



Governing Landscapes for Ecosystem Services: A Participatory Land-Use Scenario Development in the Northwest Montane Region of Vietnam

Trong Hoan Do¹ · Tan Phuong Vu² · Delia Catacutan¹ · Van Truong Nguyen²

Received: 18 February 2020 / Accepted: 10 October 2020 / Published online: 24 October 2020
© Springer Science+Business Media, LLC, part of Springer Nature 2020

Abstract

Land-use planning is an important policy instrument for governing landscapes to achieve multifunctionality in rural areas. This paper presents a case study conducted in Na Nhan commune in the northwest montane region of Vietnam to assess land-use strategies toward multiple ecosystem services, through integrated land-use planning. The assessment employed the Land-Use Planning for Multiple Ecosystem Services (LUMENS) framework and a number of methods and tools, including land-use mapping, GIS-based land-use change analysis, survey questionnaire, rapid carbon-stock appraisal for different land uses, qualitative ecosystem services assessment, and a backcasting technique. Our findings suggest that a lack of participation and acknowledgement of customary land-use practices inhibit successful implementation of current land-use planning and relevant policies such as payment for forest environmental services and the nationally determined contributions. The study also confirmed the contributions of forests and the land-use sector in achieving national emission reduction targets, especially when local stakeholders are involved early in the planning process. Other findings with important policy implications are: (i) tree-based land uses such as agroforestry are key to securing multiple ecosystem services and are highly relevant to local stakeholders, yet their potentials were not made explicit in current debates at the local level; (ii) local stakeholders are highly aware of the co-benefits of ecosystem services to climate-change mitigation and this should be considered in nationally determined contributions; and (iii) an approach for integrated, participatory land-use planning can help catalyze stakeholder engagement, and hence improve governance in rural landscapes.

Keywords Participatory scenario development · Ecosystem services · Land-use planning · Multifunctional landscapes · Nationally determined contributions · Vietnam

Introduction

Landscape governance is a challenging process in the context of achieving landscape multifunctionality due to the multiplicity of stakeholders, institutions, scales, and ecosystem services (Cockburn et al. 2018). Governing and managing the physical landscape and social actors in the landscape requires intensive knowledge and good planning systems. Land-use

planning is a powerful instrument in landscape governance because it directly guides how actors will intervene in the physical landscape (land use) to gain commonly desired values. It is essential for sustaining rural landscapes and improving the livelihoods of rural communities (Bourgoin and Castella 2011; Bourgoin et al. 2012; Rydin 1998), ensuring landscape multifunctionality (Nelson et al. 2009; Reyers et al. 2012), and enhancing efficiency in carbon sequestration in particular (Bourgoin et al. 2012; Cathcart et al. 2007). Land-use planning is also considered critical to the successful implementation of land-based climate mitigation efforts such as the nationally determined contributions (NDCs)¹, as the

✉ Trong Hoan Do
t.do@cgiar.org

¹ World Agroforestry (ICRAF) Vietnam, HCMCC Tower, 249A Thuy Khue, Hanoi, Vietnam

² Vietnamese Academy of Forest Sciences, Duc Thang Ward, Bac Tu Liem, Hanoi, Vietnam

¹ NDCs are efforts of the signatories to the Paris Agreement to reduce national emissions and adapt to climate-change impacts. Article 4, paragraph 2 of the Paris Agreement requires “each Party to prepare, communicate and maintain successive NDCs that it intends to achieve” through domestic mitigation measures.

land use, land-use change and forestry (LULUCF) sector is included in the mitigation contributions of nearly 90% of countries in sub-Saharan Africa, Southern Asia, Latin America, and the Caribbean Region (Strohmaier et al. 2016).

Vietnam proposed nine forest- and land-use-based mitigation options in its NDCs under LULUCF to reduce emissions and enhance removals (MONRE 2015). However, challenges lie in the way in which national priorities and targets are translated into subnational delivery plans and the way in which subnational actors are mobilized (Hsu et al. 2019). These challenges stem from the legal framework for climate-change mitigation, which is elaborated at the national rather than at subnational level, while coordination between government bodies and among stakeholders is generally ineffective (UNDP 2018). Our proposition is that a participatory, integrated rural land-use planning approach that involves local stakeholders in land-use decision-making and analysis of co-benefits (e.g., ecosystem services and social benefits) is key to the achievement of NDCs. Such an approach has profound implications for climate change, and local efforts addressing climate change might change the nature of local land-use patterns (Lindley et al. 2006; Moser and Luers 2008; Moser and Tribbia 2006; Travis 2008). In addition, the ability of participatory land-use planning to integrate local perspectives and knowledge into development strategies helps ensure that social, natural, and environmental features are included in site-specific solutions and reflected in more effective development plans (Strohmaier et al. 2016; van Berkel and Verburg 2012; van Lier 1998).

In many developing countries, conventional top-down, centralized land-use planning approaches have been widely practiced with very little success due to a lack of flexibility in adapting to local peculiarities (Amler et al. 1999; Ducourtieux et al. 2005; Kauzeni et al. 1993). Participatory practices, on the other hand, often enhance planning quality and feasibility (Luyet et al. 2012; Nguyen et al. 2006; Reed 2008). Enhancing participation of local stakeholders in land-use planning should be acknowledged as a part of larger debates on local empowerment and decentralization of decision-making (Bourgoin et al. 2012; Chhatre and Agrawal 2009; Phelps et al. 2010; Toni 2011). This is a challenging task considering the long history of traditional top-down planning in the land-use and forestry sectors (Castella et al. 2005; Lambin and Meyfroidt 2010; Ohlsson et al. 2005), and the implementation of poorly designed incentive mechanisms in afforestation, reforestation, and protection that often left out the poorest groups (Clement and Amezaga 2009; Landell-Mills and Porras 2002). In forest-agriculture mosaic landscapes, the fundamental question is how land-use planning can best conserve forest and agricultural lands, as sources of both income and environmental services (O'Farrell and Anderson 2010).

Our study aims to shed light on how actors in a rural landscape can prepare their own land-use plan to address

socio-economic and environmental needs, including climate-change mitigation and the provision of ecosystem services, and how this process can help to inform policy-making and implementation of strategies such as the NDCs. The study was undertaken at commune level, the lowest jurisdictional tier of the administration system in Vietnam, where socio-economic and environmental plans and decisions are made. Specific questions are: (i) how has land use changed in the Na Nhan landscape?; (ii) how have land-use changes affected aboveground biomass (AGB) carbon?; (iii) how do local stakeholders perceive their desired future landscapes and strategies to achieve them?; and (iv) how do local stakeholders perceive the impacts of past land-use changes and the development scenarios on the provision of ecosystem services and greenhouse gas emissions and carbon sequestration?

Methodology

Study Site

Our study was conducted in Na Nhan Commune, Dien Bien District, Dien Bien Province, northwest Vietnam (Fig. 1). The commune is located within a catchment upstream of the Nam Ron River running from Dien Bien District to Laos PDR. The average elevation of the commune is 850 m above sea level.

According to the Na Nhan's Commune People Committee (CPC), the commune has a population of 5000 people distributed over ~1000 households. Three ethnic groups living in the commune include the Thai (72% of the population), H'mong (27%), and Kinh (1%). Based on government standards², the majority of local households are either poor (421 households) or near poor (253 households). The primary livelihoods in the commune are agriculture and forest-related activities like collecting non-timber forest products (Na Nhan CPC 2016a).

Methods

Methodological Framework

We applied the Participatory Land-Use Planning for Multiple Ecosystem Services (LUMENS) framework developed by Dewi et al. (2015) to allow for multi-stakeholder negotiations in planning sustainable landscapes that can support livelihoods and development, while maintaining and restoring environmental services. The overall LUMENS framework (Fig. 2) consists of four main steps: (1)

² Decision No. 59/2015/QĐ-TTg issued on November 19, 2015 of the Prime Minister of Vietnam on promulgating the multidimensional approach to poverty standard for the period of 2016–2020.

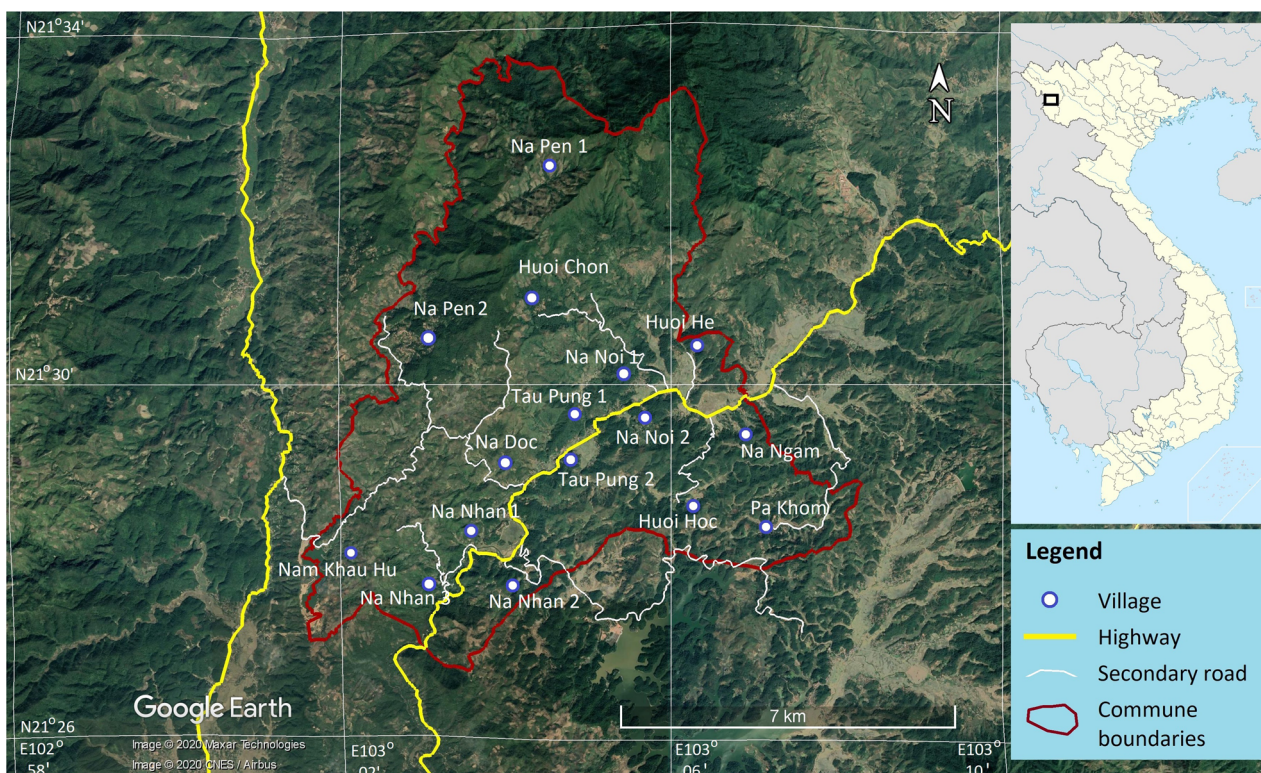


Fig. 1 Location of the Na Nhan Commune—study site in Northwest Vietnam (source: adapted from Administrative map of Na Nhan Commune and Google Earth Image 2017)

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 change; (3) participatory development of baseline and LUMENS scenarios in which the latter adopted 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, focused group discussions, land-use change mapping, rapid carbon-stock appraisal, and backcasting for scenario development were employed as described in the sub-sections below.

Structured Survey Questionnaire for Local Socio-Economic Conditions and Issues around Land-Use Planning

Household interviews were conducted using a structured survey questionnaire involving 34 households in Na Nhan Commune. The households were randomly selected from a list of households that has been stratified according to income status (poor, near poor, and nonpoor) provided by the CPC. Respondents were representatives of the stratified households who are either the household head or a family member with knowledge of the farming and economic situation of the household. Representativeness was ensured through

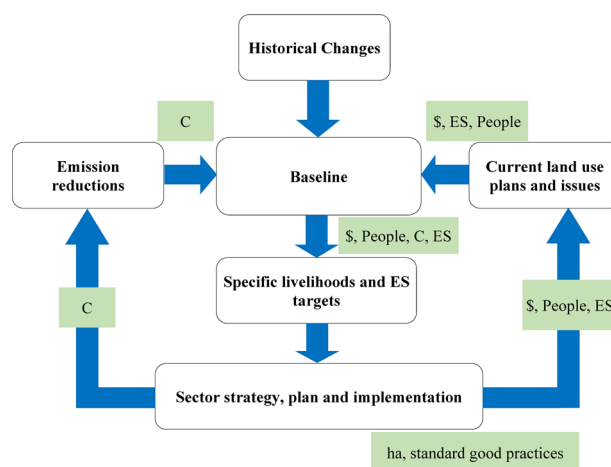


Fig. 2 LUMENS framework (C carbon, ES ecosystem services, \$ economic benefits of land uses) (source: adapted from Dewi et al. 2015)

information exchange between the enumerators and village heads. The survey aimed to generate a baseline of the households’ socio-economic conditions, as well as local perspectives on natural resource use and landscape management, including land, soil, tree, forest, and water. Data were stored in Microsoft Access and analyzed using Microsoft Excel.

Table 1 Sampling points for updating land-use maps and measurement plots for biomass estimates

No.	Land-use/cover types	Number of sampling points for maps update	Numbers of measurement plots for tree biomass estimation	
			Plot A	Plot B
1	Broadleaf evergreen forest—rich	0	0	0
2	Broadleaf evergreen forest—medium	21	6	6
5	Broadleaf evergreen forest—poor	37	5	5
4	Planted forest	6	5	0
5	Bare land (scattered trees)	10	5	0
6	Bare land (grass and shrubs)	14	5	0
7	Tree-crop plantation (mono-plantation of fruit trees or industrial tree species such as rubber)	44	3	0
8	Annual crops	68	0	0
9	Water bodies and other land uses	31	0	0
Total sampling points/measurement plots		231	29	11

Source: authors' fieldwork, 2017

Land-Use Change Mapping and AGB Carbon-Stock Estimates for 2005–2015

Land-Use Change Mapping Land-use and forest-cover classification includes nine land-use types (see Table 1) wherein eight land-use and -cover classes were defined as per the Ministry of Agriculture and Rural Development (MARD)³, and one class (tree-crop plantation) based on the guidance of the Ministry of Natural Resources and Environment (MONRE) for “perennial crops”⁴. There were no “non-tree” perennial crops (such as coffee, banana, etc.) in Na Nhan; we therefore defined “perennial crops” as “tree-crop plantations” (MONRE’S definition). Data from different sources were used to analyze land-use changes such as: (i) 2005–2015 forest-cover maps of Na Nhan Commune provided by the Forest Inventory and Planning Institute (FIPI 2006, 2016); (ii) 2015 land-use map of Na Nhan Commune (Na Nhan CPC 2016b), which was standardized according to the guidance of the Ministry of Natural Resources and Environment (MONRE)⁵; (iii) processed SPOT5 images and Landsat acquired in 2005 and 2015 from MONRE and Google Earth⁶ to update forest-cover maps; and (iv) statistical data and reports from district and commune authorities on socio-economic conditions.

A field survey was conducted to ground-truth the land-use status indicated on the maps. A total of 231 random sampling

points (see Table 1) were selected based on: (i) natural and socio-economic characteristics; (ii) agricultural practices of farmers in the study area; and (iii) reference maps such as land-use and forest-cover maps. Survey routes were designed to go through as many different types of land-cover/land-use (on the reference map) as possible. In each sampling point, the information collected included coordinates, elevation, land-use types, and vegetation-cover description.

The “object-based image analysis” approach with the support of eCognition software was applied to classify and interpret the images. The reference points for interpretation, update of the maps, and accuracy assessment were collected in the field from sampling points. Change detection, using a map overlay method, was applied for registration of the 2015 forest-cover map boundaries on the 2005 forest-cover map, ensuring consistent parcel boundaries over time where such boundaries exist. Assessment of the accuracy of land-use and forest-cover mapping followed the methods used by Olofsson et al. (2013, 2014).

Land-use changes for the period 2005–2015 were identified by overlaying the 2005 and 2015 land-use maps. Changes in land use during this period are reflected in the land-use change matrix and on the map. The drivers of land-use change were assessed through group discussions and consultation meetings.

Estimate of Changes in AGB Carbon Stock Counted carbon pool includes AGB carbon of forestland (natural and planted forests), grass and shrub land, and tree-crop plantations. Trees’ AGB in forestland and tree-crop plantation was estimated using following allometric equations:

- Trees (Chave et al. 2014): $AGB = 0.0673 * (\rho * D^2 * H)^{0.976} (1)$

³ Circular No. 34/2009/TT-BNNPTNT of MARD on criteria for forest definition and forest classification.

⁴ Circular No. 28/2014/TT-BTNMT issued on June 2, 2014 of the Ministry of Natural Resources and Environment on regulations on land statistics and inventory and mapping land-use status.

⁵ *ibid.*

⁶ Google Earth Pro Software by Google LLC.

- Shade coffee (Segura et al. 2006): $AGB = \exp(-2.719 + 1.991 \cdot \ln D) \cdot \log_{10} D$ (2)
- Pruned coffee (Arifin 2001): $AGB = 0.281 \cdot D^{2.06}$ (3)
- Fruit trees (Schroth et al. 2002): $AGB = -6.64 + 0.279 \cdot BA + 0.000514 \cdot BA^2$ (4)

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 up randomly to measure diameter at breast height (D) and total height (H) of trees. A total of 40 plots were set up, of which twenty-nine plots were type A plots of 200 m^2 each ($5 \times 40 \text{ m}$) and eleven plots were type B plots of 2000 m^2 each ($20 \times 100 \text{ m}$) (see Table 1 and Fig. 3). The A plots were used to measure D and H of all trees with D from ≥ 5 and $< 30 \text{ cm}$, and the B plots were designated to measure trees with $D > 30 \text{ cm}$ if this type of D appeared inside plot A (Hairiah et al. 2010). For non-forest land uses such as shrubs and grassland, the information on key species, average coverage, and height, etc. was recorded.

To estimate carbon stock in AGB, we used the IPCC 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 carbon stock of annual crops, residential and water bodies 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. The fruit-tree-based agroforestry system and improved home garden were two land-use types not found in the landscape at the time of measurement (hence could not be measured), but were considered later in the land-use change scenario development by local stakeholders. Therefore, we adopted time-averaged aboveground carbon-stock values for those two land-use types, drawing from Roshetko et al. (2007) who compiled the carbon-stock values of smallholder agroforestry in Southeast Asia using a similar approach as suggested by Hairiah et al. (2001, 2010).

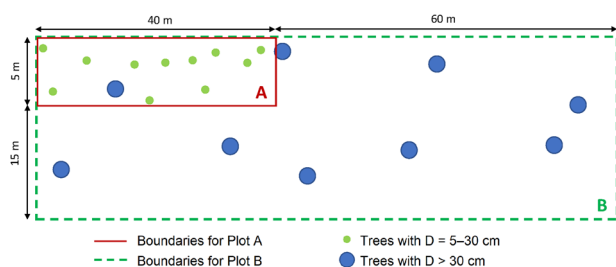


Fig. 3 Layout of plot measurement for AGB estimates (source: adapted from Hairiah et al. 2010)

Developing Land-Use Scenarios for Multiple Ecosystem Services Toward 2040

In the context of integrated landscape management in rural areas, multi-stakeholder platforms are important to achieve the goals of conservation, emission reduction, livelihoods, and agricultural production (Kusters et al. 2018). We conducted a stakeholder consultation workshop with 45 participants representing Dien Bien Province and Na Nhan Commune stakeholders, including the Department of Agriculture and Rural Development, the Department of Natural Resources and Environment (DONRE), commune leaders, agriculture extension staff, environment and cadastral staff, and some village heads. The overall objective of the workshop was to create a common understanding and vision amongst stakeholders on how to secure multiple ecosystem services in the commune—the goals, plausible interventions, actors involved, support needed, and to understand governance-related issues. The workshop began with an exercise for participants to familiarize with the topics of land use, land-use changes and impacts on greenhouse gas emissions and ecosystem services. To ensure that stakeholders easily understand 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 20 ecosystem services that aligned with four functional domains: life support, regulation, provision, and information. The ecosystem services selected for assessment were soil formation, nutrient cycling, biodiversity (although this is arguably not an ecosystem service, but herein listed considering its tight link to ecosystem services and importance to local livelihoods), climate and weather regulation, water regulation, mitigation of natural disaster, water purification and waste treatment, anti-soil erosion, carbon storage, biological control, pollination, clean water, provision of food, fuel, wood, fiber, fodder, fertilizer and medicine, natural scenery, tourism and entertainment, and 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. This was followed by a backcasting exercise (van Asselt et al. 2012) for participants to set up targets for the future landscape as well as proposing interventions to achieve their targets. After agreeing on common goals, the stakeholders were randomly split 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 2005 and 2015 (see Section 2.2.3) were provided to stimulate the group discussions. It was explained to participants that the impacts of suggested interventions will be evaluated after the workshop using a thematic software.

Table 2 Area by land-use types, Na Nhan Commune (2005 and 2015)

No.	Land-use/cover types	Area in 2005 (ha)	Area in 2015 (ha)	Change area (ha)	Change/total area ratio (%)
1	Evergreen broadleaf forest—rich	0	0	0	0
2	Evergreen broadleaf forest—medium	137.6	158.0	+20.4	+0.3
3	Evergreen broadleaf forest—poor	976.3	2951.9	+1975.5	+25.9
4	Planted forest	334.7	56.4	-278.3	-3.7
5	Bare land with scattered trees	776.8	710.4	-66.4	-0.9
6	Bare land with grass and shrubs	3369.6	774.4	-2595.2	-34.1
7	Tree-crop plantation (mono-plantation of fruit trees or industrial tree species such as rubber)	50.5	47.8	-2.7	0
8	Annual crops	1747.2	2665.9	+918.8	+12.1
9	Water bodies and other land uses	207.0	234.9	+27.9	+0.4
	Total	7599.6	7599.6		

Source: authors' work adapted from FIPI (2006, 2016)

The impacts of proposed land-use interventions to the landscape's greenhouse gas emissions and sequestration (AGB pool) were assessed using REDD Abacus⁷, a public domain software developed by the World Agroforestry (ICRAF) mainly to facilitate land-use planning for low-emission development strategies at subnational levels. The software employs a transition probability matrix, i.e., 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 time period based on initial land-use changes. Two scenarios were simulated for a 25-year period (2015–2040): a business-as-usual (BAU) scenario was based on linear projection of historical land-use change during 2005–2015 (see Appendix, Table 6), and a LUMENS scenario based on both historical land-use changes and land-use interventions suggested by local stakeholders during the backcasting exercise.

Results

Land-Use Changes in the Na Nhan Landscape (2005–2015)

Significant changes in land use in Na Nhan Commune have been recorded between 2005 and 2015 (Table 2). The largest change took place in the bare land with shrubs and grasses. This area was reduced from 3369.6 to 774.4 ha, which accounts for 34.1% of the total commune area. More than 50% of these areas were zoned and regenerated into poor evergreen broadleaf forests. The remainder was converted into cultivated land for short-term agricultural crops and other uses. The area of evergreen broadleaf forest in 2015

had increased more than 2.8 times compared to the area in 2005, with 1995.9 ha, accounting for 26.2% of the total land area of the commune. The area of annual crops was also 1.5 times higher than in 2005. The tree-crop plantations, water bodies, and other land uses were almost unchanged (Table 2). The results of accuracy assessment of land-use and forest-cover maps indicated that at 95% confidence level, the overall accuracy of land-use mapping was 94%; specifically, the accuracy level of poor and medium evergreen broadleaf forest classification was between 82 and 92%.

During this period, most of the bare lands with fallow were either restored to poor secondary forests or reused for agricultural production. Effective forest protection and development has increased the forest area by 2.8 times compared to 2005, accounting for 41.7% of the total area of the commune. The traditional farming practices of local people were mainly slash and burn. After a period of continuous cultivation, soils were eroded, resulting in a dramatic decline in food-crop yields, so that the soil was left unused for 5–6 years to restore its fertility. Since 2006, with the dissolution of the Dien Bien District Afforestation Yards, most of the forests and forestlands were allocated to the CPC with an understanding that they were to manage these lands with the participation of village communities. Some villages in Na Nhan Commune have applied for community forest management with clear regulations for forest protection and management. The village people were allowed to collect timber inside community forests for house construction under the supervision of the village leaders/committee, resulting in reduced deforestation or slash-and-burn practices.

Effects of Land-Use Changes on AGB Carbon Stocks

Our land-use time-averaged aboveground carbon-stock measurements show that the highest carbon stock is found in natural

⁷ Available at <https://sourceforge.net/projects/redd-abacus/>.

Table 3 Estimated time-averaged aboveground carbon stock of land uses in Na Nhan Commune

TT	Land-use/cover types	Timber volume (m ³ /ha)	Aboveground carbon stock	
			tC/ha	SE
1	Evergreen broadleaf forest—medium	149.8	79.3	17.2
2	Evergreen broadleaf forest—poor	78.9	49.3	7.2
3	Planted forest	100.3	36.3	10.6
4	Bare land with scattered trees	24.3	13.6	3.1
5	Bare land with grass and shrubs	16.9	10.2	2.2
6	Tree-crop plantation (mono-plantation of fruit trees or industrial species such as rubber)	43.5	26.4	6.4
7	Agroforestry (fruit trees dominant) ^a	–	30.0	–
8	Improved home garden (fruit trees dominant) ^a	–	20.0	–
9	Annual crops; water bodies and other land uses	–	0	–

Source: authors' work

tC ton carbon, SE standard error

^aAdapted from Roshetko et al. (2007)

forests (49.3–79.3 tC/ha), followed by planted forests (36.3 tC/ha) and tree-crop plantations (26.4 tC/ha) (see Table 3).

In 2005, the total amount of aboveground carbon stored in evergreen broadleaf forest accounted for 50.2% of the landscape's total carbon stock (117,576 tC), followed by the bare land with grass and shrubs (29.3%), planted forests (10.3%), and bare land with scattered trees (9.0%). By 2015, aboveground carbon storage of evergreen broadleaf forest and bare lands contributed to about 88.3% and 9.8% of landscape's total carbon stock (178,894 tC), respectively. Overall, the total aboveground carbon stock of all land uses in the commune had a net increase of 61,319 tC between 2005 and 2015 (Fig. 4). Generally, the increase in aboveground carbon stocks was mainly due to natural forest regeneration from bare lands with grass and shrubs that were abandoned (fallow period) after a certain period of cultivating upland crops. The largest increase in aboveground carbon stock (97,000 tC) was attributable to forest regeneration—a large area of bare land with scattered trees in 2005, which has developed into evergreen broadleaf forest in 2015.

Changes of Ecosystem Services Provided at Landscape Level—Stakeholders' Perceptions

By eliciting participants' assessments for 20 ecosystem services mentioned in “Developing Land-Use Scenarios for Multiple Ecosystem Services Toward 2040,” we were able to compare their relative importance, trends (declining, improving, or unchanged) during 2005–2015, and the roles of key ecosystems in providing such services (Table 4).

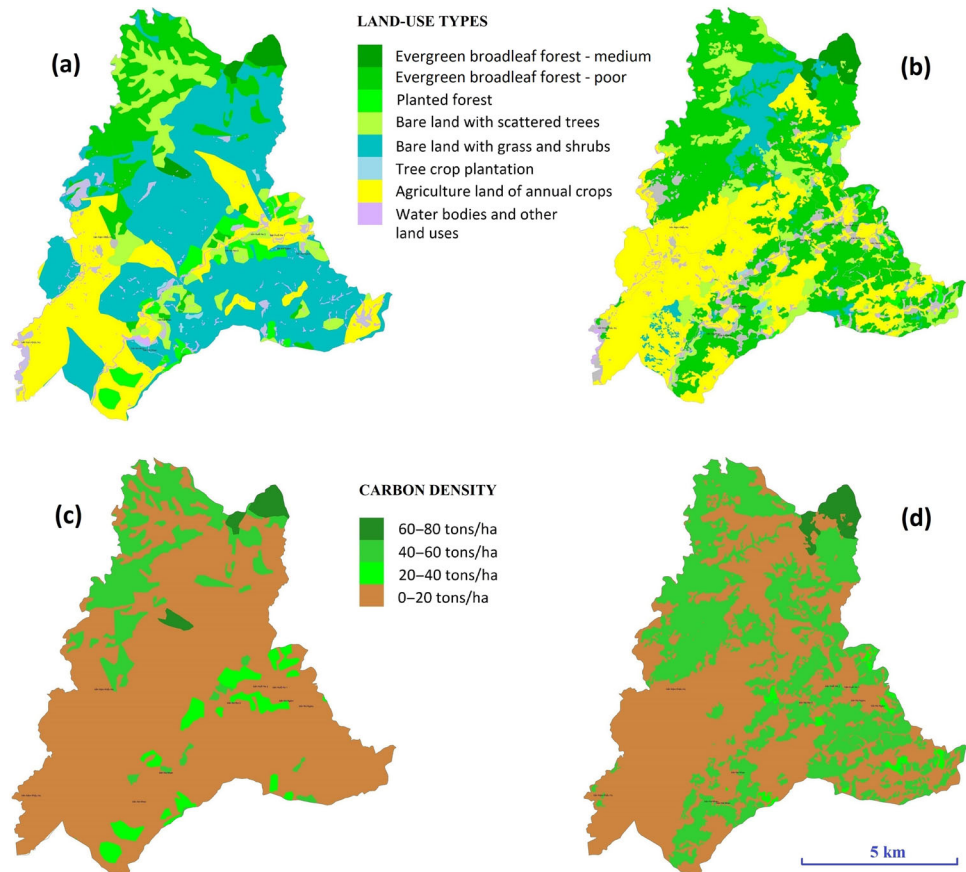
Results suggest that participants were aware of the role of tree-based ecosystems in providing several environmental

services in the landscape. The scores indicate particularly the importance of natural forest (88/100) and planted forest (61/100) in this regard, while non-tree-based ecosystems or cultivation with annual crops in flat and sloping lands were both well under 20/100 (Table 4). Specifically, stakeholders perceived a strong correlation between tree density and its role in the provision of ecosystem services. Although forest cover has been increasing recently, the forest's ecosystem service provisioning capacity has been declining as a result of decreased forest quality. On the positive side, perennial plantations and fallows are the two ecosystems that were improving in most aspects of ecosystem service provision. Perceptions of the role of forest- and tree-based land uses in securing wellbeing and agricultural production might trigger attitude and behavioral changes amongst local stakeholders. In developing the LUMENS interventions (“Local Stakeholders' Desired Future Landscapes and Strategies to Achieve Them”), stakeholders expressed their interest in enhancing tree-based systems through forest management, agroforestry, and home-garden intensification.

Local Stakeholders' Desired Future Landscapes and Strategies to Achieve Them

Household participation in the land-use planning process, which is fundamental to effective and inclusive landscape governance, was found very low. About 32% of respondents (11 out of 34 respondents) reported that they were not aware that their participation in land-use planning consultation is regulated by law, while 68% ($n = 23$) had no idea on the topic. Consequently, 94% of respondents ($n = 32$) said that they had no idea whether the existing land-use plan is satisfactory or not; only 3% of respondents ($n = 1$) said that they

Fig. 4 Land use and carbon distribution maps of Na Nhan Commune (2005 and 2015) (**a** land-use map 2005; **b** land-use map 2015; **c** aboveground biomass carbon density map 2005; **d** aboveground biomass carbon density map 2015) (source: authors' work adapted from FIPI (2006, 2016))



were satisfied with the current land-use plan; the remaining 3% ($n = 1$) was not satisfied with the plan. In terms of land-use planning implementation, only 3% of respondents ($n = 1$) said that they had been informed about the results, while 26% ($n = 9$) had not been informed and another 71% ($n = 24$) had no idea. When asked to answer a multiple-choice question about the benefits of having commune- and district-level land-use plans, only 4 out of 34 respondents made at least one choice, while 30 respondents had no choice at all. The four who perceived benefits primarily emphasized “better forest management” and “better environmental protection.” Benefits selected by two of them included “proper land allocation for different purposes,” “mitigation of land conflicts,” and “facilitation of traditional and customary cultivation and land-use practices.” Only one respondent selected “clear and secure land-use rights” as a perceived benefit of land-use plans.

In terms of land administration, all settlement and low-land agricultural areas have been legally allocated to households for permanent use. Administration of forest lands (mostly slope land) was, however, more complicated—forest dwellers have been provided with land-use rights certificates (Red Book) for forestry purposes only (forest plantation, forest enrichment, etc.). Some forestland users did not have Red Books, but were using forest lands for agricultural purposes. The use of forest plots as agricultural

land was de facto tolerated: local government acknowledged local customary cultivation practices but was reluctant to provide legal recognition. This was an obstacle for the forestland allocation process, not just in Na Nhan Commune, but in Dien Bien Province as a whole.

In order to enhance local stakeholder engagement in land-use planning, we piloted a backcasting exercise (see “Developing Land-Use Scenarios for Multiple Ecosystem Services Toward 2040”). This exercise resulted in a balanced ambition of stakeholders to take the lead in their future landscape, which included: (1) pursuing high-value agricultural production through “clean agriculture”⁸ and agroforestry; (2) maintaining and improving essential ecosystem services, particularly water regulation, biodiversity, and carbon sequestration services; and (3) ensuring social inclusion in development through appropriate landscape governance mechanisms. Workshop participants emphasized that current agricultural practices must shift

⁸ “Clean agriculture” was perceived by participants as agricultural practices that demand less “toxic” chemical inputs and therefore produce “safe” products that can be sold at higher market price. In the local context, this was particularly relevant to annual crops of canna (*Canna edulis*), peanut (*Arachis hypogaea*), and taro (*Colocasia antiquorum*), those have high market demands but at the same time are often perceived by customers as “unsafe food,” i.e., containing harmful chemical substances.

Table 4 Stakeholder's awareness of ecosystem services provided at landscape level

Ecosystem services	Natural forest	Planted forest	Upland annual crops	Perennial plantation	Mixed home garden	Lowland annual crops	Fallow land	Water surface
Soil formation	5 (--)	4 (++)	0	1 (++)	0	0	2 (++++)	0
Nutrients cycling	5 (--)	3 (++)	0	2 (++)	0	0	2 (++++)	0
Biodiversity	5 (--)	1 (++++)	0	2 (++)	1 (++)	0	4 (+)	1 (+)
Climate and weather regulation	5 (---)	4 (++)	0	2 (++)	2 (+)	0	1 (+)	2 (+)
Regulation of water flows	5 (---)	4 (--)	0	3 (-)	2 (+)	0	2 (+)	3 (---)
Mitigation of natural disaster	5 (--)	4 (++++)	0	2 (++++)	1 (--)	0	1 (++)	0
Water purification and waste treatment	5 (---)	4 (--)	0	3 (-)	2 (+)	0	2 (-)	0
Anti-soil erosion	5 (---)	4 (--)	0	2 (--)	1 (-)	0	2 (-)	0
Carbon storage	5 (---)	5 (++)	0	2 (++)	1 (+)	0	3 (++)	0
Biological control	5 (--)	3 (--)	0	2 (---)	1 (---)	0	3 (+)	3 (---)
Pollination	5 (--)	4 (---)	2 (---)	3 (--)	2 (--)	2 (---)	2 (+)	0
Clean water	5 (---)	3 (--)	0	2 (-)	0	0	2 (-)	0
Food	3 (---)	2 (-)	5 (--)	3 (-)	3 (---)	5 (++++)	0	3 (---)
Fuel	5 (--)	3 (++)	0	2 (+)	0	0	2 (+)	0
Wood and fiber	4 (---)	4 (++)	0	1 (+)	0	0	2 (+)	0
Fodder and fertilizer	3 (---)	0	5 (++++)	0	3 (++)	4 (++++)	3 (++)	0
Medicine	3 (---)	0	0	0	1 (++)	0	2 (++)	0
Natural scenery	5 (++)	4 (++)	3 (+)	3 (++)	2 (++)	2 (++)	1 (-)	3 (++)
Tourism and entertainment	2 (++)	3 (++)	0	3 (++)	1 (++)	0	1 (-)	4 (++)
Cultural and spiritual values originated or derived from land-cover types	3 (++)	2 (++)	3 (++)	2 (++)	1 (++)	3 (++)	0	2 (+)
Total	88	61	18	40	24	16	37	21
Highest possible points	100	100	100	100	100	100	100	100

Source: authors' fieldwork, 2017

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 (-), improving slightly (+), improving (++), and improving significantly (++++)

to those that preserve landscape integrity and beauty and deliver better economic opportunities to the local residents. They also discussed and agreed on strategies to achieve these goals (see Fig. 5). The strategies were initially developed for each goal, but mapping of the results by stakeholders revealed that many of them are “shared” (combined), as a result of which a single strategy contributes to more than one goal.

After agreeing on the goals and strategies, participants were asked to prepare a table of interventions. The interventions were ranked, and each one had to be linked to a specific land-use type. Participants suggested several interventions, based on perceived benefits of tree-based land uses. All suggested interventions seemed to result in positive impacts on the environment and emission reduction. Participants unanimously agreed that natural forests should be well protected for

essential services, and that villages should be supported to develop sustainable forest management plans. Some understorey agroforestry models were also recommended to help farmers obtain more income from forest and reduce pressures on forest resources. Participants suggested that economically viable models of forest plantation (acacia and some native timber plantations) should be developed in parallel with developing a market value chain for timber. This reflected concerns on past failures in forest plantation development in the study site. *Michelia mediocris* plantations have great potential to address this concern, as the tree can provide valuable fruits used as spice and herbs, and some participants preferred this species even without the need to sell timber. Conversion of upland farmland to agroforestry (intercropping agricultural crops and fruit trees) and intensification of mixed

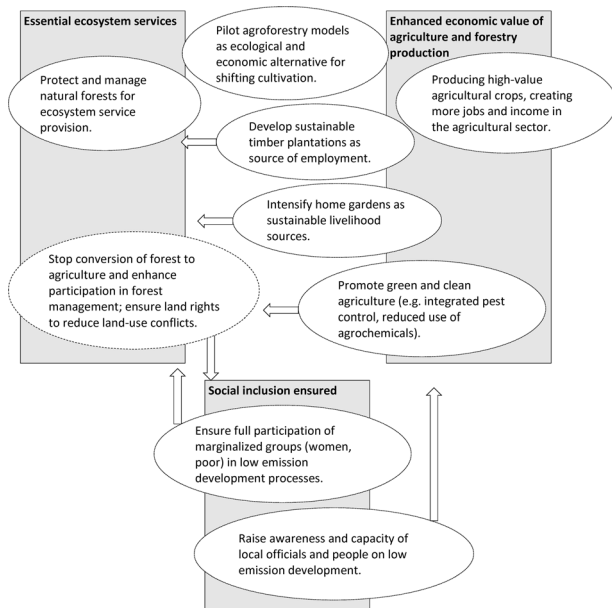


Fig. 5 Goals and strategies toward LUMENS in Na Nhan Commune (source: authors' fieldwork, 2017)

gardens were expected to address productivity and soil degradation concerns, but intensive external financial and technical support would be required. Participants wished to pursue annual crop intensification such as for peanut (*Arachis hypogaea*) and taro (*Colocasia antiquorum*) with better cultivation methods and value chain development, and to invest in livestock farming where grazing lands are available (villages of Na Noi and Na Pen). Participants also suggested relevant stakeholders to take the lead in each intervention, and in most cases agriculture and forestry extensionists and the CPC were expected to provide support and guidance. This highlights the need to develop the capacity of local agents to facilitate local land-use planning. As shown in Table 5, most interventions were in line with measures to achieve climate-change mitigation targets set out in Vietnam's NDCs, "Manage and develop sustainable forest, enhance carbon sequestration and environmental services; conservation of biodiversity associated with livelihood development and income generation for communities and forest-dependent people" (MONRE 2016).

Impact of the Scenarios on Greenhouse Gas Emissions and Carbon Sequestration

Potential impacts of stakeholders' proposed land-use interventions on GHGs emissions and sequestration are shown in Fig. 6. It should be noted that not all proposed interventions could be simulated due to limited software functionality and input data. The following interventions were parameterized and added into REDD Abacus: *Acacia* and *Michelia mediocris* plantations (as forest plantation and afforestation); fruit-tree and agroforestry development; and home-garden intensification.

Compared to BAU, emissions under the LUMENS scenario were slightly lower as forest conversion from other land uses is more restricted (Fig. 6a). According to the projection, the accumulated emissions through land-use changes under a BAU scenario would be 60,533 tCO₂eq by 2040, compared to 56,753 tCO₂eq under the LUMENS scenario, offering an emission reduction by 6.3% compared to BAU. As far as sequestration is concerned, both scenarios showed the potential of Na Nhan landscape to sequester CO₂ (Fig. 6b). The difference in accumulated CO₂ sequestration during the project period would be about 65,092 tCO₂eq, meaning that the LUMENS scenario offers an increase of 13.8% of greenhouse gas sequestration compared to BAU (Fig. 6c). It should be noted that the potential emissions reduction and carbon sequestration at landscape level could be higher if all proposed interventions could be accounted for in model simulation, such as improvement of forest quality due to protection efforts by local communities. Impacts of proposed interventions on other ecosystem services (water regulation, biodiversity, etc.) and economic benefits could also be projected to provide a more complete picture that can be used in decision-making. The simulations of LUMENS interventions in this study provided useful information for policymakers to improve the management and governance of the Na Nhan landscape.

Discussion

Functions and services provided by landscapes are vital to human being and development and should therefore be integrated into land-management decisions. In the context of Vietnam where forest- and tree-based land uses are considered key to achieving national targets of climate change and ecosystem services, it is necessary to (i) determine the role of forest- and tree-based land uses in climate-change mitigation to decision- and policymakers; (ii) enhance awareness of ecosystem services among local stakeholders and mainstream ecosystem services in local land-use planning; and (iii) engage local farmers in landscape governance. The following sections discuss each of these aspects in more detail.

Tree-based Land Uses and Climate-Change Mitigation

When it comes to climate-change mitigation, challenges to rural landscapes such as Na Nhan commune relate to the right combinations of "sparing" and "sharing" (Minang and van Noordwijk 2013) in order to achieve reduced emissions while balancing social and economic trade-offs as perceived by local stakeholders. A more "sharing" approach (i.e., bringing trees onto agricultural lands and recognizing roles of forest in providing essential services to the whole landscape) can be used for reconciling forest protection and development through

Table 5 Proposed land-use interventions for Na Nhan Commune in the LUMENS scenario

Land-use/cover types	Proposed intervention	Priority level	Area	Locations (village name)	Support policy needed/ currently available	Responsible stakeholders
Natural forest	Forest protection and enrichment; improvement of community forest management capacity for forest protection groups	High	~3000 ha	All villages with allocated natural forests	– Capacity building – Support to development of forest management plans (hiring consultant, etc.)	Provincial Forest Protection Department, forestry extension, CPC, and villagers
	Development of understory NTFP production models (<i>Cardamom</i> , <i>Amonum</i> , etc.)	Medium	–			
	Develop ecotourism models	Low	–			
Plantation forest	Planting protection and production forests	Medium	–	Tau Pung and Na Nhan villages	– Land allocation – Investment (capital and technology) – Market development	DARD, DPC
	Develop <i>Acacia</i> plantation models combined with market solution	High	200 ha	Tau Pung and Na Nhan villages	(Participants could not specify supporting policies needed)	DARD, forestry extension
	Afforestation on bare lands with native species such as <i>Schima wallichii</i> and <i>Michelia mediotocris</i> (10–15 years rotation)	High	100 ha	Bare land in Na Nhan village	(Participants could not specify supporting policies needed)	DARD, forestry extension
Upland crops	Agroforestry: select suitable species, fruit trees	Medium	–	11 villages with upland fields	– Capital investment – Technical assistance and training – Market value chains development	Agricultural and forestry extension, CPC, village communities
	Planting fruit trees, scattered forest trees, and agroforestry	Medium	50-ha fruit trees; 30 ha of agroforestry	Na Noi 1, Huoi He, and Tau Pung villages	(Participants could not specify supporting policies needed)	Households Agricultural and forestry extension
	Determination of fruit-growing areas	Medium	–	Na Nhan 1, 2, 3; Na Doc, Tau Pung 1, 2 villages Na Noi 1, 2; Huoi He, and Huoi Hoc villages	– Financial and technical support – Market development	DPC, CPC, households, and local enterprises
Grazing land	Development of taro plantation area	High	–	Na Noi, Na Ngam, Huoi He, Tau Pung villages	(Participants could not specify supporting policies needed)	Agricultural and forestry extension, CPC, village communities
	Cattle grazing	High	–	Na Pen, Na Noi	– Grass planting techniques and land allocation	Agricultural and forestry extension, Provincial Livestock Center

Table 5 (continued)

Land-use/cover types	Proposed intervention	Priority level	Area	Locations (village name)	Support policy needed/ currently available	Responsible stakeholders
Agricultural production land (rice land, vegetables)	Applying technical advances to improve rice productivity and quality	High		Whole commune	<ul style="list-style-type: none"> – Technology transfer – Capacity building – Investment/expansion 	Agricultural and forestry extension DARD, CPC, and villagers
	Develop high-value peanut cultivation models and peanut value chains	High	50 ha	Na Noi, Na Ngam, Huoi He, Tau Pung villages	(Participants could not specify supporting policies needed)	Agricultural and forestry extension, CPC, village communities
Residential land + mixed garden	Improving mixed gardens with several fruit-tree species (such as mango and pomelo) and some timber trees	High	100 ha	Whole commune, Na Noi, and Na Ngam villages would be prioritized	(Participants could not specify supporting policies needed)	(Participants could not specify responsible stakeholders)
Canna ^a processing factories	Wastewater treatment (currently three canna-processing factories are discharging wastewater directly into rivers)	–	–	Huoi He, Na Noi, Na Nhan 3 villages	– Tightened regulations on wastewater control and treatment	DARD, DONRE

Source: authors' fieldwork, 2017

CPC Commune People Committee, DARD Department of Agriculture and Rural Development, DONRE Department of Natural Resources and Environment, DPC District People Committee
^a*Cana edulis*: arrowroot-like starch used to make Vietnamese noodles

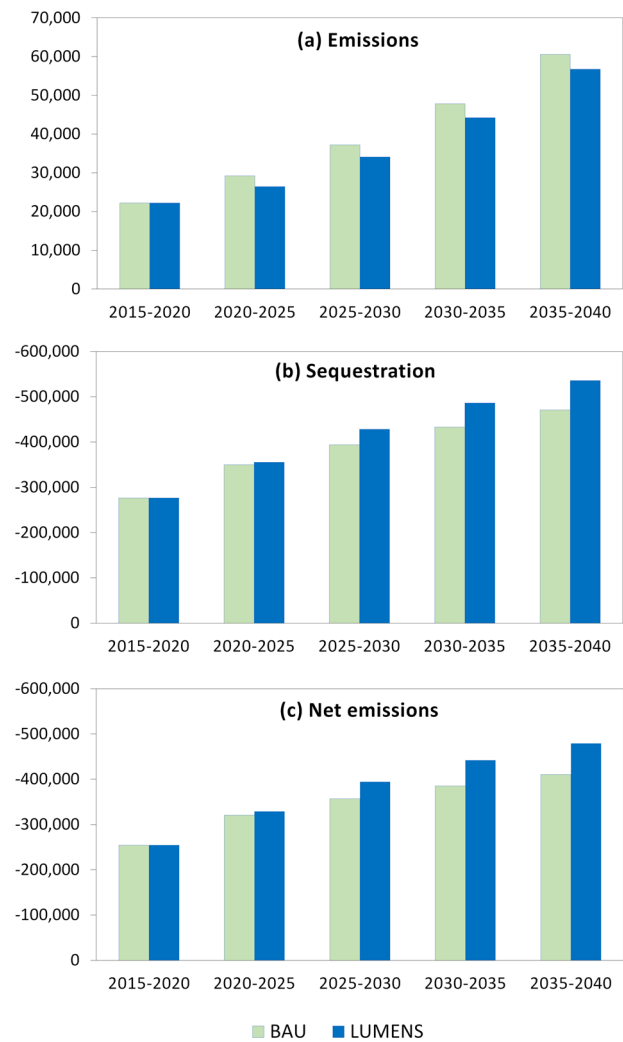


Fig. 6 Projected accumulated GHGs emissions and sequestration (as ton CO₂ equivalent (tCO₂eq)) of land-use change scenarios in Na Nhan Commune (**a** projected emissions of BAU and LUMENS scenarios; **b** projected sequestration of BAU and LUMENS scenarios; and **c** projected net emissions of BAU and LUMENS scenarios). (source: authors' work). The negative values of **b** and **c** means carbon sinks

interventions in different components of a landscape matrix (Sayer et al. 2013).

It is estimated that the land-use sector can contribute up to 10–20% of Vietnam's national emission reduction targets, mainly generated from forest and tree-based land uses. The annual estimated emission reduction and carbon sequestration enhancement for forests and the land-use sector in Vietnam ranges between 8.2 and 15.6 Mt CO₂eq/year (Vu et al. 2018). By 2030, Vietnam commits an increase of 52% in greenhouse gas removals through the forestry and other land uses activities unconditionally. With international support, this figure could reach almost 145% by 2030 (Escobar Carbonari et al. 2019). Our case study found that low-cost mitigation options such as reforestation and natural regeneration have helped the Na

Nhan landscape sequester a large amount of carbon with a net increase of about 61,000 tC between 2004 and 2015. Much of this was attributable to forest restoration in bare land with grass and shrubs and was achieved by a combination of top-down law enforcement and an economic policy instrument (through the PFES⁹ program). However, establishing forest plantations solely based on the economic attractiveness of forest plantation models were less successful. This can be explained by the fact that the economic benefits of planted forest in northwest Vietnam is significantly lower than other forms of agricultural production (Lan et al. 2016). This suggests a challenge to NDC implementation through economic plantations in upland areas with limited access to markets for timber and non-timber products.

Apart from reforestation and afforestation activities, participants in our case study actively proposed conversion of uphill shifting cultivation land and poorly managed home gardens into mixed fruit-tree systems and intensified home gardens (i.e., agroforestry), although the area available for conversion seemed to be small. From a climate-change mitigation perspective, these systems sequester carbon, and contribute to building up soil organic carbon. These benefits match with local concerns about declining productivity and soil degradation. Moreover, integrating more trees into current production lands and home gardens diversifies smallholder farmers' incomes, and enhances their economic and environmental resilience to natural disasters (Simelton et al. 2019). In Northwest Vietnam, some agroforestry models have been reported to provide average annual incomes from 870 US\$ ha⁻¹ y⁻¹ to 2905 US\$ ha⁻¹ y⁻¹ (Hoang et al. 2015), much higher than that of existing swidden farms.

The fact that Vietnam's NDCs do not include agroforestry¹⁰ (Escobar Carbonari et al. 2019) can be interpreted as a missed opportunity to substantially mitigate climate change at low or even negative marginal costs. Duguma et al. (2017) found that agroforestry can sequester between 1.1 and 34.2 Pg C globally, and that conversion of 25% of deforested area to agroforestry would help 80% of non-Annex I countries achieve their unconditional commitments under NDCs. According to Simelton et al. (2019), the total agroforestry area (i.e., the integration of trees, crops, and/or animals on the same land) in Vietnam is about 900,000 ha, and 10 million hectares are actually suitable for different types of agroforestry. The estimated average carbon gain

from the application of agroforestry practices is 2.25 (0.98–4.17) tC/ha/year (Mulia et al. 2018).

Mainstreaming Ecosystem Services in Local Integrated Land-Use Plans

Current land-use planning in Vietnam is not fostering effective forest landscape governance and management of natural ecosystems. According to the UNDP (2018), land-use plans are often developed and operated based on inaccurate data and not on considerations of ecosystem functions and services. Our study findings corroborate this claim. Discussions held with provincial and district DONRE indicated that there were no thematic surveys and assessments on the state and need for environmental services and biodiversity conservation, nor considerations of potential climate-change impacts and other environmental issues in land-use planning. The newly approved Law on Planning¹¹, which took effect on 1 January 2019, regulates the implementation of sectorial planning that includes national planning for forestry, environmental protection, and biodiversity conservation. These plans can and should provide better information for land-use planning across jurisdictional levels. The challenge is how to quickly move from ideas to actions, and that it is needed to mainstream ecosystem services into local land-use planning (Goldstein et al. 2012).

This study showed that engaging local stakeholders in land-use and scenario planning may foster integration of ecosystem services concerns in land-use planning. Participants in our case study perceived that the decline of forest quality in the landscape has led to declining provision of ecosystem services. They considered that the integration of trees in the Na Nhan landscape was obviously required to improve ecosystem services and generate income for local people. This implies that a wider range of “best-bet” tree-based alternatives for smallholders (both agroforestry and silvopastoral systems) should be examined for their environmental, agronomic, and economic benefits, and for the feasibility of their adoption. Such alternatives are certainly relevant to national policymakers seeking sustainable options for northwest Vietnam, where rice and other crop yields are projected to decline by 11–28% and 6–23.5%, respectively, in the coming years due to climate change (World Bank 2010).

Local perception of and demands to improve ecosystem services call for further considerations in implementing national policies such as Vietnam's NDCs and PFES. The NDC policy and follow-up studies (e.g., UNDP 2018; Escobar Carbonari et al. 2019) have so far been largely based on marginal abatement cost curve analysis that is not designed to incorporate environmental and social values in generating abatement costs of land-use changes. A relatively simple,

⁹ PFES is Payment for Forest Environmental Services policy that has been implemented in Vietnam since 2010. The policy requires hydropower, water supply, and tourism companies to pay forest holders for environmental services provided as input for their business. Payment is based on fixed rates and made through a Government trust fund.

¹⁰ It should be noted that Vietnam's NDCs are now under revision, and agroforestry has been added as one of the mitigation options in LULUCF sector. However, this could only be confirmed upon an official approval by the Government.

¹¹ Law on Planning was passed by the National Assembly of Vietnam on November 24, 2017.

qualitative, and participatory approach as demonstrated in our study can provide pointers in the quest for cost-effective approaches to assess co-benefits (adaptation, social, economic, environmental) of mitigation actions at both subnational and national levels, so that clear targets can be set and tracked, and additional investments can be justified. It is also important to note that although Vietnam has been running the PFES program since 2010, it is ambiguous whether PFES revenues are integrated in mitigation cost estimation, and how its outcomes are accounted for in policy planning, where a number of policies and commitments overlap (e.g., the NDCs, National Green Growth Strategy, Bonn Challenge, Aichi Biodiversity Targets, Convention on Biological Diversity post-2020 Biodiversity Framework, National Action Plan to implement the 2030 Agenda for sustainable development goals, etc.). Since PFES income alone can hardly be comparable to that of destructive economic activities in the northwest and other regions of Vietnam (Lan et al. 2016), it is necessary for local governors to develop plans that wisely combine resources of different programs and policies in a landscape in order to achieve the SDGs at the lowest possible cost. This cannot be done without integrating science and local knowledge in policymaking process, as shown in this case study.

Bottom-up, Participatory Land-Use Planning Can Help Address Gaps in Landscape Governance

Landscape governance is often perceived as a “wicked problem” (Termeer et al. 2019) wherein complexity of social, economic, and environmental issues, stakeholders and perspectives lead to difficulty in providing solutions. In the Na Nhan landscape, one of the most profound concerns of governance may be the discrepancies between planned and actual land use. Our study has shown that local farmers’ de facto use of degraded forests for agricultural cultivation has not been officially recognized in any land-use plan. The current land-use classification system used for land-use planning is not based on actual land use, but on the purpose for which the land should be used according to the government. This differs significantly from the land-use practices of ethnic groups in mountainous areas, who have long been practicing shifting cultivation in upland areas and on sloping lands classified as degraded forests, forest land without forests, bare lands, or unused lands, depending on tree cover and other criteria (CIRUM 2012; Pham et al. 2018). Conventional land-use planning may claim a large part of the total land area as forest land, but this is disregarded by local communities. Failure to recognize traditional land-use systems in land legislations, land-use classifications and land-use planning disadvantages traditional land users and creates potential conflicts during the land-allocation process, and partly leads to low-level stakeholder participation (Ironsides 2017; Nguyen et al. 2008; Pham et al. 2018). In contrast,

considering landscape multifunctionality, the use of “degraded” or “unused” forest land for agriculture may be acceptable if well managed, and restoration of “degraded” land via a combination of afforestation and agricultural production can even reduce further degradation and eventually increase the provision of selected ecosystem services (Matson and Vitousek 2006; Rey Benayas and Bullock 2012; Verburg et al. 2013). In that way, land resources can be utilized more effectively to deliver economic and ecological benefits for local inhabitants rather than leaving local governors with the notion that “shifting cultivation is impossible to eradicate and therefore left unreported” (Pham et al. 2018).

Enhanced participation in land-use planning fosters improved landscape governance because it ensures a coordinated process across actors in managing natural resources and ecosystem services and thus can deliver the full range of societal needs (FAO 2017). A number of tools and methods have been readily available to serve this purpose. For example, the LUMENS framework (Dewi et al. 2015) was successfully adopted as a negotiation support framework to develop the Green Growth Action Plan of South Sumatra Province and some other provinces in Indonesia. Barral and Oscar (2012) developed a methodological protocol of strategic environmental assessment to mainstream the valuation of ecosystem services in land-use plans, while Langemeyer et al. (2016) and Saarikoski et al. (2016) proposed the use of multi-criteria decision analysis (MCDA) for similar purposes. These tools have great potential to fill the gaps of ecosystem services assessment in land-use planning in many developing countries. Our case study demonstrated that an approach, which combines conventional land-use mapping of historical changes, participatory future-oriented land-use scenario development, and qualitative ecosystem services assessment in a modeling software (i.e., REDD Abacus) offers a good basis for a comprehensive vision for landscape planning and management. Although the picture would have been more complete if data on land-use economics were obtained, we found this approach effective, especially when maps and visuals were used to enhance stakeholder discussions and stimulate innovations (van Berkel and Verburg 2012). However, uncertainty of land-use scenarios should be acknowledged since numerous factors influence future land uses, such as policy commitment and implementation, technical and financial resources, and adequate monitoring and evaluation systems. Last, but not least, it is worth emphasizing the role of integrated and participatory land-use planning in bringing together different non-state and subnational actors, and in building consensus toward better governance of the landscape. Such functions are key to connecting different levels of government and other stakeholders in the implementation of subnational activities, and thus deliver national commitments such as NDCs (Hsu et al. 2019).

Conclusions

Our study demonstrates the use of LUMENS as a platform for multi-stakeholder negotiation toward developing a land-use plan that takes multiple ecosystem services in rural Vietnam into account. It provides insights into local engagement in land-use planning processes, its potential impacts on ecosystem service delivery in the landscape, and particularly climate mitigation potential. The study shows that well-facilitated stakeholder engagement can help fill-in current gaps in land-use planning, and can inform national climate policies on how actual emission reductions and sequestration can be achieved on the ground. It also illustrates how the governance of a carbon-rich landscape can be improved with stakeholder involvement in decision-making through processes such as land-use planning. Finally, the study highlights the roles of tree-based land uses, especially agroforestry, in securing climate-change-related targets as well as their co-benefits. National and local authorities should not only acknowledge the role of tree-based land uses in integrated landscape governance, but also use participatory-oriented spatial analysis to develop and implement such policies with multi-stakeholder involvement.

Acknowledgements This research was funded by the Australian Centre for International Agricultural Research, Grant number FST/2016/152; and the research programs on Forests, Trees and Agroforestry (TFA) and the Policies, Institutions, and Markets (PIM) Programme of the Consultative Group on International Agricultural Research. We thank our colleagues from the World Agroforestry, the Vietnamese Academy of Forest Sciences, and the Soils and Fertilizers Research Institute who provided insights and expertise that greatly assisted the research. We would also like to thank the officials and staff of the Extension Centre of Dien Bien Province, Na Nhan Commune People’s Committee in Dien Bien Province, as well as the village leaders for their active participation and support to our field activities. We thank the men and women farmers who openly shared information, their perspectives, and insights during the surveys, discussions, and other activities during the study period. Finally, we thank the anonymous reviewers and guest editors of this special issue for their careful reading of our manuscript and their many insightful comments and suggestions.

Author Contributions Conceptualization: DTH, VTP, and DC; methodology: DTH and VTP; software: DTH; validation: VTP and NVT; analysis: DTH, NVT, and VTP; investigation: DTH and NVT; data processing: NVT and VTP; writing—original draft preparation: DTH; writing—review and editing: DC; visualization: NVT; supervision, project administration, and funding acquisition: DC.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Publisher’s note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Appendix

Table 6 Land-use change matrix 2005–2015 in Na Nhan commune, Dien Bien province

2015 Land use/cover types	2005 Land use/cover types							Total 2015		
	EBF—rich	EBF—medium	EBF—poor	Planted forest	Bare land with scattered trees	Bare land with grass and shrubs	Tree-crop plantation		Annual crops	Water bodies and other land uses
EBF—rich	0	0	0	0	0	0	0	0	0	0.0
EBF—medium	0	137.6	20.4	0	0	0	0	0	0	158.0
EBF—poor	0	0.0	955.9	317.3	66.4	1612.2	0	0	0	2951.8
Planted forest	0	0	0	17.4	0	39	0	0.0	0	56.4
Bare land with scattered trees	0	0	0	0	710.4	0	0	0	0	710.4
Bare land with grass and shrubs	0	0	0	0	0	774.4	0	0	0	774.4
Tree-crop plantation	0	0	0	0	0	0	47.8	0.0	0	47.8
Annual crops	0	0	0	0	0	918.8	0	1747.2	0	2665.9
Water bodies and other land uses	0	0	0	0	0	25.3	2.7	0	207.0	234.9
Total 2005	0.0	137.6	976.3	334.7	776.8	3369.6	50.5	1747.2	207.0	7599.6

Source: authors’ work adapted from FIPI (2006, 2016)

The unit of area is hectares (ha)

EBF evergreen broadleaf forest

References

- Amler B et al. (1999) Land use planning: methods, strategies and tools. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH, Eschborn, Germany
- Arifin J (2001) Estimasi cadangan Karbon pada berbagai sistem penggunaan lahan di Kecamatan Ngantang, Malang. Thesis S1, Universitas Brawijaya
- Barral MP, Oscar MN (2012) Land-use planning based on ecosystem service assessment: a case study in the Southeast Pampas of Argentina. *Agric Ecosyst Environ* 154:34–43. <https://doi.org/10.1016/j.agee.2011.07.010>
- Bourgoin J, Castella JC (2011) “PLUP FICTION”: landscape simulation for participatory land use planning in northern Lao PDR. *Mt Res Dev* 31:78–88. <https://doi.org/10.1659/mrd-journal-d-10-00129.1>
- Bourgoin J, Castella JC, Hett C, Lestrelin G, Heinimann A (2013) Engaging local communities in low emissions land-use planning: a case study from Laos *Ecol Soc* 18(1–9):11. <https://doi.org/10.5751/ES-05362-180209>
- Bourgoin J, Castella JC, Pullar D, Lestrelin G, Bouahom B (2012) Toward a land zoning negotiation support platform: “Tips and tricks” for participatory land-use planning in Laos. *Landsc Urban Plan* 104:270–278. <https://doi.org/10.1016/j.landurbplan.2011.11.008>
- Castella JC, Gevraise V, Novosad P (2005) Centralized planning and economic reforms in a mountainous region of Vietnam. *J Contemp Asia* 35:166–182. <https://doi.org/10.1080/00472330580000111>
- Cathcart JF, Kline JD, Delaney M, Tilton M (2007) Carbon storage and Oregon’s Land-Use Planning Program. *J For* 105(4):167–172
- Chave J et al. (2014) Improved allometric models to estimate the aboveground biomass of tropical trees. *Glob Chang Biol* 20:3177–3190. <https://doi.org/10.1111/gcb.12629>
- Chhatre A, Agrawal A (2009) Trade-offs and synergies between carbon storage and livelihood benefits from forest commons. *Proc Natl Acad Sci USA* 106:17667–17670. <https://doi.org/10.1073/pnas.0905308106>
- CIRUM (2012) Customary law in forest resources use and management a case study among the Dzaio and Thai people in north-west Vietnam. AIPP Printing Press, Chiangmai, Thailand
- Clement F, Amezaga J (2009) Afforestation and forestry land allocation in northern Vietnam: analysing the gap between policy intentions and outcomes. *Land Use Policy* 26:458–470. <https://doi.org/10.1016/j.landusepol.2008.06.003>
- Cockburn J, Cundill G, Shackleton S, Rouget M (2018) Towards place-based research to support social–ecological stewardship. *Sustainability* 10(5):1434. <https://doi.org/10.3390/su10051434>
- Dewi S, Ekadinata A, Indarto D, Nugraha A, van Noordwijk M (2015) Negotiation support tools to enhance multifunctioning landscapes. In: Minang PA, van Noordwijk M, Freeman OE, Mbowa C, de Leeuw J, Catacutan DC (eds) *Climate-smart landscapes: multifunctionality in practice*. World Agroforestry Centre (ICRAF), Nairobi, Kenya, p 243–255
- Ducourtieux O, Laffort J-R, Sackloham S (2005) Land policy and farming practices in Laos. *Dev Chang* 36:499–526. <https://doi.org/10.1111/j.0012-155X.2005.00421.x>
- Duguma LA, Nzyoka J, Minang PA, Bernard F (2017) How agroforestry propels achievement of nationally determined contributions. Policy Brief. World Agroforestry Centre (ICRAF), Nairobi, Kenya
- Escobar Carbonari D, Grosjean G, Läderach P, Nghia TD, Sander BO, McKinley J, Sebastian L, Tapasco J (2019) Reviewing Vietnam’s nationally determined contribution: a new perspective using the marginal cost of abatement. *Front Sustain Food Syst* 3:14. <https://doi.org/10.3389/fsufs.2019.00014>
- FAO (2017) *Landscape management for life. Approaches to landscape management for sustainable food and agriculture*. FAO, Rome, Italy
- FIPI (2006) Báo cáo kết quả kiểm kê rừng tỉnh Điện Biên năm 2005 (Report on 2005 forest inventory in Dien Bien Province). FIPI, the Program on National Forest Resource Investigation for the period 2001–2005, Evaluation and Monitoring, Hanoi, Vietnam
- FIPI (2016) Báo cáo kết quả điều tra, kiểm kê rừng tỉnh Điện Biên năm 2015 (Report on 2015 forest inventory in Dien Bien Province). FIPI, the National Forest Inventory Project for the period 2013–2016, Hanoi, Vietnam
- Goldstein JH et al. (2012) Integrating ecosystem-service tradeoffs into land-use decisions. *Proc Natl Acad Sci USA* 7565–7570. <https://doi.org/10.1073/pnas.1201040109>
- Hairiah K, Dewi S, Agus F, Velarde S, Ekadinata A, Rahayu S, van Noordwijk M (2010) *Measuring Carbon Stocks Across Land Use Systems: A Manual*. World Agroforestry Centre (ICRAF), SEA Regional Office, Bogor, Indonesia
- Hairiah K, Sitompul SM, van Noordwijk M, Palm CA (2001) Methods for sampling carbon stocks above and below ground. International Centre for Research in Agroforestry (ICRAF), SEA Research Programme, Bogor, Indonesia
- Hoang VT, Tran VD, Kozan O, Catacutan D (2015) Cost-benefit analysis for agroforestry systems in Vietnam. *Asian J Agric Ext Econ Sociol* 5(3):158–165. <https://doi.org/10.9734/AJAEES/2015/15750>
- Hsu A, Brandt J, Widerberg O, Chan S, Weinfurter A (2019) Exploring links between national climate strategies and non-state and subnational climate action in nationally determined contributions (NDCs). *Clim Policy* 1–15. <https://doi.org/10.1080/14693062.2019.1624252>
- IPCC (2006) 2006 IPCC guidelines for national greenhouse gas inventories, vol. 4, agriculture, forestry and other land use (AFOLU). Institute for Global Environmental Strategies (IGES), Kanagawa, Japan
- Ironside J (2017) The recognition of customary tenure in Vietnam. MRLG thematic study series, vol 6. Mekong Region Land Governance (MRLG) Project, Vientiane, Laos
- Kauzeni AS, Kikula IS, Mohamed SA, Lyimo JG, Dabal-Clayton DB (1993) Land use planning and resource assessment in Tanzania: a case study. *Environmental Planning Issues*. International Institute for Environment and Development, London, UK
- Kusters K, Buck L, de Graaf M et al. (2018) Participatory Planning, Monitoring and Evaluation of Multi-Stakeholder Platforms in Integrated Landscape Initiatives. *Environ Manag* 62:170–181. <https://doi.org/10.1007/s00267-017-0847-y>
- Lambin EF, Meyfroidt P (2010) Land use transitions: socio-ecological feedback versus socio-economic change. *Land Use Policy* 27:108–118. <https://doi.org/10.1016/j.landusepol.2009.09.003>
- Lan LN, Wichelns D, Milan F, Hoanh CT, Phuong ND (2016) Household opportunity costs of protecting and developing forest lands in Son La and Hoa Binh Provinces, Vietnam. *Int J Commons* 10:902–928. <https://doi.org/10.18352/ijc.620>
- Landell-Mills N, Porras IT (2002) Silver bullet or fools’ gold? A global review of markets for forest environmental services and their impact on the poor. International Institute for Environment and Development, London, UK
- Langemeyer J, Gómez-Baggethun E, Haase D, Scheuer S, Elmqvist T (2016) Bridging the gap between ecosystem service assessments and land-use planning through multi-criteria decision analysis (MCDA). *Environ Sci Policy* 62:45–56. <https://doi.org/10.1016/j.envsci.2016.02.013>
- Lindley S, Handley JF, Theuray N, Peet E, Mcevoy D (2006) Adaptation strategies for climate change in the urban environment: assessing climate change related risk in UK urban areas. *J Risk Res* 9:543–568. <https://doi.org/10.1080/13669870600798020>

- Luyet V, Schlaepfer R, Parlange MB, Buttler A (2012) A framework to implement stakeholder participation in environmental projects. *J Environ Manag* 111:213–219. <https://doi.org/10.1016/j.jenvma.2012.06.026>
- Matson P, Vitousek P (2006) Agricultural intensification: will land spared from farming be land spared for nature? *Conserv Biol* 20:709–710. <https://doi.org/10.1111/j.1523-1739.2006.00442.x>
- Minang PA, van Noordwijk M (2013) Design challenges for achieving reduced emissions from deforestation and forest degradation through conservation: Leveraging multiple paradigms at the tropical forest margins. *Land Use Policy* 31:61–70. <https://doi.org/10.1016/j.landusepol.2012.04.025>
- MONRE (2015) Vietnam's intended nationally determined contribution—technical report. MONRE, Hanoi, Vietnam
- MONRE (2016) Intended nationally determined contribution (NDC). MONRE, Hanoi, Vietnam
- Moser SC, Luers AL (2008) Managing climate risks in California: the need to engage resource managers for successful adaptation to change. *Clim Chang* 87:309–322. <https://doi.org/10.1007/s10584-007-9384-7>
- Moser SC, Tribbia J (2006) Vulnerability to inundation and climate change impacts in California: coastal managers' attitudes and perceptions. *Mar Technol Soc J* 40:35–44. <https://doi.org/10.4031/002533206787353169>
- Mulia R, Nguyen MP, Pham TV, Dinh TH (2018) Potential mitigation contribution from agroforestry to Viet Nam's NDC. World Agroforestry Centre (ICRAF) Viet Nam, Southeast Asia Program, Hanoi, Viet Nam
- Na Nhan CPC (2016a) Báo cáo tình hình thực hiện nhiệm vụ phát triển kinh tế - xã hội, an ninh-quốc phòng năm 2016 và phương hướng nhiệm vụ năm 2017 (Report on the implementation of socio-economic and security-defense tasks in 2016 and directions in 2017, in Na Nhan commune). Na Nhan CPC, Dien Bien, Viet Nam
- Na Nhan CPC (2016b) Báo cáo kết quả kiểm kê đất đai năm 2015 tại xã Nà Nhạn, huyện Điện Biên, tỉnh Điện Biên (Report on 2015 land inventory in Na Nhan Commune, Dien Bien District, Dien Bien Province). Na Nhan CPC, Dien Bien, Viet Nam
- Nelson E et al. (2009) Modeling multiple ecosystem services, biodiversity conservation, commodity production, and tradeoffs at landscape scales. *Front Sustain Food Syst* 7:4–11. <https://doi.org/10.1890/080023>
- Nguyen HT, Tri LQ, van Mensvoort MEF, Bregt AK (2006) Comparing land-use planning approaches in the coastal Mekong Delta of Vietnam. In: Chu TH, To PT, Gowing JW, Hardy B (eds) *Environment and livelihoods in tropical coastal zones: managing agriculture-fishery-aquaculture conflicts*. CABI, Wallingford, UK, p 177–192
- Nguyen QT, Nguyen VC, Vu TH (2008) Statutory and customary forest rights and their governance implications: the case of Viet Nam. IUCN, Hanoi, Viet Nam
- O'Farrell PJ, Anderson PML (2010) Sustainable multifunctional landscapes: a review to implementation. *Curr Opin Environ Sustain* 2:59–65. <https://doi.org/10.1016/j.cosust.2010.02.005>
- Ohlsson B, Sandewall M, Sandewall RK, Phon NH (2005) Government plans and farmers intentions: a study on forest land use planning in Vietnam. *Ambio* 34:248–255. <https://doi.org/10.1579/0044-7447-34.3.248>
- Olofsson P, Foody GM, Herold M, Stehman SV, Woodcock CE, Wulder MA (2014) Good practices for estimating area and assessing accuracy of land change. *Remote Sens Environ* 148:42–57. <https://doi.org/10.1016/j.rse.2014.02.015>
- Olofsson P, Foody GM, Stehman SV, Woodcock CE (2013) Making better use of accuracy data in land change studies: Estimating accuracy and area and quantifying uncertainty using stratified estimation. *Remote Sens Environ* 129:122–131. <https://doi.org/10.1016/j.rse.2012.10.031>
- Pham TT, Moeliono M, Wong GY, Brockhaus M, Dung LN (2018) The politics of swidden: a case study from Nghe An and Son La in Vietnam. *Land Use Policy*. <https://doi.org/10.1016/j.landusepol.2017.10.057>
- Phelps J, Webb EL, Agrawal A (2010) Does REDD+ threaten to recentralize forest governance? *Science* 328:312–313. <https://doi.org/10.1126/science.1187774>
- Reed MS (2008) Stakeholder participation for environmental management: a literature review. *Biol Conserv* 141:2417–2431. <https://doi.org/10.1016/j.biocon.2008.07.014>
- Rey Benayas JM, Bullock JM (2012) Restoration of biodiversity and ecosystem services on agricultural land. *Ecosystems* 15:883–899. <https://doi.org/10.1007/s10021-012-9552-0>
- Reyers B, O'Farrell PJ, Nel JL, Wilson K (2012) Expanding the conservation toolbox: conservation planning of multifunctional landscapes. *Landsc Ecol* 27:1121–1134. <https://doi.org/10.1007/s10980-012-9761-0>
- Roshetko JM, Lasco RD, Angeles MSD (2007) Smallholder agroforestry systems for carbon storage. *Mitig Adapt Strateg Glob Chang* 12:219–242. <https://doi.org/10.1007/s11027-005-9010-9>
- Rozario P, Oduor P, Kotchman LA, Kangas M (2017) Transition modeling of land-use dynamics in the pipestem creek, North Dakota, USA. *J Geosci Environ Prot* 5:182–201. <https://doi.org/10.4236/gep.2017.53013>
- Rydin Y (1998) Land use planning and environmental capacity: reassessing the use of regulatory policy tools to achieve sustainable development. *J Environ Plan Manag* 41:749–765. <https://doi.org/10.1080/09640569811407>
- Saarikoski H, Mustajoki J, Barton DN, Geneletti D, Langemeyer J, Gomez-Baggethun E, Marttunen M, Antunes P, Keune H, Santos R (2016) Multi-Criteria Decision Analysis and Cost-Benefit Analysis: Comparing alternative frameworks for integrated valuation of ecosystem services. *Ecosystem Services* 22(B):238–249. <https://doi.org/10.1016/j.ecoser.2016.10.014>
- Sayer J, Sunderland T, Ghazoul T, Pfund JL, Sheil D, Meijaard E, Venter M, Boedhihartono AK, Day M, Garcia C, van Oosten C, Buck LE (2013) Ten principles for a landscape approach to reconciling agriculture, conservation, and other competing land uses. *Proc Natl Acad Sci USA* 110:8349–8356. <https://doi.org/10.1073/pnas.1210595110>
- Schroth G, D'Angelo SA, Teixeira WG, Haag D, Lieberei R (2002) Conversion of secondary forest into agroforestry and monoculture plantations in Amazonia: consequences for biomass, litter and soil carbon stocks after 7 years. *Ecol Manag* 163:131–150. [https://doi.org/10.1016/S0378-1127\(01\)00537-0](https://doi.org/10.1016/S0378-1127(01)00537-0)
- Segura M, Kanninen M, Suárez D (2006) Allometric models for estimating aboveground biomass of shade trees and coffee bushes grown together. *Agrofor Syst* 68:143–150. <https://doi.org/10.1007/s10457-006-9005-x>
- Simelton ES, Mulia R, Vaast P, Nguyen QT (2019) Agroforestry for mitigating climate change in Viet Nam. Brief, vol 104. World Agroforestry (ICRAF) Viet Nam, Country Program, Hanoi, Viet Nam
- Strohmaier R et al. (2016) The agriculture sectors in the intended nationally determined contributions: analysis. environment and natural resources management working paper. FAO, Rome, Italy
- Termeer CJAM, Dewulf A, Biesbroek R (2019) A critical assessment of the wicked problem concept: relevance and usefulness for policy science and practice. *Policy Soc* 38(2):167–179. <https://doi.org/10.1080/14494035.2019.1617971>
- Toni F (2011) Decentralization and REDD+ in Brazil. *Forests* 2:66–85. <https://doi.org/10.3390/f2010066>
- Travis WR (2008) Global warming and land use. In: *Proceedings of the 17th Annual Rocky Mountain Land Use Conference*, Colorado, CO, USA, 2008

- UNDP (2018) Long-term greenhouse gas emission mitigation opportunities and drivers in Viet Nam: meeting Paris agreement targets and accelerating progress towards the SDGs. UNDP, Hanoi, Viet Nam
- van Asselt MBA, Klooster SA, PWF Notten, Smits LA (2012) Foresight in action: developing policy oriented scenarios. *Foresight in action: developing policy-oriented scenarios*, 1st edn. Earthscan, London, UK, 10.4324/9781849775748
- van Berkel DB, Verburg PH (2012) Combining exploratory scenarios and participatory back-casting: using an agent-based model in participatory policy design for a multi-functional landscape. *Landsc Ecol* 27:641–658. <https://doi.org/10.1007/s10980-012-9730-7>
- van Lier HN (1998) The role of land-use planning in sustainable rural systems. *Landsc Urban Plan* 41:83–91. [https://doi.org/10.1016/S0169-2046\(97\)00061-3](https://doi.org/10.1016/S0169-2046(97)00061-3)
- Verburg PH, Mertz O, Erb K-H, Haberl H, Wu W (2013) Land system change and food security: towards multi-scale land system solutions. *Curr Opin Environ Sustain* 5:494–502. <https://doi.org/10.1016/j.cosust.2013.07.003>
- Vu TP (2006) Nghiên cứu trữ lượng các bon thảm tươi và cây bụi: Cơ sở để xác định đường các bon cơ sở trong các dự án trồng rừng/tái trồng rừng theo cơ chế phát triển sạch ở Việt Nam (Determining carbon stock of bush and grassland: a base for development of baseline carbon scenario for afforestation/reforestation project by clean development mechanism in Vietnam). *Tạp chí nông nghiệp và Phát triển nông thôn* 8:81–84
- Vu TP, Merger E, C. TL (2018) Review and update the nationally determined contribution for the land use, land use change and forestry for the period of 2010–2030. Project on creation of an overarching framework for NAMAs and MRV in Viet Nam. Ministry of Natural Resources and Environment, Hanoi, Viet Nam
- Vu TP, Tran TH, Nguyen TH, Ha TM (2015) Development of emission factors for a national FREL/FRL for REDD⁺ for Government's submission to the UNFCCC. UN-REDD Programme, Hanoi, Viet Nam
- World Bank (2010) Vietnam—economics of adaptation to climate change. World Bank, Washington, DC, USA