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CHARACTERIZING AGRO-FORESTRY SYSTEMS IN DIEM HAMLET, CHAU KHE COMMUNE, CON CUONG DISTRICT, NGHE AN PROVINCE

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ABSTRACT

In order to discover their potential for development, this study aims to characterize the agro-forestry systems (AFS) in Diem - a remote village of Chau Khe commune located within the buffer zone of Viet Nam's Pu Mat National Park. Secondary data collected from available district and provincial sources were combined with primary data obtained by seven different methods. In order to evaluate the potential of the current AFS models, the study focused on analyzing three aspects: social, economic and environmental benefits. Results of the study showed two types of AFS which were currently adopted in Diem village: traditional and innovative. The analytical results also showed that all land use types in current AFS in Diem were profitable with positive Net Present Values (NPV). The livelihoods of local people depended much on on-farm and off-farm activities. Of these, cassava planting, acacia plantation, and animal husbandry were considered the main productions contributing to household income. A cost benefit analysis of potential alternative livelihood options in Diem indicated that gross revenues for bamboo and acacia plantations were 6 million and 18 million VND/ha respectively while cassava growing generated only 2.5 million VND/ha. With regard to the environmental aspect of the AFS model, the study indicated that the average above-ground forest carbon stock in designed strata in Diem is 40.15 tons/ha, however there was more than 70 tons/ha in variance between the maximum and the minimum values. Interestingly, the plots that have few trees and where bamboo is the dominant tree, carbon stock is often low. Enhancing benefits from shifting cultivation planning area, conducting forest land allocation or contracts for forest protection, and developing home gardens and forest gardens are three proposed recommendations for sustainable development of AFS in Diem.

Keywords: Agro - forestry, carbon stock.

Phân tích hệ thống nông lâm kết hợp tại Bản Diềm, xã Châu Khê, huyện Con Cuông, tỉnh Nghệ An

TÓM TẮT

Nghiên cứu này tập trung phân tích hệ thống nông lâm kết hợp tại bản Diềm, thuộc vùng đệm của Vườn quốc gia Pù Mát theo ba nhóm tiêu chí là trữ lượng carbon, hiệu quả kinh tế và đặc điểm sinh kế của người dân. Nghiên cứu sử dụng số liệu thống kê tại địa phương kết hợp với điều tra thực tế, bao gồm phỏng vấn hộ gia đình, thảo luận nhóm người dân và đo sinh khối rừng. Kết quả phân tích cho thấy tại địa bàn nghiên cứu có hai loại hệ thống nông lâm kết hợp chính là mô hình truyền thống và mô hình cải tiến; Hiệu quả kinh tế của những loại hình sử dụng đất thuộc các hệ thống nông lâm kết hợp đều có giá trị lợi nhuận ròng NPV dương. Sinh kế của người dân địa phương phụ thuộc chủ yếu vào trồng sắn, trồng keo, và chăn nuôi; Thu nhập ròng trong trồng Mét và Keo dao động từ 6 - 18 triệu đồng/ha trong khi đó thu nhập ròng từ trồng sắn chỉ đạt 2,5 triệu đồng/ha. Hiệu quả môi trường của các mô hình nông lâm kết hợp được thể hiện quả trữ lượng carbon bề mặt với mức dao động từ 12,17 - 84,58 tấn/ha. Những ô tiêu chuẩn có giá trị carbon bề mặt thấp thường có tre nứa chiếm ưu thế và rất ít cây thân gỗ. Đề xuất cho giải pháp phát triển các mô hình nông lâm kết hợp cho bản Diềm bao gồm (i) nâng cao lợi ích từ các khu vực quy hoạch canh tác nương rẫy; (ii) thực hiện giao đất lâm nghiệp hoặc thực hiện hợp đồng bảo vệ rừng và phát triển vườn nhà và vườn rừng.

Từ khóa: Nông lâm kết hợp, trữ lượng carbon.

1. INTRODUCTION

Nghe An is a north central province of Viet Nam where shifting cultivation is still the main source of income for a large number of ethnic minority people (UNDP and FAO, 1996). Many efforts of the Vietnamese government and NGOs have been put into the practice for sedenterizing shifting cultivators in mountainous areas. Agro-forestry has been the solution that was successfully applied on the transition from shifting cultivation to the permanent agricultural production with several advantages under practicable policy for sustainable development of agricultural and forestry productions (MARD, 1996a; MARD, 1996b; MARD, 1996c). Therefore, the development of agro-forestry systems (AFS) in the areas of shifting cultivation has been often found in the uplands of Viet Nam, including Nghe An province (SIDA and IUCN, 1991).

The practice of shifting cultivation under the sedenterised context is also referred to as "swiddening cultivation" (Do, 1994) and it can be classified as an agro-forestry system (Tran, 2005). This AFS is now recognized as an applied science in assuring food security, reducing poverty and enhancing ecosystem resilience on small farms in the tropics (Sanchez, 1999). However, the advantages of this system are not always fully understood by policy makers due to the diverse practices and the dynamic nature of the systems (Tran, 2005 and Sanchez, 1999).

The lack of information on characteristics of current AFS is a major constraint for sustainable development of these models in the uplands of Nghe An province. Recent studies (Tran, 2005; Nguyen et al., 2007) only focused on the general classification of AFS and marketing issues under implementation of government forest and land allocation (FLA) policies. It is necessary to understand the contributions of current AFS to local livelihoods, household income and environmental protection and for planning and managing natural resources sustainably and conserving biodiversity in this area (World Bank, 1995).

This paper aims to analyze current AFS in Diem, a typical remote upland hamlet, to identify their contributions to the livelihoods of the local people, to determine the potential and constraints in developing AFS and propose recommendations for future development of the AFS based on environmental, social and economic perspectives.

2. MATERIALS AND METHODS

2.1. Data collection

Secondary data about natural, socio-economic and environmental conditions, shifting cultivation status and land use/land cover types were collected from the local and central government offices. Additionally, spatial data such as current land use maps, topography, administrative boundaries, and transportation and rivers/streams systems were collected from previous studies, provincial and district departments.

Primary data collection was conducted using several tools including household surveys with structured questionnaires, key informant interviews, focus group discussions, participatory mapping, and participatory monitoring of above ground forest biomass.

Household surveys were carried out with 50 randomly selected households in Diem hamlet. Collected information focused on factors influencing farmer's adoption of AFS such as soil conditions, water sources, land tenure, labour use, education, household income, and off-farm activities.

Key informant were interviewed to investigate the local leaders' opinions and view points about the potential and constraints related to the development of AFS at the study site.

Focus group discussions were held with two different groups of farmers who engaged in AFS and those who did not. The purpose was to gather their ideas, experiences and problems that they have faced in the practice of their AFS. During these discussions, all participants were asked to describe their areas and to

visualize their homes, roads, rivers and special land marks and to sketch on the maps.

The participatory monitoring of above ground forest biomass was applied based on the Rapid Carbon Stock Appraisal framework (Grace et al., 2008). The land-use base map was used to let the community group indicate one representative strata for forest type/tree density of the village. Randomly 30 plots were selected from Diem village in a strata design from transects work. When the design strata and plots were completed, the research group and selected farmers located the plots in the forest by using Global Positioning System (GPS) receivers and printed maps of strata and plots. Groups of three researchers and four local farmers then recorded the GPS information of each plot center and marked each plot center permanently with paint on a vertical tree trunk. The plot was established using a measuring tape and compass and then information was collected on the DBHs and tree taxa/wood density classes. Wood density classes of low, medium, heavy, very heavy ("sinkers") allow the use of different equations to convert stem measurements to biomass according to wood density.

2.2. Data analysis

2.2.1. Qualitative analysis

A descriptive analysis was used to analyze key parameters of shifting cultivation and AFS potential. This allowed the authors to determine the reasons why local farmers were giving up shifting cultivation and why only a few households had selected agro-forestry practices. It also analyzes factors influencing farmer's adoption of AFS.

2.2.2. Quantitative analysis

All primary data were analyzed by descriptive statistical methods to explore the current effects of AFS on livelihoods of people in Diem hamlet. Above ground carbon stock (C) was calculated according to formula of Hairiah et al. (2011) as following:

C = (WD*0.11*D^2.62)/PS*10*0.46

Where:

WD is Wood density

D is Diameter

PS is Plot size

2.2.3. GIS mapping and analysis

GIS extensions in ArcGIS 9.3 software was used to generate current and previous land use maps and carbon stock maps. All data is registered with Geo-reference of UTM - WGS84 Zone 48N.

3. RESULTS AND DISCUSSIONS

3.1. Background of the study area

The study site (Diem hamlet) is located an upland community in Chau Khe commune, Con Cuong district of Nghe An province of Viet Nam (See Figure 1). This hamlet has been selected because it has been mainly inhabited by ethnic minority people and AFS has been introduced in the shifting cultivation areas.

The study area is characterized by poverty with low crop productivity, low income and poor infrastructure. The climate of the site is characterized as monsoon tropical with two main seasons. The hot season is usually from April to October with temperatures sometimes reaching 43^0C, while in the winter season the temperatures might drop to 5^oC in January. Diem village was established around 1890 with only 15 households of Kinh people who came from Do Luong district (about 60 km away) to look for better livelihood opportunities. Later, many men married Thai women in the area. At the beginning, most households were scattered over a large area but around 1989 they gathered in Diem village. In the village, nowadays, immigration was much more than migration. In 1956 a main road was built to connect other places to Diem village and so that trucks can easily access the village. In 2000 the village was connected to the electric grid. The land use status of Diem village is presented in Figure 2.

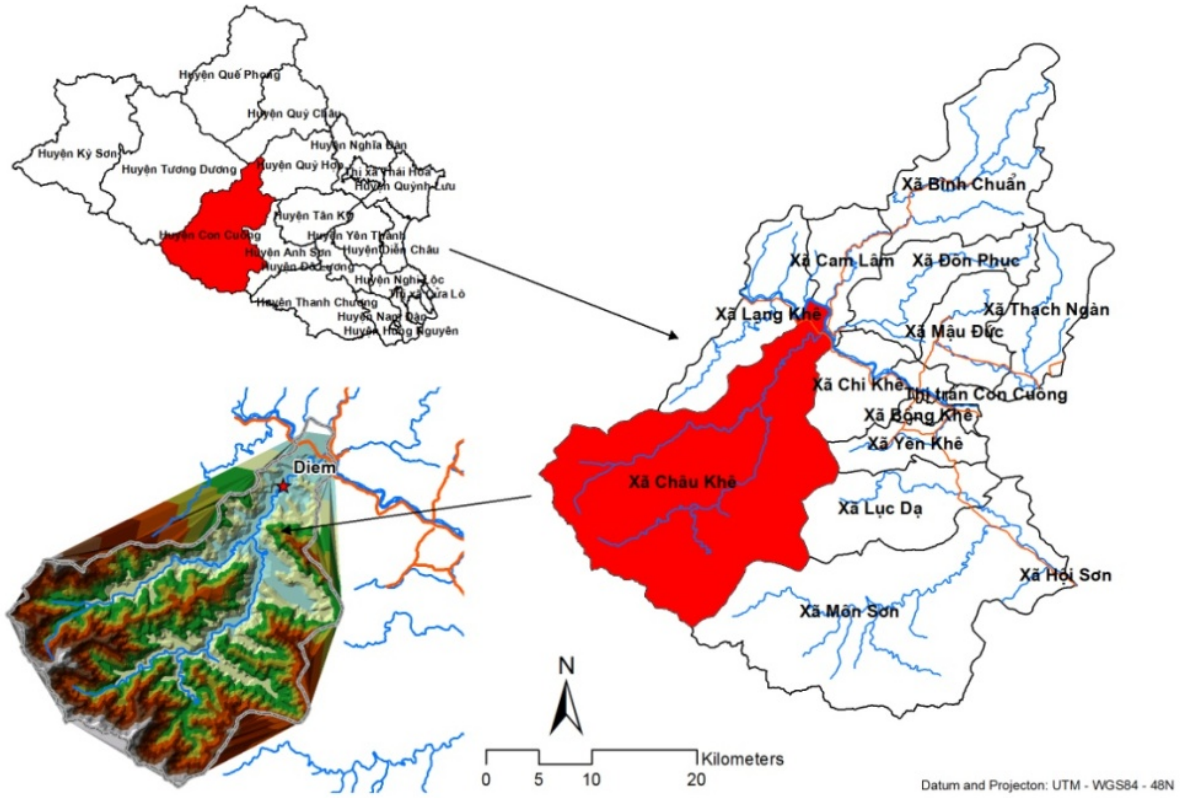

Figure 1. Map of study area

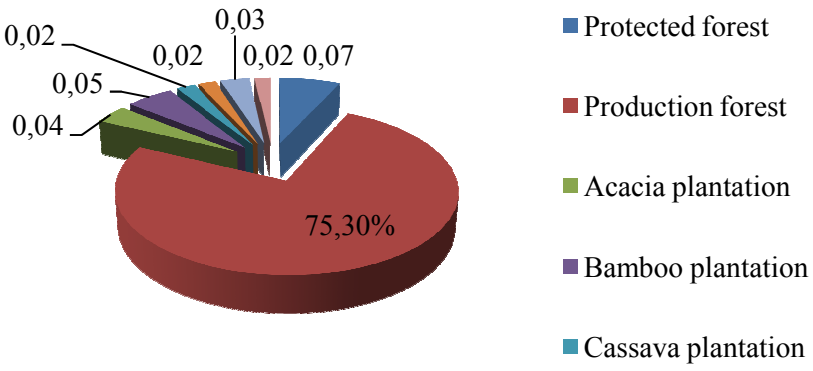

Figure 2. Land Use Status of Diem village in 2013

Data source: Chau Khe People Committee, 2013

The statistical results pointed out that production forest was the dominant land use type which accounted for three fourths of total natural land of Diem while other land use types occupied only small areas. Interestingly, there were no upland rice areas in the land use statistics of Diem village. This could be explained by FLA's implementation process in 1999.

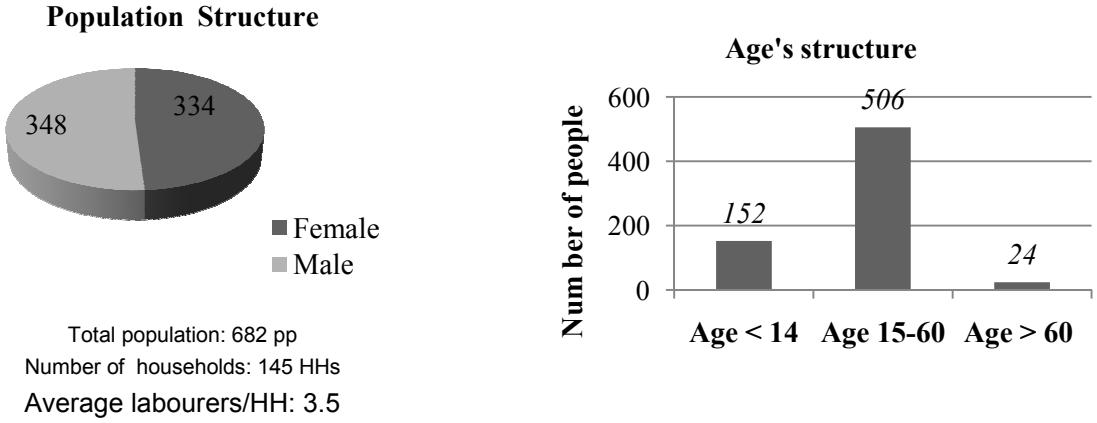

Figure 3. Population Characteristics - Diem village 2013

Data source: Chau Khe People Committee

The assessment of the population in Diem village showed that the male population is slightly higher than the female. Persons ranging in age from 15 to 60 accounted for 74% of the total population of the village. The average number of labourers per household in Diem was 3.5, which is higher than other villages of Chau Khe commune. The main livelihood activities in local small-scale agriculture production were rice, upland cultivations, livestock grazing, and collecting non-timber forest products (NTFPs). The main food crops include rice, maize and cassava. Livestock and afforestation activities and non-agricultural production (selling groceries, hired labour, and logging) were the major sources of household income.

3.2. Classification of current AFS and their characteristics

The classification of AFS is basically based on certain criterions such as their structure, function, socio-economic, and environmental conditions. Tran D.V. (2005) has stated that in the upland of Viet Nam, the AFS were divided into two main categories: traditional and innovative AFS. The traditional AFS were developed and innovated over many generations by ethnic minority groups living near or in the forests. The innovative AFS were often introduced and developed in some areas by technicians. In innovative AFS, tree species and biodiversity in general, were simpler than those of traditional systems. These systems have been introduced into Viet Nam by programs and development projects of the government or NGOs. Currently, many innovative AFS have been introduced and adopted in different upland regions in Viet Nam. According to a literature review, key-informant interviews, group discussions and field surveys in the study site, AFS in Diem village can be classified into 8 categories as shown in Table 1.

3.3. Potentials of Agro-forestry systems

According to Chundawat, et al. (1993) the potential of AFS can be evaluated by three aspects: environmental, economic, and social. In this regard, the farmers were asked to rate potential of the benefits from AFS.

3.3.1. Environmental potential

The study of AFS in Diem village has focused on forest carbon storage as an important environmental index to evaluate the environmental potential of AFS. Analytic results from GIS extension for carbon stock measurement are shown in Figure 4.

The results pointed out that the plots which had low value of carbon stock often had few trees and were dominated by bamboo. These plots were often located in comfortable terrain

such as forest trails which were easier for logging and transporting wood. The average above ground carbon stock in the designed strata in Diem is 40.15 tons/ha with a maximum of 84.58 tons/ha and a minimum of 12.17 tons/ha.

3.3.2 Economic potential

An analysis of contributions of the present AFS to local household incomes is presented in Figure 5.

The analytical results from the above table showed that all types of land use were profitable. Study results also indicated that bamboo plantation had a high economic efficiency due to low labour use and investment requirements. While acacia plantations can generate income seven years after planting, it requires a high capital and labour investment in the planting stage. Profit from acacia plantations depends on the convenience of transport conditions. Local farmers in Diem adopted intercropping cassava in the first several years of bamboo and acacia plantations because benefits from these models were higher than that of Bamboo and acacia monoculture.

Table 1. AFS' Classification and Characteristic in Diem village

No	Name of AFS	Characteristics	Advantages	Popularity
I	**Traditional AFS**			**++**
1.1	Innovated Shifting Cultivation System	- Forest rotation-swidden fields on hillsides - No slash and burn - Planting food crops in fallow periods	- Maintaining food security	+
1.2	Forest and Terrace System	The forest and rice terrace system	- Reducing soil erosion - Preserving irrigation water	+
1.3	Traditional Home Garden	Perennial and annual crops, animal husbandry and aquaculture	- Producing foodstuff - Generating household income	+++
1.4	Forest Garden	- The primary timber canopy which is only one type of tree. - The under tree canopy crops (Food crops such as rice, maize, cassava, bean; or perennial and fruit trees; medicinal herbs e.g. ginger, lemongrass)	- Supplying highly value products - Generating household income	++
1.5	Garden-Fish Pond - Livestock (VAC)	- Upper canopy, included multi-purpose timber trees or fruit trees - Lower canopy, included fruit trees, root crops or medicinal herbs, and a small vegetable garden - Livestock and fish pond	- Diversifying products - Promoting biological relationship between species - Supplying highly value products	+++
16	Forest - Garden -Fish pond - Livestock (RVAC)	Combination of forest, fruit tree garden, fish fond and livestock	- Diversify products - Promoting biological relationship between species - Generating household income	+++
II	**Innovative AFS**			**+**
2.1	Alley Cropping	- Trees/crops which are planted in contours in the slope lands - Hedgerows and cash crops that are grown between hedgerows. Normally, the distance between hedge rows is around one meter	- Reducing surface flow, - Supplying feed sources for livestock or humus to restore soil fertilizer.	+
2.2	Taungya	Bamboo intercropping with food crops	- Reducing management costs - Increasing household benefits - Protecting environment (Increase forest covers and carbon stock)	+

Data source: Key-informer interview; group discussions and field survey 2013
Note: +++ very popular; ++ popular; + less popular

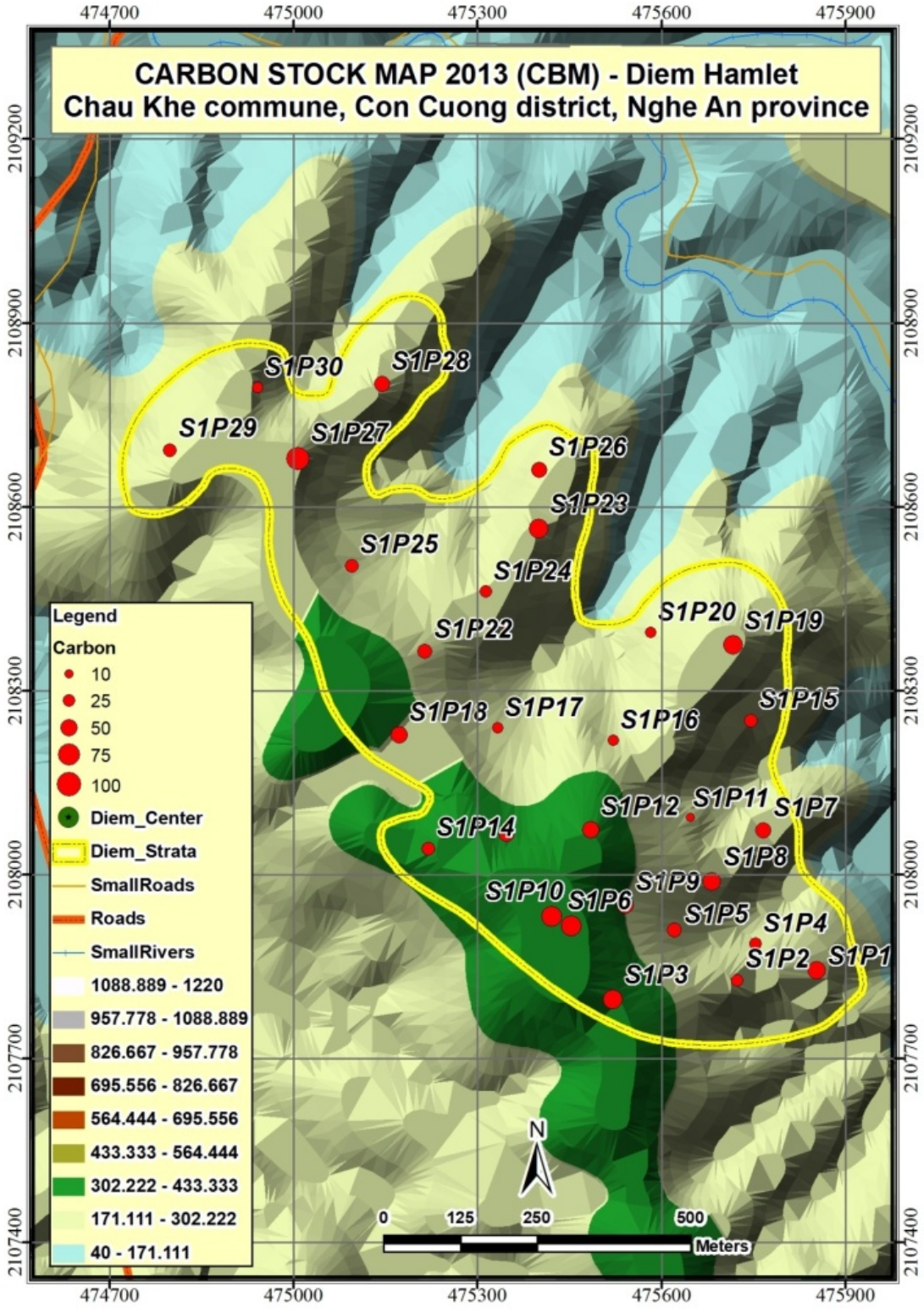

Figure 4. Above ground forest carbon stock map of selected strata and plots in Diem village

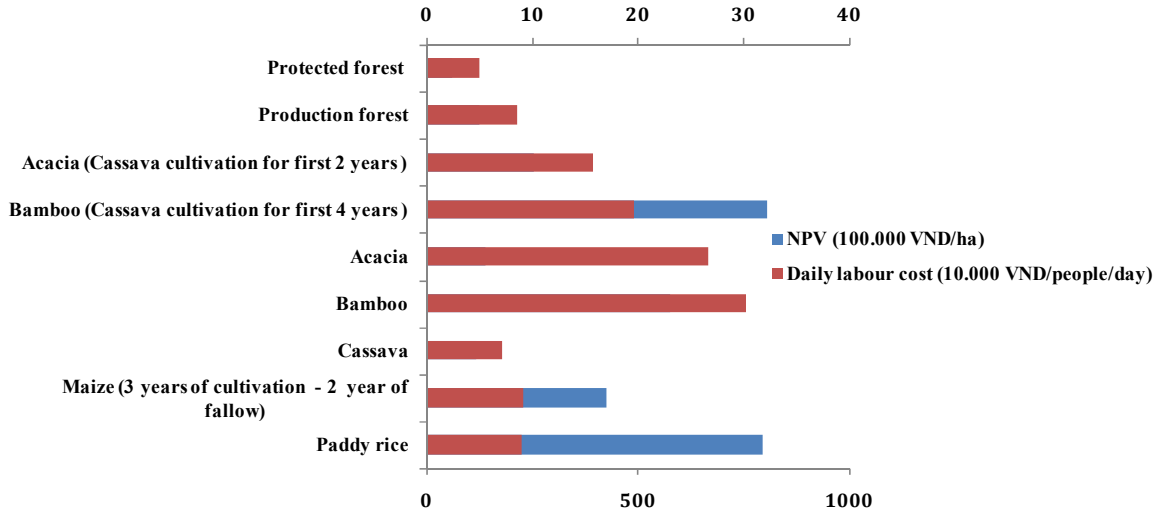

Figure 5. Current Net Present Value (NPV) and daily labour cost of each type of land use in Diem in 2013

Source: Household survey, 2013

3.3.3. Social potential

- Current livelihood sources of Diem village

Regarding on-farm activities, the local people concentrated on activities such as shifting cultivation, paddy rice cultivation, home gardens production, and animal husbandry. For off-farm activities, Diem villagers carried out many activities related closely to the natural forest, such as shifting cultivation, logging, gathering NTFPs, and hunting wildlife. Hunting or trapping activities were carried out simultaneously with the shifting cultivation cycle. The ethnic minorities used traps around their fields to protect the plants. Formerly, local people hunted wildlife for subsistence, to improve their family meals. Trapping animals for sale was increased as an option to enhance household income. Household income sources in Diem village mainly came from the agricultural and forestry sectors including: cultivating paddy rice; cassava plantation, afforestation (Acacia and Met); raising pigs, buffalo and cows; collecting bamboo; and cutting firewood. Households ranked important roles of livelihood activities for their income. This is shown in Table 2.

- Products for potential value chain analysis

The study results pointed out that main products produced by local households of Diem village were Met (bamboo), Cassava and Acacia. These were potential products for development and value chain analysis.

a) Met (bamboo)

Met has been grown in their forest gardens and allocated forestry areas. This crop is mainly produced for sale at the market. The local people planted met for sale at the market. The market chain of met consists of three main actors: the producer, the middle man/collector, and businessmen (see Figure 6). The middle men are people coming from Con Cuong town, they purchase the met product within the district, and then transport it to business owners in Anh Son, Dien Chau, Quynh Luu districts of Nghe An Province for sale.

b) Acacia

The acacia market chain is composed of three main actors: the producer, the middle man and the processing company (Figure 7). Middle men are persons within or outside commune that buy the living acacia timber at

Table 2. Ranking and livelihood options in Diem village

Ranking sectors	Ranking point
Paddy rice cultivation	+
Cassava planting	+++
Acacia plantation	++
Bamboo plantation (Met)	+
Animal husbandry (Raising pigs, buffalos and cows)	++
Collecting NTFPs	+

Note: Ranking point: + High priority; ++ Average priority; +++Low priority. (Source: Synthesis from local resource person interview at commune level and Focus group discussions)

Figure 6. Met market chain analysis in Diem

Figure 7. Acacia market chain analysis in Diem

the household's forest, then hire labourers to cut and transport the trees to Cua Lo wood processing company for sale.

c) Cassava

The market chain of cassava consists of four main actors: the producer, two levels of middle men, and the manufacturer (Figure 8). The first level middle man is the person within Diem village or Chau Khe commune who purchases the cassava from the households. The second level middle man is found at the district level in Con Cuong, Yen Thanh, and Thanh Chuong or at the provincial level. When the level one middle man purchases a significant amount of cassava to transport, this is then sold to the middle man at level two, who transports the cassava to be sold to manufacturers in Yen Thanh or Thanh Chuong districts.

Cost-benefit analysis of potential alternative livelihood options

Presently, most households concentrate on paddy rice cultivation to ensure food security, although its area and productivity is still limited. In order to generate income, households tend to use swidden land to plant cassava, acacia, and met. The most common model is to intercrop acacia and cassava. However, farmers prefer to plant cassava and met over acacia, for the following reasons:

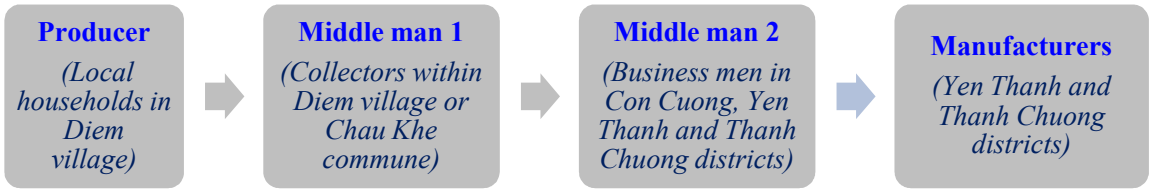

Figure 8. Cassava market chain analysis in Diem

Table 3. Cost-benefit analysis of potential alternative livelihood options in Diem village

No	Criteria	Cassava (per ha/year)	Met (per ha in first 7 years)	Acacia (per ha in 7 years)
1	Total Input Costs	500,000 VND (excluding labour and seedlings)	2,000,000 VND (excluding labour)	7,920,000 VND (excluding labour)
1.1	*Seedling*	-	*250 seedlings x 5,000 VND = 1,250,000 VND*	*2200 seedlings x 6,000 VND = 1,320,000 VND*
1.2	*Labour used (family labour)*	*104 days*	*186 days (including harvest days)*	196 days (including harvest days)
1.3	*Fertilizer*	*50 kg x 10,000 VND/kg = 500,000 VND*	*75 kg x 10,000 VND/kg = 750,000 VND*	*660 kg x 10,000 VND/kg = 6,600,000 VND*
2	Gross return	1,500 kg x 2,000 VND = 3,000,000 VND	1,000 trees x 8,000 VND = 8,000,000 VND	18,000,000 VND (price at forest by purchase live trees)
3	Net return	3,000,000 VND - 500,000 VND = 2,500,000 VND	8,000,000 VND - 2,000,000 VND = 6,000,000 VND	18,000,000 VND - 7,920,000 VND = 10,800,000 VND

- Short turn-around period: cassava is about 1-3 years; met is about 4-5 years; acacia is about 5-7 years

- Cassava and met are easy to plant and are suitable to the local soil and other natural conditions

- Local households in Diem village have experience in planting cassava and met

- Sources of seeds/seedlings are readily available locally

- Long cropping and return period for met: 60-70 years from first time harvesting

- Market demand is higher for Cassava and Met

- The cost-benefit analysis of potential alternative livelihood options is presented in Table 3.

Interestingly, from the 6th year in met plantations, households invest only labour for tending and harvesting the crop (tending: 20 days; harvesting: 50 days).

4. CONCLUSIONS AND RECOMMENDATIONS

4.1. Conclusions

Diem is a remote village of Chau Khe commune within the buffer zone of Pu Mat National Park in Con Cuong district. It is characterized by poverty with low crop production, low income and poor infrastructure.

There are two main categories of AFS which are currently adopted in Diem village: traditional AFS (6 types: Innovated Shifting Cultivation System, Forest and Terrace System, Traditional Home Garden, Forest Garden, Garden-Fish Pond -Livestock (VAC), and Forest -Garden-Fish Pond -Livestock (RVAC)) and innovative AFS (2 types: Alley Cropping and Taungya). The present research found that the most popular AFS in

Diem are traditional AFS including RVAC, VAC, and Traditional Home Garden.

The analytical results showed that all land use types in current AFS in Diem were profitable with positive Net Present Values (NPV). Local livelihoods depended much on on-farm and off-farm activities in which Cassava planting, Acacia plantation, and Animal husbandry (Raising pigs, buffalos and cows) are ranked as higher priority sectors in household incomes.

The value chain analysis showed that collectors (middle man) coming from Con Cuong town and business owners in other districts of Nghe An province played an important role in the marketing chain for bamboo products while processing companies in Vinh city and other district of Nghe An province were the key links of cassava and acacia marketing chains.

Cost benefit analysis of potential alternative livelihood options in Diem indicated very good Net Return for bamboo and acacia plantations with 6 million and 18 million VND per ha respectively while cassava generated only 2.5 million VND per ha.

The average above ground carbon stock in designed strata in Diem is 40.15 tons/ha however there was more than 70 tons/ha in variance between the maximum and the minimum values. Interestingly, the plots that have few trees and where bamboo is the dominant tree, carbon stock is often low.

4.2. Proposed recommendations

According to the study results presented above, some recommendations are proposed to reduce further pressure on forests and limit deforestation, as well as to find suitable ways to improve the local people's livelihoods. The appropriate solutions are proposed as follows:

a) Enhance benefits from shifting cultivation planning area: For ethnic minority households in Diem, shifting cultivation is an indispensable activity, not only connecting them to traditional culture and customs, but also playing an important role in meeting daily food demands. Local authorities and government agencies in Con Cuong district should have a proper land use planning project to preserve a definite area for shifting cultivation. This will reduce the pressure on natural forests and contribute to improvement of food security for local people, especially poor households. Furthermore, it needs to build more sustainable models of shifting cultivation to link livelihood improvement with forest protection.

b) Conduct forest land allocation or contracts for forest protection: Con Cuong district can improve livelihoods by supporting households to plant met and to plant rattan under natural forest canopy in Diem village and other communes of Con Cuong district. Local people should be made aware of the role and necessity of forests. This awareness can be raised by organizing contests of forest roles and by establishing an environmental protection club which introduce the role of forest and environment protection for local people in Diem village.

c) Developing animal husbandry: Animal husbandry should be further developed by offering training in poultry and cattle breeding techniques as well as training in disease prevention in Chau Khe commune. Furthermore veterinary services must be improved to increase local people's ability to effectively raise animals.

d) Developing home gardens and forest gardens: Home gardens in Diem should be enhanced with new varieties and species. Furthermore, the villager's knowledge of the final consumption market and value chain must also be improved.

e) Developing micro-finance programs: Micro-finance programs for local farmers in Diem village should be offered and marketing of AFS products should be improved.

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