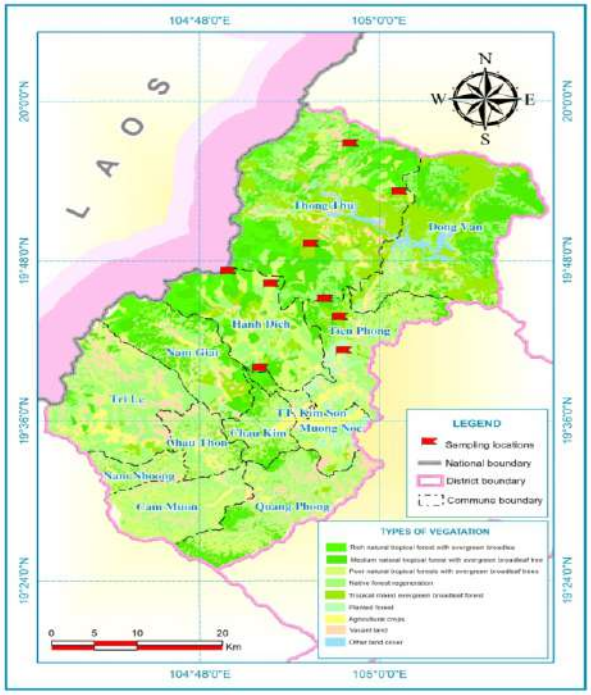


Fig. 5. Location of TSC

(96.67%). Out of the 300 respondents, 157 (52.33%) answered the purpose of the payment is to protect watershed, remaining 143 (41.33%) answered that it is for protecting the forest as well as to ensure livelihoods of forest owners (Table 7). People were also asked about the main responsibility for implementing the forest environment payment service, virtually all of those who responded said that it was hydropower plants. In total, 219 people (73%) opined that the payment was for hydropower plant service (Table 8). The payment for the forest environment and the method of payment determination were relatively simple, which only apply for watershed protection services. Payment levels were not too high, suitable for the process of operation as well as revenue/expenditure of the payers. Methodology of payment service was not much clear to the respondent, so most of them expressed their dissatisfaction.

The level of satisfaction of the beneficiary: In the study area, local people were aware of the importance of forest payment services. Out of the 300 house inhabitants interviewed, 294 people (98%) said that payment for forest environment was very necessary (Table 9). During interviews, most of the respondents said that the amount of money they received from the services contributed significantly in improving their living condition. Analysis of survey data indicated that for their daily living, 58.33% people expressed satisfaction with the amount they received, whereas 32.34% people were unsatisfied (Table 10). This study reveals that the payment for the forest environment services is still inadequate. Therefore, it is required to be revised and enhanced to improve further quality of their living condition.

Suggestions of Management to Improve PES Effectiveness in Western Nghe An

Orientation of the carbon exchange market model: The carbon exchange market model include the suppliers and enterprises for PES as below (Fig. 6):

Suppliers: Carbon credits are provided by many people and agencies (local people, protected area management boards, forest protection stations, and those directly involved in the protection and replanting of forests). Parties of verification and calculation of services include foreign-invested joint

Table 6. The amount of money, which the hydropower plants were required to pay

Forest area	Average price	Coefficient K	Area (ha)	Total amount (USD)
Special purpose forests				
i. Natural forest	14.07	1.3	30929.43	565730.20
ii. Planted forest	14.07	1.1	0	0
Protective forest				
i. Natural forest	14.07	1.3	42210.43	772070.98
ii. Planted forest	14.07	1.1	1.01	15.63
Planted forest				
i. Natural forest	14.07	0.9	319.56	4046.59
ii. Planted forest	14.07	0.7	0	0
Total			73460.43	1207488.41

Table 8. Payment responsibility to ecosystem services

Payment responsibility	Number of people	Portion (%)
Authorities	4	12
Hydropower plants	25	73
Tourism enterprises	2	3
Others	4	12
Total	35	100

Table 9. Evaluate the necessity of forest environmental payment services

Levels of evaluation	Number of vote (person)	Scale (%)
Unnecessary	2	0.67
Normal	4	1.33
Necessary	102	34.0
Very necessary	192	64.0
Total	300	100

Table 10. Assess the degree of satisfaction with the amount

Result (n=300)	Levels of assessment		
	Very satisfied	Satisfied	Unsatisfied
The number of vote	28	175	97.0
Portion (%)	9.33	58.33	32.34

Table 7. Local perception of ecosystem services of tropical forests

Levels of knowing about the service	Number of people	Portion (%)	Payment purposes	Number of people	Portion (%)
Yes	32	91.45	Pay for forest owners to ensure livelihoods	124	41.33
No	0	0	Pay for the state	4	1.33
Unknown	1	2.85	Pay for watershed protection	157	52.33
No idea	2	5.7	Others	15	5.01
Total	35	100	Total	300	100

Table 11. Assess the time of payment

Result (n=300)	Levels of assessment			
	Unreasonable	Reasonable	No comment	Suggestion
The number of vote	156	50	94	Payback regulators
Scale (%)	52	16.67	31.33	

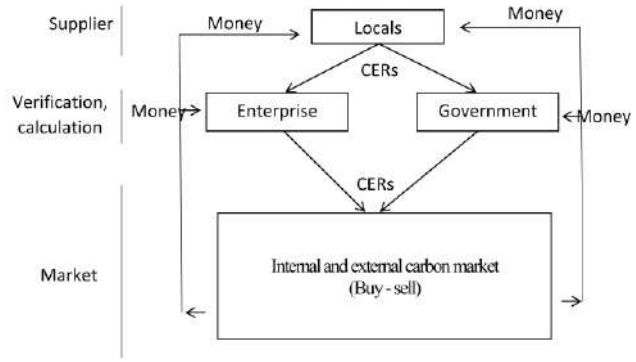


Fig. 6. Flow diagram of the carbon exchange market model in Nghe an province

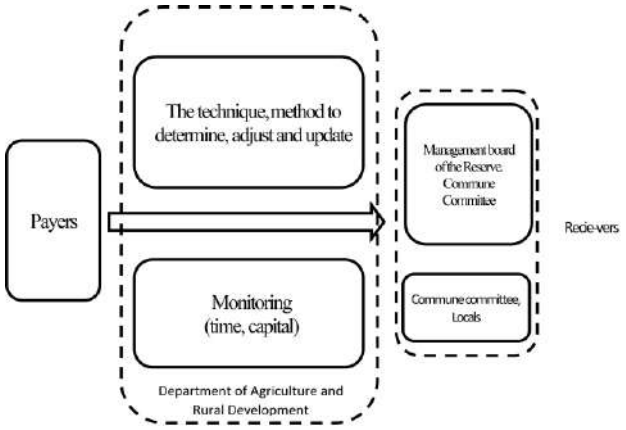


Fig. 7. Direct payment model applied for West Nghe An

ventures, private companies, or government agencies, which calculate the carbon sequestration from the forests.

Enterprises: Enterprises who can participate in this market are forestry companies, hydropower plants companies such as Ban Coc, Khe Bo.

Building a model of direct payment: Payers (hydropower plants, water plants) in the province will pay directly to the receivers (forest guards, mainly forest owners and management staffs of nature reserves, national parks). Funding would be provided by the management boards of nature reserves, national parks/authorities. In order to make payments directly, it is necessary to have an agency to calculate and determine the level of payment reasonably and logically. Technical and professional department under the Department of Natural Resources and Environment. Supervision (including monitoring the implementation of calculation and distribution, implementation of payments) are also required to be strengthened. This will help in direct cash transfer directly from "seller" to "buyer". This will ensure timely payment and more transparency by avoiding intermediaries (Fig. 7).

CONCLUSIONS

The mountains West Nghe An province, Vietnam has enriching forest capital for the development PES. This potential to become very valuable mechanisms for generating new revenues and transfer of money to concerned people for sustainable development. The benefits of the Forest (environmental) Payment Service (FPS) the shortcomings that need to be addressed. This method would also help in building capacity of development in poor and indigenous communities, especially ethnic minorities. The implementation of forest environmental services have been proposed for the study area, which can also be applied in other areas. Payments for environmental services (PES) model help in the better protection of forest and in the implementation of policies for the forest area development. With this model local people realized the purpose and value of forest protection, thus, they agreed to participate in the conservation of forest and development of the area. Government is willing to pay for tree planting and protecting forest activities in the western Nghe An area. The carbon exchange market in the times to come for the western region of Nghe An. This model was applied for the limited period in the study area, which is recommended to be continued for long term assessment of its effect on the ethnic population.

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