Working Paper

Understanding tree-cover transitions, drivers and stakeholders' perspectives for effective landscape governance: a case study of Chieng Yen Commune, Son La Province, Viet Nam

Vu Tan Phuong, Nguyen Van Truong, Do Trong Hoan, Hoang Nguyen Viet Hoa, Nguyen Duy Khanh

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ABSTRACT

Integrated landscape management for sustainable livelihoods and positive environmental outcomes has been desired by many developing countries, especially for mountainous areas where agricultural activities, if not well managed, will likely degrade vulnerable landscapes. This research was an attempt to characterize the landscape in Chieng Yen Commune, Son La Province in Northwest Viet Nam to generate knowledge and understanding of local conditions and to propose a workable governance mechanism to sustainably manage the landscape. ICRAF, together with national partners — Vietnamese Academy of Forest Sciences, Soil and Fertilizer Research Institute — and local partners — Son La Department of Agriculture and Rural Development, Son La Department of Natural Resources and Environment, Chieng Yen Commune People's Committee — conducted rapid assessments in the landscape, including land-use mapping, land-use characterization, a household survey and participatory landscape assessment using an ecosystem services framework. We found that the landscape and peoples' livelihoods are at risk from the continuous degradation of forest and agricultural land, and declining productivity, ecosystem conditions and services. Half of households live below the poverty line with insufficient agricultural production for subsistence. Unsustainable agricultural practices and other livelihood activities are causing more damage to the forest. Meanwhile, existing forest and landscape governance mechanisms are generally not inclusive of local community engagement. Initial recommendations are provided, including further assessment to address current knowledge gaps.

Keywords
Son La, ecosystem services, forestry, governance, household survey, mapping, land use, land-use planning, landscape, tree-based land uses, Viet Nam

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SUMMARY

The research assessed different aspects of land use in Chieng Yen Commune, including socio-economic conditions, land use and land-use changes, and changes in carbon stock and produced land-use scenarios towards 2040 based on local people's perceptions of improving environmental services. Land Use Planning for Multiple Ecosystem Services (LUMENS), a participatory planning framework, was the main tool used in this research. The key findings are summarized below.

Socio-economic conditions of Chieng Yen Commune: Ethnic minority groups account for 98% of the commune's population, of which Thai people had the largest proportion with 44.3% of the total population followed by Dao (41%) and Muong (13.1%). The average number of family members in a household was 4.7 and about 90% were female-headed households. Poor households accounted for about 55%, and 89% of those households dependent on farming. Annual income of households varied greatly among the poor, near-poor and non-poor groups. Total household income of 48–69% was from farming and the total average income of the poor, near-poor and non-poor households was VND 28 million, 48 million and 75 million, respectively. Average size of land owned by households was 2.47 ha. The size of land owned by the poor, near-poor and non-poor groups was 1.78, 3.25 and 3.37 ha, respectively.

Characterization of land uses: Land uses were divided into several types: 1) forest land (natural and planted forests); 2) upland agricultural cultivation (maize, cassava etc); 3) lowland agriculture (wet rice); and 4) home-gardens. The dominant land uses in the commune were 1) forest land, covering 62% of total commune land; and 2) annual crops and tree-crop plantations, covering 30% of the commune land. Community-based forest management is practised in all villages of the commune with payment for forest protection through the national policy on payment for forest environmental services. Economic benefits from land uses are quite low. The average net annual income per hectare from crops was highest, at VND 33 million (VND 18.4 million–44.3 million), followed by tree-based crops, with average income value of VND 30.5 million (VND 15.3 million–46.4 million), and plantation, between VND 8.6 million and 36.0 million, depending on tree species. The annual economic benefits from natural forests was the lowest, at about VND 1.1 million per hectare, of which VND 0.52 million was from payment for forest environmental services. There has been an expansion of trees on farms for timber and other commercial purposes, of which timber and bamboo species account for about 52% and fruit trees for 25%.

Land-use change 2010–2020: Significant changes in land uses were observed over the period 2010–2020. The area of natural forest decreased by 185 ha, however, there was a net forest increase of 231 ha recorded in the period. There were also increases in area of crop land and tree-crop plantations. Land-use change caused changes in biomass carbon stock. The net aboveground carbon stock was reduced by about 4% (or 7146 tC) during 2010–2020. The key drivers of land-use change were illegal logging and conversion of forest to crop land.

Integrated land-use planning for improving ecosystem services: Local people recognized the important role of appropriate land uses in maintaining and improving ecosystem services.

This awareness encompassed soil erosion and degradation, lack of water for domestic use and irrigation, floods and landslide, climate change. With the perceptions of local people of ecosystem services, a land-use scenario towards 2040 was collectively developed by villages, local management agencies and socio-civil organizations. The development of a land-use plan considered the targets for improving environmental services in the national green-growth strategy and for emission reduction, especially the protection of headwaters and potential ecotourism areas. The proposed future land uses focus on protecting and improving natural forests and development of non-timber forest products, implementing reforestation of non-forest land (bare land) to expand forest areas using native tree species, improving wet rice productivity, developing fruit tree systems and applying agroforestry practices. The integrated land-use planning projection towards 2040 can help reduce emissions and increase sequestration compared to land uses in the business-as-usual scenario. The estimated reduction of emissions and increase in sequestration between the integrated land-use planning and business-as-usual scenarios are 3 and 8 percent, respectively.

Policy options: Policy and technical support are needed to achieve integrated landscape management at local (commune) level to meet the objectives of the national green-growth strategy. This support includes technical capacity building for community-based management, investment in forest enhancement and reforestation, development of non-timber forest products and expansion of tree-based land uses for improved resilience to environmental issues and securing livelihoods for local people. A practical and effective monitoring mechanism is also required to improve management of the landscape at local level.

1. INTRODUCTION

Land use and land-use changes are driven mainly by human activities during socio-economic development. Understanding of land-use change (LUC) dynamics is crucial for sustainable land resource management where the majority of people depend on natural resources in a landscape for their livelihoods (Wood et al 2004). LUC is linked with the sustainable development of a particular geographical area because it is associated with socio-economics, landscape conditions and bio-physical characteristics. LUC, particularly forest conversion and degradation, is widely acknowledged to increase soil erosion, land and habitat degradation, the loss of biodiversity and increases in carbon emissions (Foley et al 2005, Lambin et al 2003, MEA 2005, Olson et al 2004). Land-use changes are closely associated with agricultural expansion and intensification, urbanization, deforestation and the conversion of wetlands to pasture and agricultural lands (FAO 1997).

In Viet Nam, socio-economic development and population growth have caused significant land-use changes. Although forest cover has seen a net increase since 1990 at the national level, at local levels forest conversion and degradation continues in places, causing degradation of environmental services. Viet Nam is in the process of implementing its nationally determined contribution (NDC) and green-growth strategy for 2021–2030. These focus on reduction of carbon emissions, enhancement of carbon sequestration and improvement of other environmental services. Land use, land-use change and forestry (LULUCF) is one of the priority sectors for NDC and green-growth implementation. Integrated land-use planning plays an important role in achieving the national green-growth and emission-reduction targets in the LULUCF sector. The current legal framework and preparation of land-use plans have not paid sufficient attention to land-use changes, related environmental issues and effective engagement of stakeholders in the planning process, particularly at commune level.

Characterization of land uses and understanding the drivers of land-use changes is important for integrated tree-based planning to meet the targets of the national green-growth strategy through improved land and forest governance.

This research was conducted at Chieng Yen Commune in Son La Province as a case study site to generate understanding of current land uses and land-use changes considering socio-economic conditions, drivers of land-use changes, local perception of climate change and ecosystem services. Taking into consideration current land uses and drivers of land-use change, a land-use plan towards 2040 was jointly developed, including local people at commune level. The planning considers local perspectives in terms of economic and environmental issues.

The study was a part of the project, Developing and Promoting Market-based Agroforestry and Forest Rehabilitation Options for Northwest Viet Nam (AFLI-II), supported by the Australian Centre for International Agricultural Research and the research programs on Forests, Trees and Agroforestry, and Policies, Institutions and Markets of the CGIAR. The project has been implementing comprehensive agroforestry and forest rehabilitation research and development activities with local partners in Northwest Viet Nam.

This working paper presents details of research results on socio-economic conditions of LULUC for the period 2010–2020 and the drivers of changes, historical changes in aboveground carbon stock of land uses and development of a land-use scenario towards 2040.

2. RESEARCH METHODS

2.1. Study site

The study was conducted in Chieng Yen Commune, Van Ho District, Son La Province in Northwest Viet Nam (Figure 1). The commune is located in the protection zone of the Hoa Binh hydropower reservoir, part of the Da River Basin that extends from China. The average elevation of the commune is 956 m above sea level. The average temperature is 17 °C, average humidity is 82%, and average rainfall is 1680 mm y^{-1}.

According to the Chieng Yen's Commune People's Committee (CPC), the commune has 11 villages with a population of 4036 distributed over approximately 966 households. Five ethnic groups live in the commune, including Thai (46.1% of total population), Dao (29.1%), Muong (18.4%), Kinh (5.8%) and H'Mong (0.6%). Based on Government standards[1], the majority of local households are poor (55.2% of total households). The primary livelihoods in the commune are from agriculture, planting and protecting of forests, planting and processing tea, growing fruit trees, raising cattle and poultry (Chieng Yen CPC 2019).

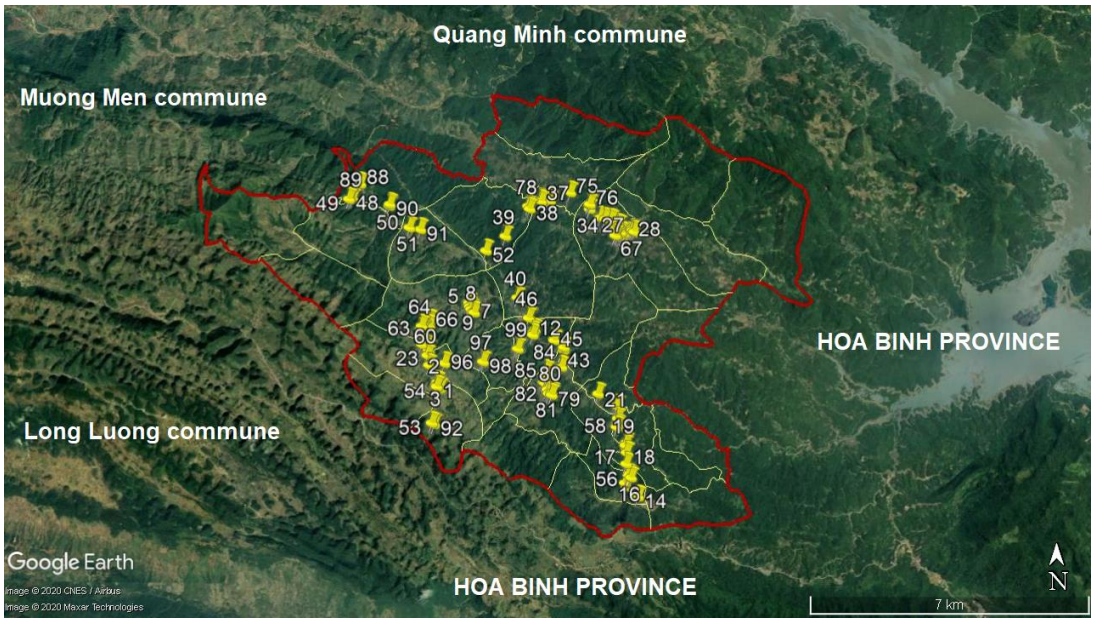


Figure 1. Location of the Chieng Yen Commune study site in Northwest Viet Nam
*S*ource: adapted from the administrative map of Chieng Yen Commune and Google Earth Image 2020

[1] Prime Minister of Viet Nam. 2015. Decision No. 59/2015/QD-TTg, 19 November 2015 on promulgating the multi-dimensional approach to poverty standard for the period of 2016–2020. Ha Noi, Viet Nam: Government of Viet Nam.

2.2. Methodological framework

Several methods were applied in this study, including LUMENS, a participatory planning framework developed by Dewi et al (2015), facilitate more effective multi-stakeholder discussions and agreement in developing a sustainable landscape plan to support livelihoods and development while maintaining and restoring environmental services. The LUMENS framework is shown in Figure 2. It consists of four main steps: 1) Compilation of local land-use issues and perspectives on current land-use plans; 2) Estimation of historical greenhouse-gas emissions and sequestration from all land-use changes; 3) Participatory development of a baseline and LUMENS scenarios in which the latter adopt land-use interventions preferred by local stakeholders; and 4) Assessment of impacts of the developed scenarios on the landscape's ecosystem services with stakeholder feedback.

Methods such as structured interviews, focus-group discussions, land-use-change mapping, rapid carbon stock appraisal, and back-casting for scenario development were also employed, as described in the sub-sections below.

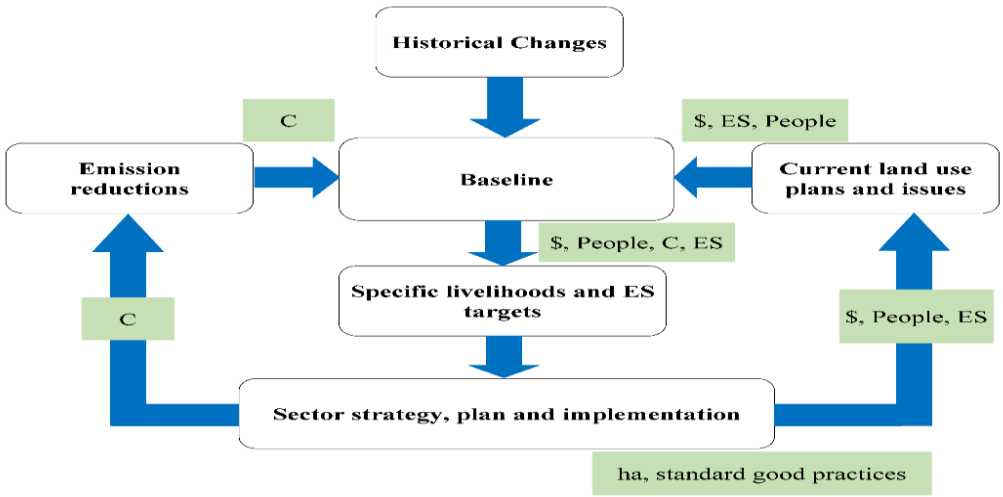


Figure 2. LUMENS framework
Note: C = carbon; ES = ecosystem services; $ = economic benefits of land uses
Source: adapted from Dewi et al (2015)

2.3. Land-use classification

A modified land-use/-cover classification was applied to better capture both the ecological and management status of the landscape (Table 1 below) and importantly, the presence and management of trees in the landscape. Accordingly, 17 land-use types were identified, including six types of forests, one type of mosaic land use, nine types of non-forest vegetation, four types of agriculture, and three types of non-vegetated land. Classification of forest land-cover types was based on Circular 34/2009/TT-BNNPTNT.

Table 1. Land-use/-cover classification system of Chieng Yen Commune

			No.	Forest and land-use type	Code
Forest	Tree-based	Vegetated	1	Evergreen broadleaf forest—rich	EBR
			2	Evergreen broadleaf forest—medium	EBM
			3	Evergreen broadleaf forest—poor	EBP
			4	Mixed forest (bamboo + timber)	MXF
			5	Regenerated forest	RGF
			6	Planted forest	PFR
Non-forest			7	Tree-crop plantation	PLA
			8	Bare land with scattered trees	BST
			9	Bare land with grass and shrubs	BGS
			10	Agroforestry	AGR
			11	Home-garden	HGN
	Non-tree-based		13	Upland crops	UPC
			14	Lowland crops	LLC
			15	Wet rice	PDR
		Non-veg	16	Waterbody	WTR
			17	Residence and construction (settlement etc)	ONF

2.4. Assessment of land uses and socio-economic status

A set of structured questions was prepared for interviewing households. A total of 61 households in Chieng Yen Commune were interviewed. The households were randomly selected from a list of households that had been stratified according to income status (poor, near poor and non-poor) provided by the CPC. Respondents were representatives of the stratified households who were either the household head or a family member with knowledge of the farming and economic situation of the household. Representativeness was ensured through information exchange between the enumerators and village heads. The survey aimed to generate a baseline of households' socio-economic conditions as well as local perspectives on use of natural resources and management of the landscape, including land, soils, trees, forests and water. Data was stored in Microsoft Access and analyzed using Microsoft Excel.

Transect walks were also conducted to discuss in depth the issues of LULUC and drivers. A transect walk is a systematic walk along a defined path across the project area together with local people to explore topography, soil, water and sanitation conditions by observing, asking, listening, looking and then producing a transect diagram. In Chieng Yen Commune, we conducted two transect walks with a total of 14 residents to gain a better understanding of village and commune issues relating to agriculture and forestry. Dominant land-use systems associated with an elevation gradient and slope classes were identified, including current crop varieties, cropping systems and patterns (monocultural cropping or crop association). Biophysical indicators were registered, such as soil type, erosion status and water resources.

2.5. Assessment of local perspectives of ecosystem services

Ecosystem services are the benefits that human populations derive, directly or indirectly, from ecosystem functions (Costanza et al 1997, MEA 2005). These services include provisioning (for example, food, timber and fuel), regulating (for example, climate regulation and water purification) and cultural (for example, aesthetic values, sense of place) services. The provision of these services is based upon the performance of ecological structures, processes and functions. Ecosystem services play fundamental roles in human economies and quality of life and shape the ways in which we manage the environment and development activities in it (Everard and Waters 2013). In recent years, the concept of ecosystem services has been increasingly studied and used in environmental science, policy making and practical application.

When using an ecosystem services' concept and approach, landscapes play an important part because they provide a wide range of ecosystem goods and services. The approach defines functions and services at a landscape scale so as to better integrate the concept into land-management decisions. In this study, by assessing ecosystem services in the targeted landscape of Chieng Yen Commune, our aim was not to value or 'put a price tag' on ecosystem services provided by the landscape but to determine the role of ecosystem services in decisions and policies, to consider options for the future management of the landscape, and to communicate and enhance local communities' awareness of ecosystem services and their engagement in the project's activities.

Focus-group discussions were used to assess the perceptions of local people of environment-related issues, including changes in forest area and quality, and environmental services. Key informants were selected representing villages, management agencies and social organizations (women's union, youth union etc). The discussion was guided and facilitated by the study team for information collection.

2.6. Mapping of land-use changes

Land-use and forest-cover classification included nine land-use types[2] (see Table 1). Data from different sources were used to analyse land-use changes, such as 1) 2010–2019 forest-cover maps of Chieng Yen Commune provided by the Forest Inventory and Planning Institute (FIPI 2011, 2020); 2) 2019 land-use map of Chieng Yen Commune (Chieng Yen CPC 2020), which was standardized according to the guidance of the Ministry of Natural Resources and Environment (MONRE)[3]; 3) processed SPOT5 and Landsat images acquired in 2010 and 2020 from MONRE and Google Earth[4] to update forest-cover maps; and 4) statistical data and reports from district and commune authorities on socio-economic conditions.

[2] [MARD] Ministry of Agriculture and Rural Development. 2009. *Circular No. 34/2009/TT-BNNPTNT on criteria for forest definition and forest classification*. Ha Noi, Viet Nam: Ministry of Agriculture and Rural Development.

[3] [MONRE] Ministry of Natural Resources and Environment. 2014. Circular No. 28/2014/TT-BTNMT 2 June 2014 on regulations on land statistics and inventory and mapping land-use status. Ha Noi, Viet Nam: Ministry of Natural Resources and Environment.

[4] Google Earth Pro Software by Google LLC.

A field survey was conducted to ground-truth the land-use status indicated on the maps. A total of 115 random sampling points (see Table 1) were selected based on 1) natural and socio-economic characteristics; 2) agricultural practices of farmers in the study area; and 3) reference maps, such as land-use and forest-cover maps. Survey routes were designed to go through as many different types of land cover and/or land use (on the reference map) as possible. At each sampling point, the information collected included coordinates, elevation, land-use types, and vegetation-cover description.

An 'object-based image analysis' approach with the support of eCognition software was applied to classify the images and the collected information from sampling points was used to verify image interpretation and to update the maps. Change detection, using a map overlay method, was applied for registration of the 2020 forest-cover map boundaries on the 2010 forest-cover map, ensuring consistent parcel boundaries over time where such boundaries existed. Assessment of the accuracy of land-use and forest-cover mapping followed the methods used by Olofsson et al (2014, 2013).

Table 2. Sampling points for updating land-use maps and measurement plots for biomass estimates

No.	Land-use/-cover type	Number of sampling points for maps' update	Number of measurement plots for tree-biomass estimation	
			Plot A	Plot B
1	Broadleaf evergreen forest—medium	5	5	5
2	Broadleaf evergreen forest—poor	5	5	5
5	Broadleaf evergreen forest—very poor	5	5	5
4	Mixed wood–bamboo forest	5	5	2
5	Bamboo forest	5	-	-
6	Planted forest	15	5	-
7	Bare land with scattered trees	8	5	-
8	Bare land with grass and shrubs	7	5	-
9	Tree-crop plantation	23	5	-
10	Annual crops	22	-	-
11	Water bodies and other land uses	15	-	-
Total sampling points/measurement plots		115	40	17

Source: authors' fieldwork, 2020

Land-use changes for the period 2010–2020 were identified by overlaying the 2010 and 2020 land-use maps. Changes in land-use during this period were reflected in the land-use change matrix and on the map. The drivers of land-use change were assessed through group discussions and consultations.

2.7. Estimate of changes in aboveground biomass carbon stock

The counted carbon pool included aboveground biomass carbon of forest land (natural and planted forests), grassland and tree-crop plantations. Trees' aboveground biomass (AGB) in forest land and tree-crop plantations was estimated using the following allometric equations.

- Trees (Chave et al 2014): AGB = 0.0673*(ρ*D^2*H)^0.976 (1)
- Fruit trees (Schroth et al 2002): AGB = -6.64 + 0.279*BA + 0.000514*BA^2 (2)

where: ρ is basic wood density (g cm^{-3}); D is diameter at breast height (cm); H is total tree height (m); and BA is basal area (cm^2). The values of ρ depend on specific tree species and are taken from (Vu et al. 2015).

The plot measurement for AGB estimates was set randomly to measure diameter at breast height (D) and total height (H) of trees. A total of 40 plots were established, of which 29 plots were type A plots of 200 m^2 each (5 × 40 m) and 11 were type B plots of 2000 m^2 each (20 × 100 m) (Table 1 and Figure 3). The A plots were used for measurement of D and H of all trees with D from ≥ 5 cm to 30 cm and the B plots were designated for measurement of trees with D > 30 cm if this type of D appeared inside plot A (Hairiah et al 2010). For non-forest land uses such as shrubs and grassland, information on key species, average coverage and height etc was recorded.

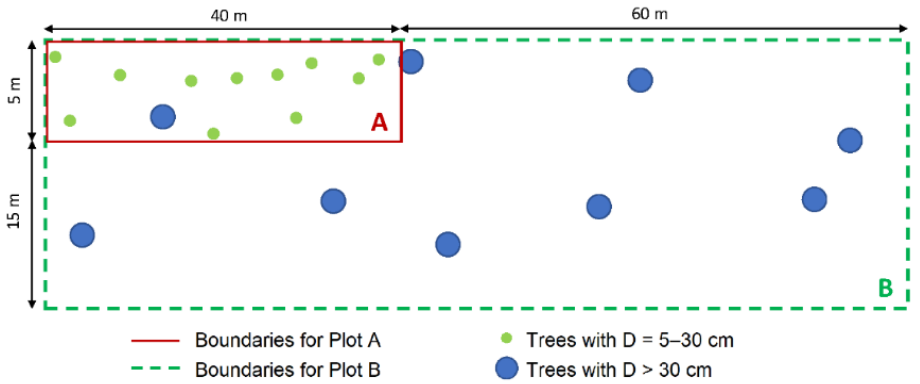


Figure 3. Layout of plot measurement for AGB estimates
Source: adapted from Hairiah et al (2010)

To estimate carbon stock of aboveground biomass, we used the Intergovernmental Panel on Climate Change's default values for carbon fraction (0.47) (IPCC 2006). The aboveground carbon-stock values of grass and shrub lands were adapted from Vu (2006) and the carbon stock of annual crops, residential areas and waterbodies were assumed to be zero (IPCC 2006). Since there was no future estimate for carbon stock of land uses, we conservatively estimated the carbon stock of land uses per hectare to be unchanged.

2.8. Developing land-use scenarios for multiple ecosystem services toward 2040

A 3-D model was used to discuss current and future land uses in the commune. Knowledgeable people in the villages who knew well their land and its uses, were invited to make a 3-D model of the whole commune's land area.

The current land uses were then coloured to indicate key features, including road systems, streams and waterbodies, natural forests, planted forests, wet rice fields, fruit trees and upland crops. During the mapping, the invited villagers made comments and suggestions to finalize the 3-D model.

Once the 3-D model was completed, a stakeholder consultation was held with 30 participants. These were commune leaders, agricultural extension staff, environmental and cadastral staff, village heads and representatives of socio-civil organizations. The participants were guided in discussion of changes in land uses and their expectations on future land uses, taking into consideration ecosystem services. All expected changes (land uses, location and area) were marked by colours on the 3-D model and recoded.

Figure 4. A 3-D model for mapping current and future land uses in the Chieng Yen Commune
Source: authors' fieldwork, 2020

To ensure that stakeholders easily understood the concept of ecosystem services, we interpreted ecosystem services as 'benefits' that the landscape provides to local communities for current and future generations. Based on existing studies and frameworks, we identified 15 ecosystem services that aligned with four functional domains: 1) life support; 2) regulation; 3) provision; and 4) information.

The ecosystem services selected for assessment were 1) soil formation; 2) nutrient cycling; 3) biodiversity (although this is arguably not an ecosystem service but herein listed considering its tight links with ecosystem services and importance to local livelihoods); 4) climate and weather regulation; 5) water regulation; 6) mitigation of natural disasters; 7) water purification and waste treatment; 8) anti-soil erosion; 9) carbon storage; 10) biological control; 11) pollination; 12) clean water; 13) provision of food, fuel, wood, fibre, fodder, fertilizer and medicines; 14) natural scenery, tourism and entertainment; and 15) cultural and spiritual values.

Participants were asked to identify key land uses and land-use changes in the commune and to rank changes in ecosystem services (shown on cards) with respect to each land-use type. After agreeing on common goals, the stakeholders were randomly divided into two groups for the sake of discussion facilitation to formulate a LUMENS scenario (interventions, location for each intervention, actors and policy support needed for the interventions). Land-use maps

from 2010 and 2020 (see Section 3.2) were provided to stimulate the discussions. It was explained to participants that the impacts of suggested interventions will be evaluated after the workshop using thematic software.

The impacts of the proposed land-use interventions on the landscape's greenhouse-gas emissions and sequestration (aboveground biomass pool) were assessed using REDD Abacus[5], public domain software developed by ICRAF to facilitate land-use planning for low-emission development strategies at sub-national levels. The software employs a transition probability matrix, that is, the Markov chain, (Rozario et al 2017) in land-use-change projection. A transition is defined as a change in land use/cover and the matrix shows the probability of a land-use/-cover change taking place from one state to another within a specified period based on initial land-use changes. Two scenarios were simulated for a 20-year period (2020–2040): 1) business-as-usual (BAU) scenario, based on linear projection of historical land-use change during 2010–2020 (see Appendix 1); and 2) a LUMENS scenario based on both historical land-use changes and land-use interventions suggested by local stakeholders during the back-casting exercise.

3. RESULTS

3.1. Socio-economic conditions of Chieng Yen Commune

3.1.1. Key features of household interviews

A total of 61 households were interviewed, representing 6.3% of the commune's households, of which female respondents accounted for about 51% of total interviews. The average age of respondents was 44 years, belonging to the mid-level working-age group of the agricultural sector. The interviews indicated that the majority (90.2%) of the households were male-headed (see Table 3).

Table 3. Population and sample size

Information	Chieng Yen Commune
Population (people)	4,036
Population (number of HHs)	966
Number of respondents (HHs)	61
Percent of population (% of commune total HHs)	6.3
Average age of respondents (year)	44
Female respondents (% HHs)	50.8
Male respondents (% HHs)	49.2
Male-headed (% HHs)	90.2
Female-headed (% HHs)	9.8

Source: Chieng Yen CPC (2019) and authors' fieldwork, 2020

[5] Available at https://sourceforge.net/projects/redd-abacus/

3.1.2. Demographic profile of sample households

There were three large ethnic minority groups in Chieng Yen Commune, who accounted for 98.2% of the total surveyed households. The Thai ethnic group had the largest proportion, with 44.3% total population, followed by Dao (41%) and Muong (13.1%). The average number of family members in a household was 4.7. Most of the household heads had completed secondary school but about (4.9%) of the respondents never attended school (see Table 4).

Table 4. Demographic profile of household respondents (2020)

Information	Chieng Yen Commune
Ethnic group (% HHs)	
Thai	44.3
Dao	41.0
Muong	13.1
Kinh	1.6
Average age of household head (year)	46.3
Average household family size (people)	4.7
Education of household head (% HHs)	
Primary	41.0
Secondary	50.8
High school	3.3
Never	4.9

Source: authors' fieldwork, 2020

3.1.3. Socio-economic conditions

According to commune records, about 43.7% of Chieng Yen Commune's households were considered non-poor; 55% of households were poor and 1.1% of households were in near-poor status, although the difference between near-poor and non-poor households was not great (see Table 5).

Table 5. Economic status of households in Chieng Yen Commune

Socio-economic status	Whole commune*		Survey (N=61)**	
	Number of HHs	% of commune total number of HHs	Number of HHs	% of survey total number of HHs
Non-poor	422	43.7	17	27.9
Near poor	11	1.1	11	18.0
Poor	533	55.2	33	54.1
Total	966	100	61	100

Note: * reported by Chieng Yen CPC (2019); ** authors' fieldwork, 2020

Source: authors' fieldwork, 2020

Farming was the main occupation of most household heads (88.5%) and the main income source for households (55.8% total income). However, a significant number of households in Chieng Yen Commune also reported other income sources, such as wage labour, employment, business and trading (see Table 6).

Table 6. Main occupation of household head and source of income (estimated for 2019)

Main occupation	% of total HHs number	Source of income	% of total HHs income
Farmer	88.5	Farming	55.8
Official	4.9	Salary	19.1
Employment	1.6	Wage labour	12.2
Business and trading	3.3	Business and trading	10.7
Retired	1.6	Others	2.2
Total	100	Total	100

Note: average annual household income is VND 44.76 million y^{-1} HH^{-1}

Source: authors' fieldwork 2020

In term of income sources, the income from livestock production accounted for the largest proportion, with 43.7% of total agroforestry and livestock income, of which the largest was cattle raising (32.7%), followed by poultry raising (6.6%) and pig raising (4.3%). Next, income from annual crops accounted for 30.9% of total income, of which rice production brought the highest income (18.0%), followed by maize (9.9%) and passionfruit (1.7%). The income from forests accounted for 16.8%, of which the largest was income from bamboo shoots from community forests (7.6%), followed by timber from planted forests (4.7%) and payment for forest environmental services (3.7%). The income from perennial crops accounted for the lowest proportion, of which the majority was tea production (5.6%) and fruits (2.2%). There was no income from timber-tree plantations (yet) because the trees, if any, had only been planted very recently (Table 7). Apparently, trees provided no to very little economic benefit to households in Chieng Yen Commune in this context.

Table 7. Income structure from agroforestry and livestock production

Source of income	Annual income*	% of total income	Income by socio-economic status of household*		
			Poor household	Near-poor household	Non-poor household
TOTAL INCOME	24.98	100.0	18.94	24.94	36.73
1. Annual crops	7.71	30.9	5.31	10.08	10.84
Rice	4.48	18.0	3.36	4.06	6.95
Maize	2.48	9.9	1.26	5.69	2.76
Passionfruit	0.43	1.7	0.35	0.00	0.85
Other crops (cassava, arrowroot…)	0.32	1.3	0.34	0.33	0.28
2. Perennial crops	2.16	8.7	1.05	1.01	5.07
Tea	1.41	5.6	0.21	0.00	4.64
Fruits	0.56	2.2	0.82	0.00	0.42
Timber	0.2	0.8	0.02	1.01	0.00
3. Forests	4.20	16.8	3.70	5.54	4.31
Timber	1.18	4.7	1.29	1.81	0.57
Firewood	0.16	0.6	0.16	0.11	0.18
Bamboo shoots	1.90	7.6	1.14	3.19	2.56
Fruits	0.02	0.1	0.04	0.01	0.00
Honey	0.01	0.0	0.01	0.00	0.00
PFES	0.93	3.7	1.06	0.42	1.00
4. Livestock production	10.91	43.7	8.88	8.30	16.51
Cattle	8.16	32.7	6.63	5.38	12.94
Pig	1.06	4.3	1.04	0.86	1.24
Poultry	1.65	6.6	1.19	2.05	2.27
Poultry eggs	0.03	0.1	0.02	0.02	0.06

Note: * Unit: million VND y^{-1} HH^{-1}; PFES = payment for forest environmental services
Source: authors' work 2020

Total income of households varied greatly among household economic status (poor, near poor and non-poor). The average annual income of the non-poor households was VND 75.3 million that was about 2.7 times higher than that of poor households. The near-poor households had average annual income of VND 47.7 million and average annual income of poor households was VND 28.0 million. The income of poor households depended largely on farming, at about 67%. This figure for near poor and non-poor was 52% and 49%, respectively (see Table 8).

Table 8. Source of incomes by socio-economic status of households in Chieng Yen Commune

Source of income	Poor household		Near-poor household		Non-poor household	
	Annual income*	% of total income	Annual income*	% of total income	Annual income*	% of total income
Farming	18.9	67.6	24.9	52.3	36.7	48.8
Salary	0.9	3.2	16.4	34.3	18.4	24.4
Wage labour	5.8	20.6	3.8	7.9	5.9	7.8
Business and trading	1.6	5.9	1.5	3.1	13.0	17.3
Others	0.8	2.7	1.1	2.4	1.3	1.7
Total	28.0	100	47.7	100	75.3	100

Note: * Unit: VND million y^{-1} HH^{-1}

Source: authors' fieldwork, 2020

3.1.4. Land size and ownership

Land area owned by households was quite small, with an average area per household of 2.49 ha. The land area owned varied significantly among the household groups. The average land area owned for the poor, near poor and non-poor groups was 1.78, 3.25 and 3.37 ha per household, respectively. Of the land area owned, annual upland crops covered the largest land area (29%) followed by planted forests (25%), perennial crops (22%) and fallow land (10%). Land for wet rice and home-gardens contributed about 7% to total land of households (Table 9). This was quite common for mountainous areas where flat land is limited for wet rice and other annual crops. With a growing population, the demand for arable land will increase, which could become a driver of conversion of forests to agricultural land. Therefore, better and proper land-use planning is required to ensure sustainable landscape management.

Table 9. Average household landholding (ha per household) by socio-economic status

Agricultural land	Poor household (N=33)	Near-poor household (N=11)	Non-poor household (N=17)	Average (N=61)
Wet rice and annual crops	0.12	0.24	0.25	0.18
Upland annual crops	0.58	0.93	0.93	0.74
Perennial crops	0.43	0.52	0.85	0.57
Fallow land	0.16	0.41	0.26	0.23
Planted forest	0.24	1.12	0.82	0.56
Home garden	0.24	0.02	0.25	0.21
Total	1.78	3.25	3.37	2.49
Minimum land owned	0.10	1.42	0.08	0.08
Maximum land owned	6.81	8.41	10.70	10.70

Source: authors' fieldwork, 2020

Land ownership included two types that were 1) legally recognized (land-use certificate); and 2) traditionally owned by local people. The results indicated that about 68% of land owned by individual households was granted a land-use certificate while 32% of land was owned

traditionally (through different family generations). Upland annual crops had the largest portion of land-use certificates followed by planted forest and perennial crops (Table 10). In addition to land tenure that was granted or traditionally owned by households, natural forests were allocated to village communities for management.

Table 10. Ownership of agricultural land by households in Chieng Yen Commune (%)

Agricultural land	Land-use certificate	Traditionally owned	Total
Wet rice and annual crops	6.4	0.9	7.3
Upland annual crops	20.4	9.4	32.8
Perennial crops	12.4	10.3	22.7
Fallow land	5.0	4.3	9.3
Planted forest	15.3	7.2	22.5
Home garden	8.2	0.2	8.4
Total	67.7	32.3	100

Note: No household land-use right status can be taken over by the Government at any time
Source: authors' fieldwork, 2020

3.2. Land uses and land-use changes (2010–2020)

3.2.1. Characterization of current land uses

The land uses in Chieng Yen Commune included three major groups: 1) forest land (natural forests and planted forests); 2) agricultural land (upland and lowland farming, fallow land); and 3) home-garden and settlement. The key features of land uses are described in Table 11.

Table 11. Description of land uses in Chieng Yen Commune

Land use	Description
Natural forest	These are broad-leaf evergreen forests at 800–1000 masl, which include very poor, poor and medium timber forests based on standing wood volume, mixed timber and bamboo forests and bamboo forests. The forests are allocated to villages for community-based management. The villages receive payment for forest protection through the national policy on payment for forest environmental services. The payment rate for 2019 was VND 0.52 million ha^{-1}.
Planted forest	Mainly timber and bamboo plantations. Timber plantation is pure plantation covering an area of 225.44 ha. Key species are *Melia azedarach* ('xoan ta'), *Magnolia conifera* ('mo'), *Michelia mediocris* ('gioi xanh'). The area of bamboo forest is about 2,477.75 ha. *Dendrocalamus barbatus* ('luong') is commonly planted. The plantations are managed mainly by individual households through forest land allocation policy.
Upland agriculture	Maize, cassava and rain-fed rice are the most common crops. This type of land is often found on clay soils at elevation of 750 masl or above. Irrigation depends entirely on natural water; terrace rice is also found at this elevation.
Fallow	Fallow is often applied 3–4 years or longer, depending on soil fertility, after 1–2 years of crop cultivation. Vegetation cover is mainly grass, shrubs and small woody plants
Lowland agriculture	Used for cultivation of wet rice and maize. This type of land use is often found in flat valleys between high mountains at elevations of 400–600 masl. Depending on water availability, farmers can cultivate 1–2 crops per year; managed mainly by individual households.
Home-garden and settlement	These land-use types are distributed mostly in low valleys and on relatively flat land. Most common tree species found are orange, tangerine, plum; managed mainly by individual households

Source: authors' fieldwork, 2020

3.2.2. Economic benefits and land-use issues

Economic analysis of key land uses indicated that the main income was from annual crops (wet rice, maize etc). The average net annual income per hectare from crops was VND 33 million (VND 18.4 million–44.3 million). The net annual income per hectare from tree-based crops varied greatly with average income value of VND 30.5 million (VND 15.3 million–46.4 million). The income per hectare from plantation was between VND 8.6 million and 36.0 million, depending on tree species. The annual economic benefits from natural forests was very low, at about VND 1.1 million per hectare. As the natural forests are designated for protection, local people are only allowed to harvest bamboo shoots, honey and timber for home use. They are paid for protection by the payment for forest environmental services program (VND 0.52 million ha^{-1} y^{-1}). Details of economic benefits of land uses are shown in Table 12.

Table 12. Economic benefits of land uses in Chieng Yen Commune

#	Land use	N	Rotation (y)	Net revenue (VND million ha^{-1})	Net income (VND million ha^{-1} y^{-1})
1	Natural forest	10	na	na	1.06
2	Plantation				
	Timber plantation	5	7	180.0	25.7
	Bamboo plantation	5	20	172.2	8.6
3	Tree-based land use				
	Tea and fruit trees (tangerine)	5	10	185.3	18.5
	Tea + timber tree (*Mangletia conifera)*	5	10	153.1	15.3
	M. azedarach and *Amomum vilosum*	5	10	417.4	41.7
	Fruit tree (tangerine)	5	10	464.2	46.4
4	Annual crops				
	Wet rice (2 crops/year)	31	1	18.0	18.0
	Maize (upland)	5	1	18.4	18.4
	Passionfruit (upland)	5	3	44.3	44.3

The interview results revealed that maize was the dominant crop (34.3% of total cropland) followed by intercropping annual crops (21.2%) and wet rice (18%) (see Table 13). Most households also had some plots of cassava or often a mix of annual crops.

Table 13. Common agricultural crops in HH farming production

Crops	Area (ha HH^{-1})	Percentage (%)
Wet rice	0.20	18.0
Maize	0.39	34.3
Cassava	0.11	9.9
Intercropping annual crops (maize, cassava, arrowroot etc)	0.24	21.2
Intercropping annual and perennial crops (peanut, plum, orange, tangerine, mango etc)	0.19	16.6
Total	1.13	100

Land degradation and lack of water for irrigation were the prevalent issues of land uses on sloping areas. Therefore, these issues were discussed during interviews. The interview results also indicated several issues related to land uses, such as soil erosion and degradation of soil fertility. Soil erosion was a serious issue. It occurs in different farming systems owing to inappropriate cultivation of (steep) sloping land. The associated decline of soil fertility is also a considerable problem. Similarly, water availability for irrigation of agricultural crops is seen as being a continuing and declining trend (see Table 14).

Table 14. Assessment of irrigation water, soil erosion and soil fertility in different farming systems

Status	Irrigation water (%)	Soil erosion (%)	Soil fertility (%)
Improving significantly	1.7	5.1	0.0
Improving slightly	3.4	8.5	3.4
Unchanged	33.3	16.9	22.0
Declining slightly	28.3	23.7	35.6
Declining significantly	33.3	45.8	39.0
Total	100	100	100

Source: authors' fieldwork, 2020

Although respondents were aware of soil erosion on their agricultural land, only 26.2% applied soil conservation measures (tree planting, soil cover, grass strips etc.) (see Table 15). The main reasons were lack of knowledge of how to protect the soil and the financial capacity to invest in soil protection, particularly on sloping land.

Table 15. Soil-conservation measures reported by respondents

Soil-conservation measures	Number of households	Percentage (%)
No	45	73.8
Yes	16	26.2
Total	61	100

Note: Measures applied by local people: protecting forests, planting perennial trees, agroforestry etc
Source: authors' fieldwork 2020

3.2.3. Trees on farms and support needed for expanding tree plantations

Trees on farms are an important indicator of sustainable farming and land-use practices. In total, there were 21 tree species identified with a total of 17,914 trees on several land-use types: 1) tree-crop plantation, including agroforestry (44.8%) and fruit trees of all kinds (49.5%); and 2) mixed home-garden (only 5.6%) (see Table 16 and Appendix 2).

In contrast, only 1–3 trees of some species — such as *Michelia mediocris*, *Artocarpus heterophyllus*, *Mangifera foetida*, *Psidium guajava*, *Persea americana* and *Syzygium samarangense* — were also found during the survey (see Appendix 2). Overall, on-farm tree density was estimated at 41 trees per hectare but the actual number of trees could be lower as some respondents tended to overestimate the number of trees on their farms.

Table 16. Structure of tree species according to main purpose by land use

Tree group	Total trees		% of total trees by land use (%)		
	Number	%	Agroforestry	Tree-crop plantation	Mixed home-garden
Timber species	6,463	36.1	29.0	6.8	0.3
Bamboo species	4,636	25.9	0.0	25.7	0.2
Fruit trees	4,686	26.2	6.9	14.3	5.0
Ornamental	2,129	11.9	8.9	2.8	0.2
Total	17,914	100	44.8	49.2	5.6

Note: N=61 households
Source: authors' fieldwork, 2020

3.2.4. Land-use changes 2010–2020

Significant changes in land-use in Chieng Yen Commune have been recorded between 2010 and 2020. Generally, the forest area increased by 231 ha and annual crops by 397 ha. The largest change in forest area incurred in bamboo forest, with an increase of 578 ha. However, timber natural forests showed a decrease of 306 ha during 2010–2020 (see Table 17). The results of an accuracy assessment of land-use and forest-cover maps indicated that at 95% confidence level, overall accuracy was 94%, and this was from 82–92% classification of poor and medium evergreen broadleaf forests (see Table 17 and Figure 5).

Table 17. Land-use changes, 2010–2020

Land-use/-cover type	Area in 2010 (ha)	Area in 2020 (ha)	Change in area (ha)	Change/total area ratio (%)
Evergreen broadleaf forest—medium	0	201.91	+201.91	+2.3
Evergreen broadleaf forest—poor	1,909.06	1,491.29	-417.77	-4.7
Evergreen broadleaf forest—very poor	111.35	21.04	-90.31	-1.0
Mixed wood–bamboo forest	952.80	1,073.76	+120.96	+1.4
Bamboo forest	1,900.12	2,477.75	+577.63	+6.6
Planted forest	386.36	225.44	-160.92	-1.8
Bare land with scattered trees	1,144.01	455.76	-688.26	-7.8
Bare land with grass and shrubs	143.50	92.72	-50.77	-0.6
Tree-crop plantation	23.93	57.31	+33.38	+0.4
Agroforestry	0	60.00	+60.00	+0.7
Annual crops	2,113.50	2,554.60	+356.10	+4.0
Water bodies	6.21	0.94	-5.27	-0.1
Other land-uses	82.61	145.95	+63.33	+0.7
Total	8,798.46	8,798.46	0	

Source: authors' work, adapted from FIPI (2011, 2020)

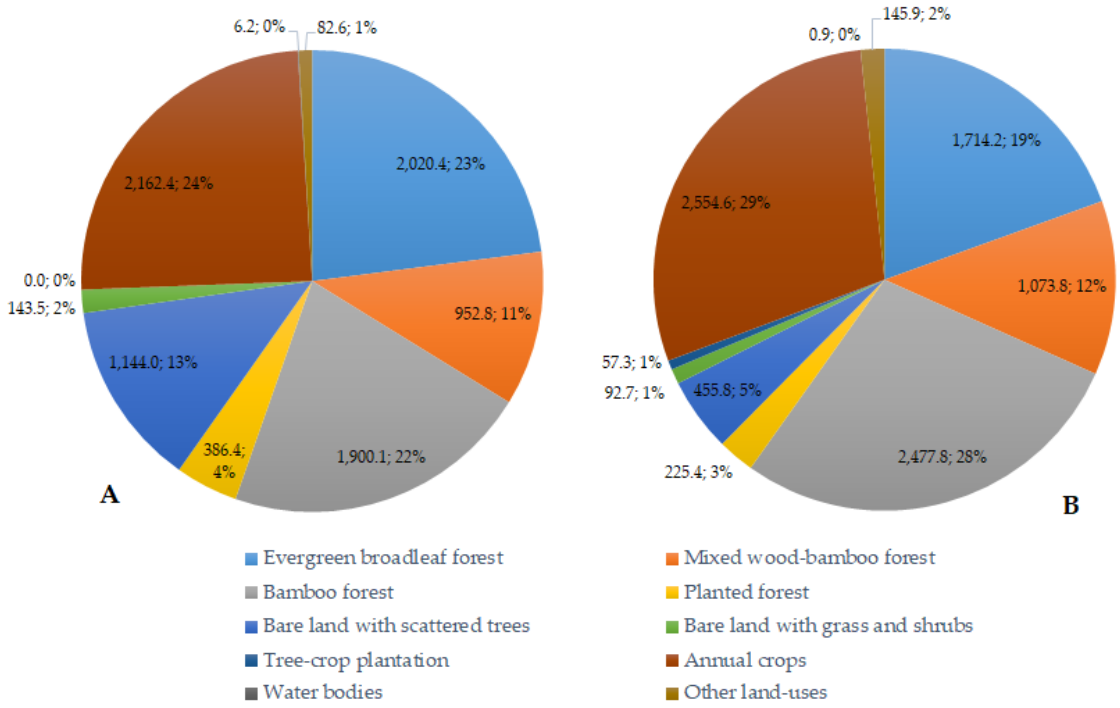


Figure 5. Land-use structure in Chieng Yen Commune in 2010 (A) and 2020 (B)

3.2.5. Historical land-use changes and their drivers

The significant change in forest area was reported to start in 2005 owing to economic development through expansion of agricultural crops on sloping land. Between 2005 and 2015, shifting cultivation was recognized as a common practice in mountainous areas, causing the conversion of forests to agricultural production. However, since 2015 the Government has implemented a forest-land allocation policy and invested in improving agricultural crop productivity to reduce pressure on forests and deforestation. In addition, an incentive policy also provides cash payment for forest protection, for example, the national policy on payment for forest environmental services and other economic development support programs of the Government (see Table 18).

Table 18. Historical land-use changes over time and their drivers

Time	Main characteristics	Drivers of changes
Before 2005	Natural forests and planted forests cover large area	Forests were managed and supported by the State through State forest enterprises
2005–2010	Natural forests and planted forests: sharply reduced area Wet rice: sharply reduced area Upland fields: sharply increased area, mainly growing maize and cassava	The State forest enterprises were dissolved across the country owing to the Government's change in forest management and development policies, leading to local people cutting natural forests to grow maize and cassava Planted forests after exploitation have not been replanted, mainly abandoned Landslides have increased, especially in 2007, causing a loss of wet-rice land
2010–2015	Natural forests and planted forests: decreased slowly Wet rice: stable Shifting-cultivation land: reduced, many areas fallow Tree-crop plantation: starting to develop fruit trees and tea on ineffective upland fields	The State increased local people's participation through a policy of allocating forests to households, starting in 2010 Shifting cultivation was ineffective owing to high production costs, especially seeds and fertilizer
2015–2020	Natural forests: tending to increase Wet rice and shifting land: continue to be reduced Tree-crop plantation: thriving fruit trees such as tangerines, passion fruit, orange, mango, grapefruit	The State has a more effective forest protection policy, such as payment for forest environmental services and natural forests allocated to villages for community management; many fallow fields have been moved to community forests to be zoned off for natural regeneration promotion Reducing wet-rice land owing to landslides in 2017 and a shortage of water in many places Inefficient shifting cultivation There are many projects to support fruit-tree development, especially citrus for beverage production

Source: authors' fieldwork 2020 (focus-group discussions)

Assessments were carried out of people's perceptions of changes in forest area and quality over the period 2010–2020. The results showed that there were different assessments of changes in forest area and quality. Forty-seven percent (47%) of respondents supposed there had been an increase in forest area and 36% argued there had been an improvement in forest quality. However, 29–33% of responses said that forests were stable in area and quality. Other responses were that forests were declining in area (25%) and quality (31%) (see Figure 6).

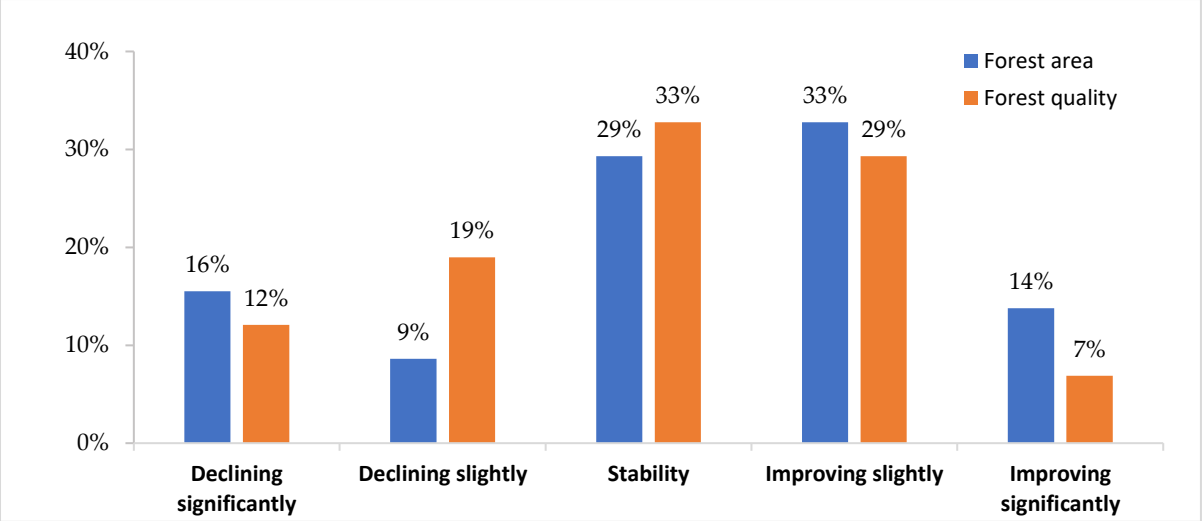
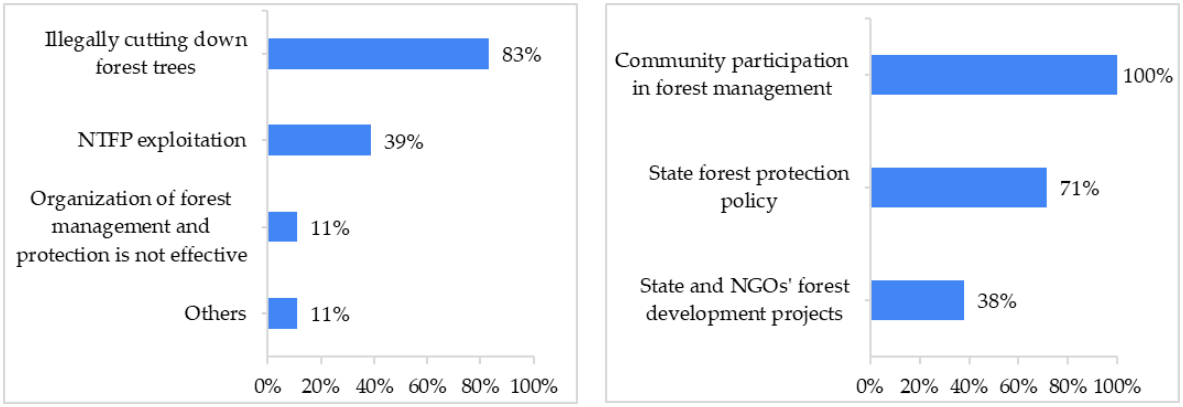


Figure 6. Local people's assessment of changes in forest area and quality in the period 2010–2020

According to respondents, illegal logging for timber and firewood was most frequently found as a cause of degraded forest quality, followed by exploitation of non-timber forest products (Figure 7A). Meanwhile, 100% of the respondents said that the participation of people in forest management, especially community forests, was the most important reason to protect and improve the quality of forests. Other reasons were the improvement of forest protection policies and the investment of the state and non-governmental organizations in forest planting and development activities (Figure 7B).



A B

Figure 7. Main causes of deforestation and forest degradation (A); improvement of forest quality (B)
Note: % of number of choices made by respondents

3.3. Assessment of changes in carbon stock

3.3.1. The carbon stock of land uses

Our land-use time-averaged aboveground carbon-stock measurements showed that the highest carbon stock was found in poor and medium evergreen broadleaf forests (49.6–78.0 tC ha^{-1}), followed by mixed wood–bamboo forests (30.5 tC ha^{-1}) and planted forests (30.1 tC ha^{-1}) (see Table 19).

Table 19. Estimated time-averaged aboveground carbon stock of land uses in Chieng Yen Commune

#	Land-use/-cover type	Timber volume (m^3 ha^{-1})	Aboveground carbon stock	
			tC ha^{-1}	SE
1	Evergreen broadleaf forest—medium	148.3	78.0	17.4
2	Evergreen broadleaf forest—poor	83.5	49.6	5.4
3	Evergreen broadleaf forest—very poor	22.6	20.1	4.6
4	Mixed wood-bamboo forest	28.5	30.5	9.5
5	Bamboo forest[a]	-	16.0	-
6	Planted forest	29.4	30.1	10.1
7	Bare land with scattered trees	20.2	13.6	3.1
8	Bare land with grass and shrubs	10.6	10.2	3.5
9	Tree-crop plantation	25.3	25.0	7.1
10	Agroforestry[b]	-	30.0	-
11	Annual crops; water bodies and other land uses	-	-	-

Note: [a] adapted from Le et al (2015); [b] adapted from Roshetko et al (2007); tC = ton carbon; SE = standard error
Source: authors' fieldwork, 2020

3.3.2. Changes in carbon stocks 2010–2020

In 2010, the total amount of aboveground carbon stored in evergreen broadleaf forest accounted for 52.2% of the landscape's total carbon stock (185,639.8 tC), followed by bamboo forest (16.4%), mixed wood–bamboo forest (15.7%), bare land with scattered trees (8.4%), and planted forests (6.3%).

By 2020, aboveground carbon storage of evergreen broadleaf forest and bamboo forest contributed to about 50.2% and 22.1% of the landscape's total carbon stock (179,695.7 tC), respectively. Overall, the total aboveground carbon stock of land uses in the commune had a net decrease of 5944.1 tC between 2010 and 2020 owing to land-use changes (see Table 20 and Figure 8).

Overall, the net carbon stock generated by land-use change in the period 2010–2020 in the commune showed a decrease of 5944.1 tC. The main decrease in carbon stock occurred in poor evergreen broadleaf forest (decreased by 20,721 tC), followed by bare land with scattered trees that was converted to annual crops (-9,360 tC) and planted forest area (-4,844 tC).

Table 20. Changes in carbon stocks 2010–2020 in Chieng Yen Commune

#	Land-use type	Carbon stock (tC)		Carbon change 2010–2020 (tC)
		2010	2020	
1	Evergreen broadleaf forest—medium	0.0	15,748.7	+15,748.7
2	Evergreen broadleaf forest—poor	94,689.4	73,968.0	-20,721.4
3	Evergreen broadleaf forest—very poor	2,238.2	422.9	-1,815.3
4	Mixed wood–bamboo forest	29,060.4	32,749.8	+3,689.3
5	Bamboo forest	30,402.0	39,644.0	+9,242.0
6	Planted forest	11,629.4	6,785.6	-4,843.7
7	Bare land with scattered trees	15,558.6	6,198.3	-9,360.3
8	Bare land with grass and shrubs	1,463.7	945.8	-517.9
9	Tree-crop plantation	598.3	1,432.7	+834.4
10	Agroforestry	0.0	1,800.0	+1,800.0
11	Annual crops; water bodies and other land uses	0.0	0.0	0.0
	Total	185,639.8	179,695.7	-5,944.1

Note: '+' = increase; '-' = decrease

Source: authors' work 2020

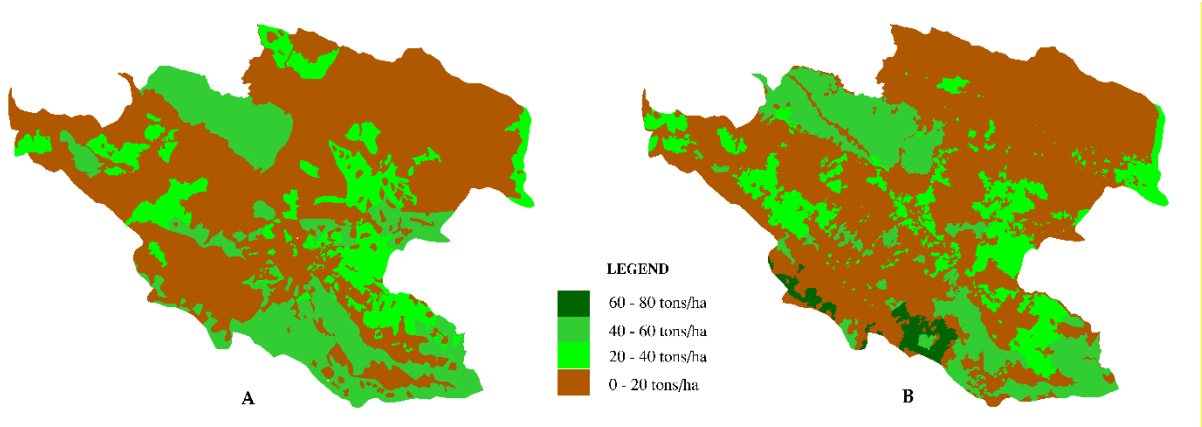


Figure 8. Aboveground carbon-stock distribution of land uses for 2010 (A) and 2020 (B)

3.4. Land-uses scenarios towards 2040 for improving ecosystem services

3.4.1. Local perceptions of environmental issues related to land uses

To elicit stakeholders' perceptions of landscape ecosystem services—which can be an unfamiliar concept — we first explored issues concerning forests, agriculture and the environment, gradually incorporating them into the discussions. As shown in Figure 9 below, the three most pressing issues perceived by farmers were lack of water for domestic use and cultivation, floods and landslides, and the changing climate affecting agricultural crops; these were all related to agricultural production.

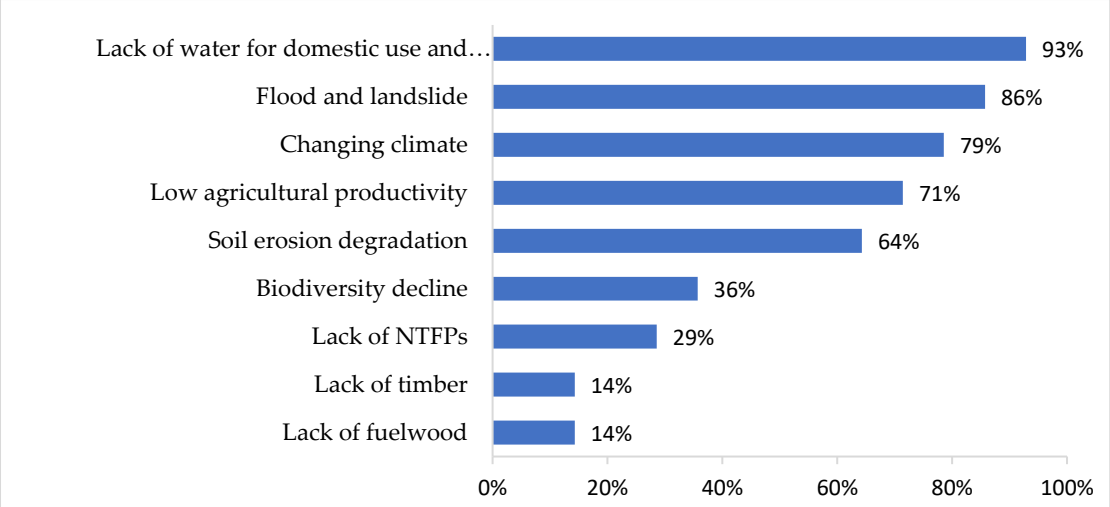


Figure 9. Local people's assessment of environmental issues related to land uses

Landscape management decisions were considered complex owing to the multiple-use nature of goods and services, the difficulty in quantifying ecosystem services, and the involvement of all stakeholders in the landscape.

In this section, we provide a quick assessment of stakeholders' perspectives of the ecosystem services provided by the landscape, the forests and key agro-ecosystems, insights into current forest and landscape governance mechanisms, and stakeholders' recommendations on how to improve landscape governance to secure and enhance ecosystem service flows, which, in turn, can be used as inputs for policy making and decisions regarding sustainable landscape management.

3.4.2. Stakeholders' awareness of ecosystem services provided at landscape level

Local understanding of ecosystem services and the forest landscape was translated into 'benefits' of ecosystem services, an easier concept for local people to understand, during the assessment. Numbers of ecosystem services were provided to local people for their understanding and assessment. The results revealed that local people had a good understanding of the role of forest landscapes in mitigating and preventing natural disasters (75% of responses), for example, flash floods and landslides. Other environmental benefits also featured good awareness of local people, such as environmental quality, soil-erosion control, and climate regulation. However, other benefits were not well recognized, such as biological control and natural scenery. (Table 21).

Table 21. Stakeholders' awareness of ecosystem services

Ecosystem service	Choice made by respondents*	Percentage (%)
Mitigation of natural disasters	42	75.0
Making the environment clean	32	57.1
Anti-soil erosion	32	57.1
Climate and weather regulation	28	50.0
Clean water	26	46.4
Regulation of water flows	22	39.3
Food	19	33.9
Biological control	15	26.8
Fuel	12	21.4
Medicine	12	21.4
Natural scenery	12	21.4
Fodder and fertilizer	10	17.9
Wood and fibre	9	16.1
Tourism and entertainment	6	10.7
Cultural and spiritual values originated or derived from nature/natural resources	3	5.4

Note: * compiled from household survey with responses of 56 households. Each respondent could choose no more than 5 ecosystem services

Source: authors' fieldwork, 2020

Local people also provided assessments of forest protection organized by the community. Ninety percent (90%) — 55 of 61 respondents — reported that forest-protection teams had been formed in all villages to coordinate and implement forest-protection activities. Also, 87.3% of the respondents said forests were well protected by effective coordination and engagement of local people (Table 22).

Table 22. Local assessment of effectiveness of community-based forest management

Effectiveness	Number of respondents	Percentage (%)
Very effective	11	20.0
Effective	37	67.3
Moderate	3	5.5
Not effective	2	3.6
No response	2	3.6
Total	55	100

The interviews revealed that in addition to forest protection led by the community teams, local people actively participated in forest protection (over 50%). The influence of stakeholders on community-based forest management was assessed. Village communities and households played important roles in community-based forest management (see Table 23).

Table 23. Actors' influence on community-based forest management

Key actors influencing community forests	Choice made by respondents*	Percentage (%)
Household	32	52.5
Household group	2	3.3
Village community	35	57.4
Commune people's committee	18	29.5
Forest management board	5	8.2
State forest company	2	3.3
Forest ranger	7	11.5
Household outside the village	4	6.6
Other (the state, projects etc)	4	6.6
Not clear	7	11.5

Note: * compiled from household survey with responses of 61 households. Each respondent could choose more than one option

Source: authors' fieldwork, 2020

Although the national policy on payment for forest environmental services has been in operation since 2011, not all local people knew about it. The interviews indicated that 79% of respondents knew of the policy and about 64% supposed that the policy was overall quite effective with local people protecting the forests. About 56% of the respondents assessed that the policy was 'effective' (Table 24).

Table 24. Local assessment of effectiveness of payment for forest environmental services

Effectiveness	Number of respondents	Percentage (%)
Very effective	5	8.2
Effective	34	55.7
Moderate	4	6.6
Not effective	0	0.0
No response	18	29.5
Total	61	100

3.4.3. Local perspectives of ecosystem services

Considering the local assessment of the benefits of ecosystem services, the most important ecosystem services were selected by taking into account the four functional domains: 1) life support; 2) regulation; 3) provision; and 4) information. The quantitative assessment was facilitated through focus-group discussions using a relative assessment scale for every ecosystem service that were declining, improving or unchanged.

The results implied that better awareness and understanding of local people should be built of forests and tree-based crops. The scores indicated, particularly, the importance of natural forest (30/30), planted forest (24/30), perennial plantation (20/30), while the non-tree-based ecosystems — including upland annual crops and flat land annual crops — were both well

under (10/30) (Table 25). Specifically, there was a strong correlation between the number of trees in the ecosystem (relatively) and their role in provision of ecosystem services, as perceived by stakeholders. This result reaffirmed the forest-status assessment mentioned above: that forest quality (and thus their ecosystem service provisioning capacity) has been improving in the whole landscape of Chieng Yen Commune. Tree-crop plantations and fallows were the two ecosystems that were improving in most aspects of ecosystem service provision. Awareness of the role of forest- and tree-based land uses in securing wellbeing and agricultural production might trigger attitudinal and behavioural changes in local stakeholders. In developing the LUMENS interventions (see Section 3.4.5), stakeholders expressed their interest in enhancing tree-based systems through forest management, agroforestry and home-garden intensification.

Table 25. Stakeholder's awareness of ecosystem services provided at landscape level

Ecosystem service	Natural forest	Planted forest	Upland annual crops	Tree-crop plantation	Mixed home-garden	Lowland annual crops	Fallow land	Water surface
Mitigation of natural disasters	5 (++)	4 (++)	1 (-)	4 (+)	2 ()	0 (--)	2 (+)	0 ()
Making the environment clean	5 (++)	4 (++)	2 (-)	3 (+)	2 ()	1 (-)	2 (+)	1 (-)
Anti-soil erosion	5 (++)	5 (++)	1 (+)	4 (+)	3 ()	1 ()	2 (+)	0 ()
Climate and weather regulation	5 (+++)	4 (++)	2 (+)	3 (++)	3 ()	2 ()	1 (+)	4 (---)
Clean water	5 (++)	4 (++)	1 ()	2 (++)	1 ()	1 ()	2 (+)	0 (-)
Regulation of water flows	5 (++)	3 (++)	1 (-)	4 (++)	3 ()	2 (-)	1 (+)	0 (--)
Total point	30	24	8	20	14	7	10	5
Highest possible points	30	30	30	30	30	30	30	30

Note: Number scores indicate the significance of ecosystem services that are: vital (5), important (4), fairly important (3), somewhat important (2), slightly important (1) and not relevant (0). The letters in brackets indicate qualitative assessment of ecosystem service quality: declining significantly (---), declining (--), declining slightly (-), stability (), improving slightly (+), improving (++), and improving significantly (+++)
Source: authors' fieldwork, 2020

3.4.4. Actors' engagement in land use and management

The Forestry Law 2017[6] and Land Law 2013[7] are the two key instruments governing forest and land management. These legal documents also provide detailed responsibility of line agencies across levels in forest and land management. At local level, the identified actors engaged in forest and land management in the Chieng Yen Commune were as follows.

Chieng Yen CPC is in charge of law enforcement, public services and implementation of all government policies in Chieng Yen Commune. The CPC is also responsible for developing

[6] Forestry Law No. 16/2017/QH14 issued on 15 November 2017 by Viet Nam National Assembly.

[7] Land Law No. 45/2013/QH13 issued on 29 November 2013 by Viet Nam National Assembly.

annual socio-economic development and land-use plans, implementing the approved plans, and reporting to the next governmental level (district).

District People's Committee (DPC) is a state management agency tasked with land and forest governance, that is, to **p**repare and implement land-use planning and annual land-use plans (including commune land-use plans); allocate and lease land and forests; make decisions on conversion of land and forests; revocation of land and forests for land users and forest owners who are individuals, households and communities.

Forest Protection Department (FPD) is responsible for forest law enforcement at both district and commune levels. In some cases, a special task force is formed for patrolling forests, which includes forest rangers, police and sometimes even the army. However, according to farmers' perceptions, the role of local authorities is not clearly regulated and the rights of forest rangers are not reflective of their assigned duties. Moreover, the rights and responsibilities of forest owners are not clearly defined in legal documents, which leads to, or exacerbates, conversion and degradation of forest land because some regulations under the law give forest owners more rights over land than rights over the resources of that land. In general, the enforcement of laws to control illegal logging is considered ineffective.

Department of Environment and Natural Resources (DONRE) is in charge of land-use planning and environment-related issues. This department is a functional unit to support DPC in development and monitoring of implementation of land-use plans; implementation of law enforcement of land and environmental aspects.

Son La Forest Protection and Development Fund (Son La FPDF) is responsible for implementation of the national policy on payment for forest environmental services. Specifically, this organization arranges the payment contract for forest protection and monitors implementation.

Village communities are allocated forests for community-based forest management. The communities have to comply with their forest protection contracts under the payment for forest environmental services' policy and the forestry law for forest management. As the allocated forests are designated as 'protection forests', timber logging for commercial purposes is not allowed, only for home-use with approval of local authority. The communities receive annual payments for forest protection from Son La FPDF and are responsible for forest protection and for sharing the payments in the village.

Smallholders manage their land for crop production and plantation forestry. According to the land law and the forestry law, smallholders are allowed to cultivate any crops, fruit trees and timber plantations, but may not convert forest land to non-forest land without the approval of the local authority.

In summary, it can be seen that there are two key actors engaged in land and forest management in Chieng Yen Commune. The first is the state organizations responsible for planning and law enforcement. The second is the smallholders (individual land and forest users) who are legally allocated agricultural and forest land. A third actor is village communities responsible for forest management (see Table 26).

Table 26. Stakeholders' analysis of landscape governance

Land use	Management objective	State (DONRE, FPD, Chieng Yen CPC)	Village community	Smallholder
Natural forest	Protection of water sources and conservation of biodiversity	Planning; law enforcement and monitoring	Organization for forest protection	Participate in forest protection according to village regulations
Planted forest	Timber production and in combination with crops	Planning; law enforcement and monitoring	Information dissemination	Comply with land-use plans and forest management
Non-forest land (upland)	Planned for forestry plantations and crop cultivation	Planning; law enforcement and monitoring	Support state organization in planning	Temporary use for shifting cultivation, grazing etc
Tree-crop plantation and agroforestry	Production for livelihoods and commercial purposes	Support production, including technical capacity, access to finance	Information dissemination	Make decisions on crop production
Annual crops	Production for food and commercial purposes	Support for improving crop productivity	Information dissemination	Make decisions on crop production
Waterbody	Manage of sources for irrigation and other purposes (fisheries etc)	Planning and management of water sources	Manage streams according to village regulations	Participate in water management following village regulations
Home-garden	Residential land and housing	Planning and law enforcement	Support in planning and management	Manage land for housing and home-gardens

Source: authors' work, 2020

3.4.5. Proposed land uses and interventions towards 2040

A land-use plan towards 2040 was discussed by participants representing villages, local authorities and civil-social organizations. The land-use scenario towards 2040 considers environmental services, in particular, tree-based land uses that help achieve sustainable growth and national emission-reduction targets.

The key interventions for future land-use focus on 1) protecting, and improving, natural forests to safeguard water sources for villages and development of non-timber forest products; 2) reforestation of non-forest land (bare land) to expand forested areas using native tree species; 3) improving wet-rice productivity by applying advanced techniques, seed varieties and irrigation systems; 4) development of fruit trees and application of agroforestry practices (see Table 27) to enhance economic value and ecosystem services' protective functions in upland areas.

Participants also mentioned potential for ecotourism development (for example, cultural tourism sites in Na Bai and Phu Mau villages, Tat Nang waterfall and Bo Am hot springs in Phu Mau Village, Buot fish-stream in Buot Village, caves in Phu Mau and Nien villages) but did not seem keen to raise them higher on their action agenda. This was because of the perception that eco-tourism development was very demanding in terms of financial investment, which, in turns required strong interests from enterprises outside of the commune. We suggested that immediate support toward this end was to help the commune develop a business plan for ecotourism that was well connected to nearby tourist attractions (that is, in Moc Chau and Mai Chau districts). A business plan is a very useful instrument — that builds on the potential high popularity of sites such as the hot-spring, waterfall and fish stream — to attract investment from business actors in, or even outside, of Son La Province. It should also be noted that a new highway (Hoa Binh–Son La) is planned to cut through Chieng Yen Commune, which could open new opportunities for eco-tourism development.

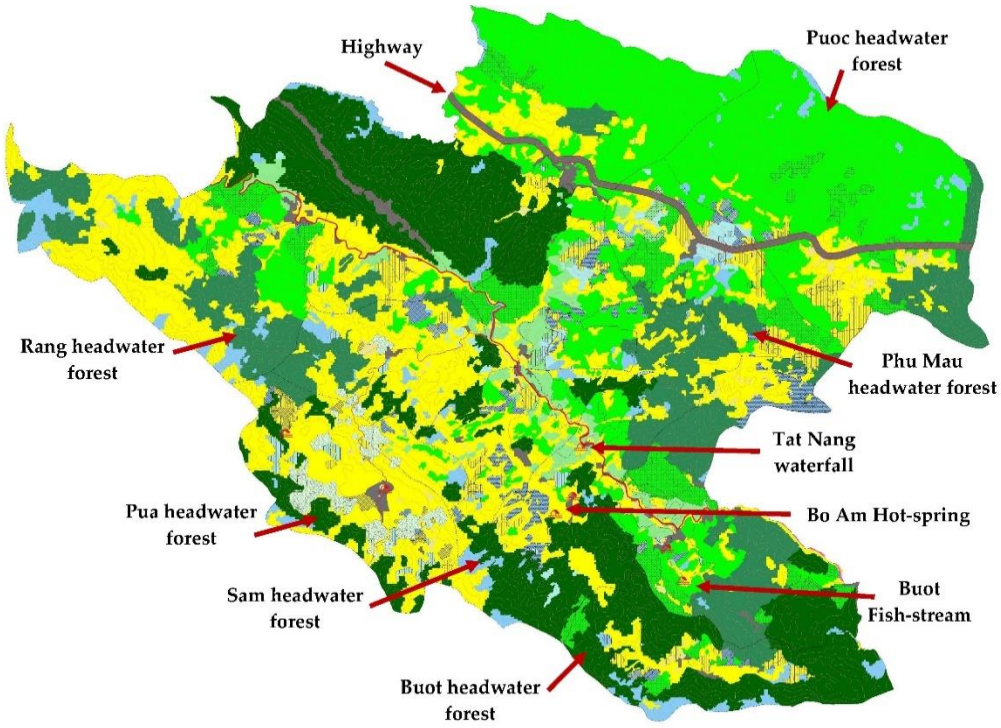


Figure 10. Headwaters and potential eco-tourism areas in Chieng Yen Commune

The discussion outlined above reveals local people's modest willingness to transform current land uses (for example, bare and fallow land, and upland crops) to tree-based ones. In total, only about 490 ha of Chieng Yen's land is planned for conversion to agroforestry or native timber plantations in the next 10 years (up to 2030). This area equals about 15% of 'potential land uses for conversion' and only 5.5% of the total land area of the commune. This reflects local concerns on economic benefits and markets for tree plantations, especially, their recent negative experience with passionfruit plantations. On the other hand, the potential for forest

rehabilitation with native species seems to be large, with more than 1,000 ha planned to be enriched. The main focus of this objective is to maintain and enhance ecosystem services, especially, watershed protection. However, it was unsure how this target would be delivered and whether or not it would include bamboo plantations (which help to provide annual incomes via harvesting bamboo shoots but which are also somewhat detrimental to the soil, as some participants mentioned).

To implement this land-use plan, effective support from the Government will be needed. The support would include technical assistance by extension agencies, capacity building, preferential loan and market access (see Appendix 4). Village communities need the support of the Provincial FPD, forestry extension and CPC to develop forest-management plans and capacity building to protect, and develop, community-managed natural forests in most villages. For planted forests, local people and communities need DARD and DPC's support in land allocation, investment and technology, and market development of products.

Table 27. Proposed land use and interventions towards 2040

Land use	Proposed intervention	Priority level	Planned area (ha)
Natural forest	Protect and stabilize existing watershed protection forests for water sources and reduction of soil erosion, landslides and other natural disasters, especially for community-managed forests	High	1,693
	Improve forest quality by enrichment	Medium	1,073
	Improve community-based forest management	High	2,788
	Development of non-timber forest products' production models (for *Amomum*, bamboo shoots etc) for livelihoods' improvement	Medium	100
	Develop ecotourism (for example, growing flowers and peach trees along the way to existing tourist attractions (Tat Nang waterfall, Bo Am hot spring, Buot fish stream etc) to create a pleasant feature) for livelihoods' improvement	Low	-
Planted forest	Maintain plantations for commercial purposes	Medium	2,225
	Enrichment planting using native species and high-value exotic species (for example, *Nauclea orientalis*, *Melia azedarach*) for income improvement	Medium	448
Upland crops (tree-crop plantations and agroforestry)	Convert annual crops to fruit trees for income improvement	Medium	50
	Planting fruit trees — peach, plum, orange, tangerine, mango, longan — and passionfruit for income improvement	High	100
	Application of agroforestry (tea and other woody species) for income improvement and reduction of land degradation	Medium	299
	Convert to plantations for timber production for domestic and commercial purposes	Medium	100

Lowland crops (wet rice)	Stabilize current wet-rice area and apply technical advances to improve productivity and quality for food security	High	2,554
	Expand rice area by cultivating terraced fields and improving irrigation for intensive rice cultivation for food security	High	50
Waterbodies and home-gardens	No significant change Improve irrigation systems for rice cultivation Develop residential land according to land-use plans	Medium	147

Source: authors' fieldwork, 2020

Impacts of proposed land-use interventions on a landscape's greenhouse-gas emissions and sequestration were assessed using REDD Abacus software. The land-use change matrix of 2010–2020 (see Appendix 1) was used as the baseline to project both Business as Usual (BAU) and Integrated Land-Use Planning (ILUP) scenarios for each 10-year period up to 2040. Not all proposed interventions could be simulated owing to limited software functionality and input data. The following interventions were parameterized and added to REDD Abacus: 1) strict protection, and support for regeneration of, natural poor forest (EBF – poor); 2) limiting shifting cultivation to land designated for forestry (bare land with scattered trees); 3) conversion of shifting-cultivation land in fallow stage (bare land with grass and shrubs) to tree-crop plantation; and 4) fruit-tree and agroforestry development (Table 27). Such proposed land-use changes were converted to a Transition Probability Matrix for projection (Appendix 2).

Based on historical trends (BAU), emission projections for land-use changes for the 20-year period (2020–2040) showed that the Chieng Yen landscape would continue to be a net emitter until 2040, mainly owing to forest degradation as a continuation of the past trend (2010–2020) (Figure 11). Carbon sequestration would surpass emissions in 2030–2040 as forest regeneration would become the dominant land-use change.

Compared to the BAU, emissions from the ILUP scenario were lower because conversion of forests to other uses was more restricted. However, the difference was not significant, only about 3%. According to the projection, the accumulated emissions from land-use change under BAU by 2040 would be 531,677,000 tons CO_2e while that of ILUP would be 515,474,000 tons CO_2e. Both scenarios showed the potential of the Chieng Yen landscape for net CO_2e sequestration in terms of land-use changes in the 20-year period. The BAU and ILUP sequestration toward 2040 were 535,734,000 and 580,206,000 tons CO_2e, respectively. This implies that the ILUP towards 2040 could reduce emissions by 3% and increase sequestration by 8% compared to that of BAU.

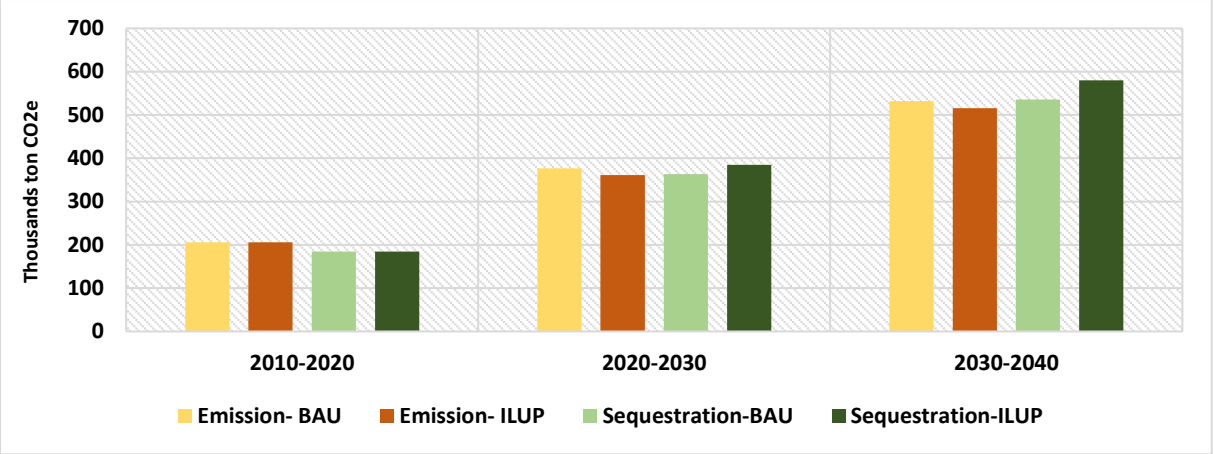


Figure 11. Projected accumulated greenhouse-gas emissions and sequestration (as thousand tons CO_2e) in Chieng Yen Commune until 2040

Owing to lack of data and the model's functional limitation, the impact of the proposed interventions on other ecosystem services (water regulation, biodiversity etc) and economic benefits were not simulated. Nevertheless, information in this study about possible interventions for low-emission development can be useful for policy makers in governing Chieng Yen towards green growth and sustainable rural landscapes.

4. Conclusion

The research assessed different aspects of land uses in Chieng Yen Commune, including the socio-economic conditions, land uses and land-use change, changes in carbon stock, and put forward a land-use scenario towards 2040 based on local people's perceptions of improving environmental services.

Farming is the major occupation and income source for local people. Landholding sizes and annual incomes of households vary greatly among the poor, near-poor and non-poor households. The average landholding by household and annual income were 2.49 ha (1.78–3.37) and VND 49.7 million (VND 27.9 million–75.2 million). Key land uses were divided into several types: 1) forest land (natural and planted forests); 2) upland agriculture (maize, cassava etc); 3) lowland agriculture (wet rice); and 4) home-garden. Significant conversion of forests into agricultural land was observed during 2010–2020, particularly, the poor natural forests. Consequently, the net aboveground carbon stock was reduced by about 3% (or 5944.1 tC) over the period 2010–2020.

Local people are now facing environmental issues related to land use, including soil erosion and degradation, lack of water for domestic use and irrigation, floods and landslides, and climate change. However, local people have a good awareness of the significance of environmental services provided by forests and tree-based land uses that address and mitigate the identified environmental issues.

An integrated land-use plan scenario towards 2040 was collectively developed by villages, local management agencies and socio-civil organizations. The development of the plan considered the targets for improving income and maintaining local environmental services' provisioning functions, especially, the protection of headwaters and identification of potential eco-tourism areas. The proposed future land uses focus on protecting and improving natural forests and development of non-timber forest products, implementing reforestation on non-forest land (bare land) to expand forest areas using native tree species, improving wet-rice productivity, developing fruit trees and applying agroforestry practices. The projected land-use plan toward 2040 can reduce 3% of emissions and increase 8% of sequestration compared to the business-as-usual scenario.

Policy and technical support are needed to achieve integrated landscape management at local (commune) level to meet the objectives of the national green-growth strategy. The support includes technical capacity building for community-based forest management, investment in forest enhancement and reforestation, development of non-timber forest products and expansion of tree-based land uses for improved resilience to environmental issues and securing livelihoods for local people.

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Appendices

Appendix 1. Land-use-change matrix 2010–2020 for Chieng Yen Commune

2010 land use-/-cover type	2020 land-use/-cover type													Total 2010
	EBF—medium	EBF—poor	EBF—very poor	Mixed wood–bamboo forest	Bamboo forest	Planted forest	Bare land with scattered trees	Bare land with grass and shrubs	Tree-crop plantation	Agro-forestry	Annual crops	Water bodies	Other land uses	
EBF—medium	0.0													0.0
EBF—poor	163.3	1,064.8	13.4	74.3	78.5	0.4	128.2	13.4	6.1		345.8	0.8	20.2	1,909.1
EBF—very poor	0.5	4.9	0.0	23.7	0.0		31.6	0.0	1.0		49.1		0.5	111.4
Mixed wood–bamboo forest		4.9		498.3	243.4	10.9	46.2	6.4	1.3		137.6		3.8	952.8
Bamboo forest		149.9		127.1	1,219.4	30.9	26.6	25.1	13.5		297.3		10.4	1,900.1
Planted forest		10.6	1.5	6.1	189.0	60.3	12.2	10.1	3.6		84.2		8.8	386.4
Bare land with scattered trees	36.7	126.7	6.1	130.5	246.9	61.6	95.7	6.7	4.8		416.6	0.2	11.6	1,144.0
Bare land with grass and shrubs		7.6		18.4	15.7	2.0	13.1	0.0	1.3		85.3		0.3	143.5
Tree-crop plantation									0.0		23.9			23.9
Agroforestry										0.0				0.0
Annual crops	1.5	121.7	0.0	195.4	480.5	54.6	101.5	30.8	23.5	60.0	1,015.2		53.7	2,138.5
Water bodies		0.2			1.7	0.2	0.5				2.3	0.0	1.4	6.2
Other land uses		0.2			2.6	4.6	0.2	0.1	2.2		37.3		35.4	82.6
Total 2020	201.9	1,491.3	21.0	1,073.8	2,477.8	225.4	455.8	92.7	57.3	60.0	2,494.6	0.9	145.9	8,798.5

Note: The unit of area is hectare (ha). EBF = evergreen broadleaf forest

Source: authors' work, adapted from FIPI (2011, 2020)

Appendix 2. Projected land-use-change matrix 2020–2030 for Chieng Yen Commune

2020 land-use/-cover type	2030 land-use/-cover type													Total 2020
	EBF—medium	EBF—poor	EBF—very poor	Mixed wood–bamboo forest	Bamboo forest	Planted forest	Bare land with scattered trees	Bare land with grass and shrubs	Tree-crop plantation	Agro-forestry	Annual crops	Water bodies	Other land uses	
EBF—medium	201.9													201.9
EBF—poor	200.0	1,291.3												1,491.3
EBF—very poor		21.0	0.0											21.0
Mixed wood–bamboo forest				1,071.5									2.3	1,073.8
Bamboo forest					2,429.9								47.9	2,477.8
Planted forest						223.4							2.1	225.4
Bare land with scattered trees			150.0				302.9						2.9	455.8
Bare land with grass and shrubs								37.4	50.0				5.4	92.7
Tree-crop plantation									54.8				2.6	57.3
Agroforestry										60.0				60.0
Annual crops						100.0		50.0	100.0	50.0	2,168.9		25.7	2,494.6
Water bodies												0.9		0.9
Other land uses													145.9	145.9
Total 2030	401.9	1,312.3	150.0	1,071.5	2,429.9	323.4	302.9	87.4	204.8	110.0	2,168.9	0.9	234.6	8,798.5

Note: The unit of area is hectare (ha). EBF = evergreen broadleaf forest

Source: authors' work adapted, from FIPI (2020), and focus-group discussions with local people

Appendix 3. Trees on farms as reported by respondents

#	Vietnamese name	English name	Scientific name	Main use	Total number of trees	% of grand total (%)	% of Grand total by the land uses (%)		
							Agroforestry	Perennial crops (excluding agroforestry)	Mixed home-garden
1	Xoan	Melia	*Melia azedarach*	Timber	6,422	35.8	29.0	6.6	0.3
2	Luồng	Dendrocalamus	*Dendrocalamus* sp	Bamboo for pulp or construction	4,636	25.9	-	25.7	0.2
3	Đào	Peach	*Prunus persia*	Ornamental	2,129	11.9	8.9	2.8	0.2
4	Quýt	Tangerine	*Citrus reticulata*	Fruit for food	1,974	11.0	1.2	7.9	2.0
5	Cam	Orange	*Citrus sinensis*	Fruit for food	1,072	6.0	2.5	2.9	0.6
6	Mận	Plump	*Prunus salicina*	Fruit for food	1,052	5.9	3.0	2.8	-
7	Bưởi	Pomelo	*Citrus grandis*	Fruit for food	225	1.3	-	0.6	0.7
8	Chanh	Lemon	*Citrus limonia*	Fruit for food	212	1.2	-	-	1.2
9	Xoài	Mango	*Mangifera indica*	Fruit for food	82	0.5	0.3	0.1	0.1
10	Mỡ	Mangletia	*Manglietia conifera*	Timber	40	0.2	-	0.2	-
11	Nhãn	Longan	*Dimocarpus longan*	Fruit for food	26	0.1	-	-	0.1
12	Mơ	Apricot	*Prunus mume*	Fruit for food	11	0.1	-	-	0.1
13	Vải	Litchi	*Litchi chinensis*	Fruit for food	10	0.1	-	-	0.1
14	Quất	Kumquat	*Citrus japonica*	Fruit for food	9	0.1	-	-	0.1
15	Giổi	Michelia	*Michelia mediocris*	Fruit for food	3	0.0	-	-	-
16	Mít	Jack fruit	*Artocarpus heterophyllus*	Fruit for food	3	0.0	-	-	-
17	Muỗm	Horse mango	*Mangifera foetida*	Fruit for food	3	0.0	-	-	-
18	Ổi	Guava	*Psidium guajava*	Fruit for food	2	0.0	-	-	-
19	Gáo vàng	Nauclea	*Nauclea orientalis*	Timber	1	0.0	-	-	-
20	Bơ	Avocado	*Persea americana*	Fruit for food	1	0.0	-	-	-
21	Roi	Java apple	*Syzygium samarangense*	Fruit for food	1	0.0	-	-	-
	Grand total				17,914	100.0	44.8	49.5	5.6

Note: Compiled from household survey; respondents: 61 households

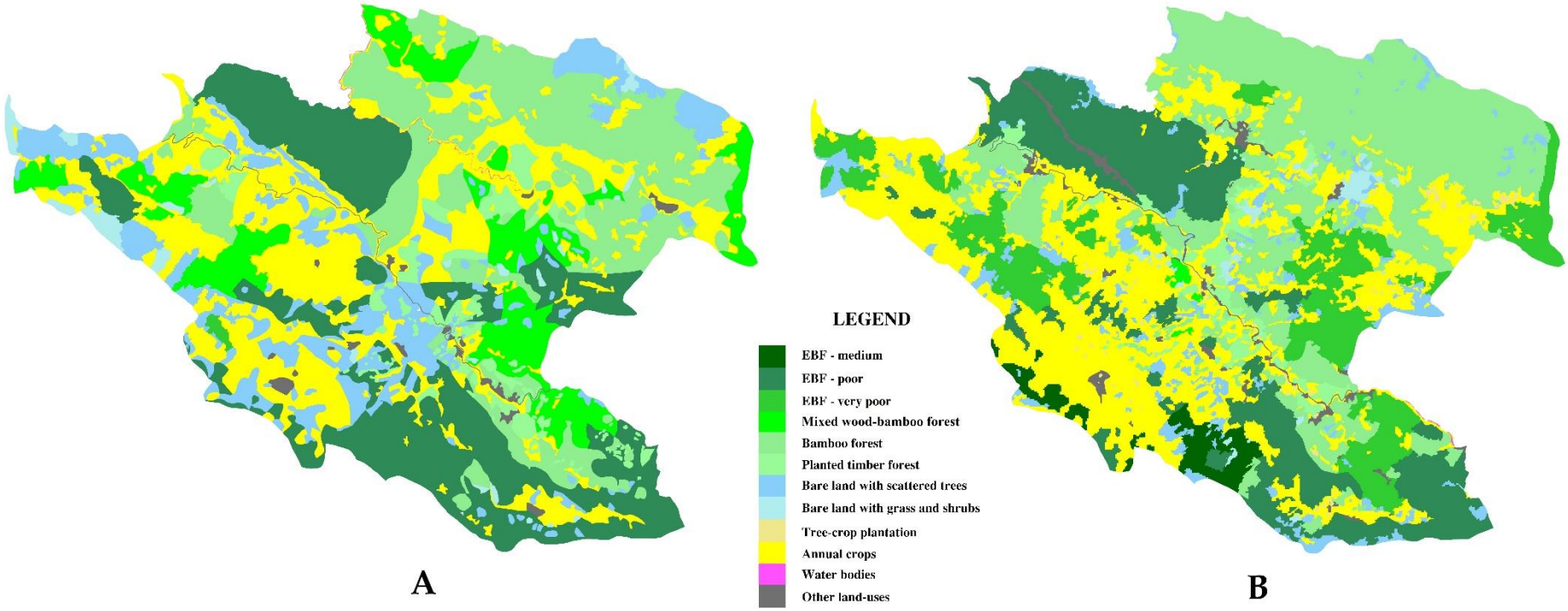
Appendix 4. Proposed participatory land-use plan towards 2040

Land use	Proposed intervention	Priority level	Planned area (ha)	Location	Support policy needed or currently available	Stakeholders
Natural forest	Protect and stabilize existing watershed protection forests for water source and reduction of soil erosion, landslides and other natural disasters, especially in community-managed forests	High	1,693	All villages with allocated natural forests, especially Pa Puoc, Na Bai, Pieng Cha, Bong Ha, Buot, Suoi Muc	Capacity building Support for development of forest-management plans	Provincial Forest Protection Department, forestry extension, CPC, communities
	Improve forest quality by forest enrichment	Medium	1,073			
	Improve community-based forest management	High	2,788			
	Develop non-timber forest products' production models (for example, *Amomum*, bamboo shoots) for livelihoods' improvement	Medium	100			
	Develop ecotourism models (for example, growing flowers and peach trees along the way to create a pleasant highlight) for livelihoods' improvement	Low	-			
Planted forest	Maintain plantations for commercial purposes	Medium	2,225	Whole commune	Land allocation Investment (capital and technology) Market development	DARD, DPC
	Enrichment planting using native species and high-value species (for example, *Nauclea orientalis*, *Melia azedarach*) for income improvement	Medium	448	Bare land in Chieng Yen village		
Upland crops (tree-crop plantations and agroforestry)	Convert annual cropland to fruit trees for income improvement	Medium	50	Whole commune	Technical support Market access Preferential loan access	Households, CPC, agricultural and forestry extension
	Grow fruit trees — peach, plum, orange, tangerine, mango, longan — and passionfruit for income improvement	High	100	Shifting land in villages such as Na Bai, Co Ba, Buot, Suoi Muc, Bong Ha, Pha Le, Pa Puoc	Seed and fertilizer Cultivation techniques	Households, agricultural and forestry extension, CPC, local enterprises
	Apply agroforestry (tea and other woody species) for income improvement and reduction of land degradation	Medium	299	Co Ba, Phu Mau, Nien, Bong Ha, Pha Le, Leo	Loans with preferential interest rates Seed, planting and processing techniques	Agricultural and forestry extension, CPC, communities
	Convert to plantations for timber production for domestic and commercial purposes	Medium	100			

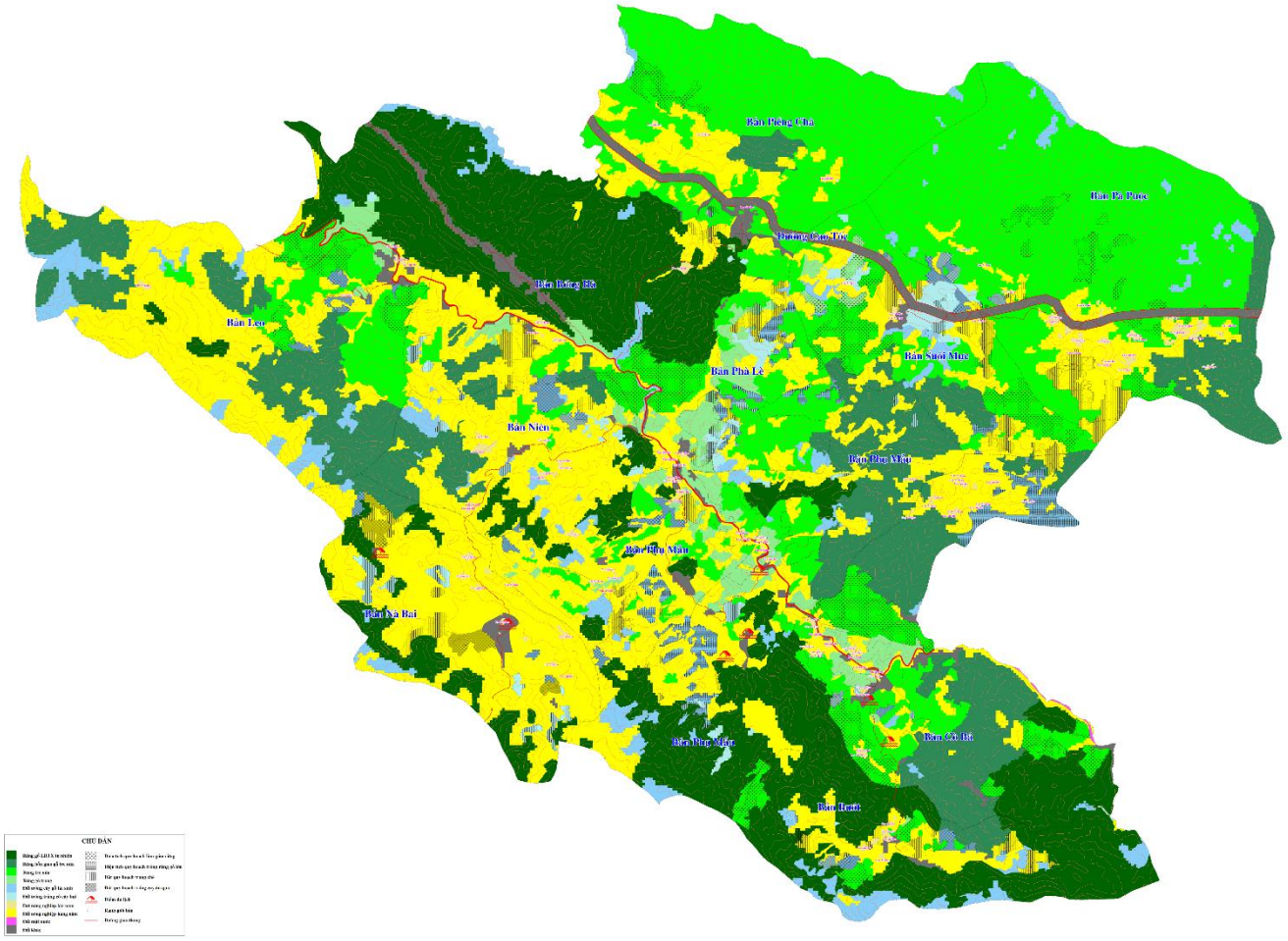
Land use	Proposed intervention	Priority level	Planned area (ha)	Location	Support policy needed or currently available	Stakeholders
Lowland crops (wet rice)	Stablise current wet-rice area and apply technical advances to improve productivity and quality for food security	High	2,554	Whole commune	Technology transfer Capacity building Investment/expansion	Agricultural and forestry extension DARD, CPC and communities
	Expand rice area by cultivating terraced fields and improving irrigation for intensive rice cultivation for food security	High	50	Most of the villages, especially Ban	Seed, techniques, fertilizer Investment capital	Agricultural and forestry extension
Water bodies and home gardens	No significant change Improve irrigation systems for rice cultivation Develop residential land according to land-use plans	Medium	147	Whole commune	Technical support	Agricultural and forestry extension, CPC

Note: CPC = Commune People's Committee; DARD = Department of Agriculture and Rural Development; DPC = District People's Committee
Source: authors' fieldwork, 2020

Appendix 5. Land-use maps of Chieng Yen Commune for 2010 (A) and 2020 (B)



Appendix 6. Land-use orientation map of Chieng Yen Commune until 2040



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