CHAPTER 2

Drivers of forest changes: mapping actors and motivations in Bac Kan province, Northeast Viet Nam

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Summary

Forest cover in Viet Nam has significantly increased since mid1990s, reportedly as a result of numerous policies and programs that support forest land allocation, protection and development. However, little has been understood about how such policies and programs, and furthermore local community affected local forests. Our research analysed the historical (1990-2010) and future (2010-2020) forest pathways in Bac Kan province, Northeast Viet Nam, as a pilot province for REDD+ and identified the proximate and underlying factors as well as the actors involved. Spatial analysis of time-series, land-cover and forest-ownership maps was conducted at provincial level with the support of household surveys in some communes and districts.

Results indicated that illegal logging and shifting cultivation, coupled with weak forest management, were the main causes of forest degradation between 1990 and 2000. Reforestation programs, followed by financial support and land allocation, were identified as factors driving reforestation and afforestation throughout the entire period. Moreover, Program 147, which supported the conversion of natural forest to planted forest, was the driver of both forest gain and loss from 2008 to 2020. Policy makers and households were, therefore, the key actors in the process. We expect the results of this study can help slow the process of forest loss by contributing to policy improvement. The criteria of natural forest to be converted to forest plantation under Program 147 should be clarified to avoid natural forest loss in the future.

1. Introduction

The Intergovernmental Panel on Climate Change (IPCC) reported in 2007 that more than 20% of global greenhouse-gas emissions came from tropical deforestation (Pachauri and Reisinger 2008). Compared to the 1990s, global deforestation between 2000 and 2010 decreased but still remained high. During this period, approximately 13 million hectares of forests were lost each year, according to the Global Forest Resources Assessment Report in 2010 by the Food and Agriculture Organization (FAO 2010a).

Subsequently, forest carbon stocks decreased by 0.5 Gt/year. A key driver of this forest decline was agricultural expansion. This process was counterbalanced by large-scale reforestation and afforestation in many parts of the world, particularly, in China. Positive results from reforestation programs included a reduction in global forest loss from 8.3 million hectares per year between 1990 and 2000 to 5.3 million hectares per year in 2010. Planted forest accounted for 7% of the global forest area in 2010 (FAO 2010a).

Viet Nam is among the world's nations in which forest cover has been increasing. The total forest area of the country has increased from 28% in 1990 to 38% in 2006. According to FAO, Viet Nam's forest cover increased 0.5% annually during the period 2000–2005 (FAO 2010b). Reforestation activities were implemented in mountainous areas since the 1990s (Castella et al 2002). Meyfroidt and Lambin (2008), indicated that the increase in forest cover was caused by regeneration of natural forest and forest plantation and that the area of forest restoration was larger than the area of deforestation. Their research also found that forest biomass changed owing to forest degradation and regeneration.

Most studies on forest transition in Viet Nam have focused on reforestation and the impact of policies on the increase of forest plantation (Clement 2009), as well as the roles of farmers in decision-making related to reforestation. Researchers have focused on either the spatial aspects of forest transition or on a theoretical approach to analyse the relations between forest changes and policies and farmers. However, there has been a lack of analysis of actors involved in the transition process.

To meet this gap, this study focused on the proximate and underlying factors as well as actors with respect to forest change. There are a number of studies focusing on drivers of forest changes such as proximate causes of deforestation (Rademaekers et al 2010, Müller et al 2012), illegal logging in South East Asia (Rosander 2008) drivers of deforestation and forest degradation (Hosonuma 2012, Kissinger 2012) or causes of reforestation (Meyfroidt and Lambin 2008). However, forest-cover changes are not only the result of complex interactions between, and amongst, biophysical, social, economic and policy factors but also agents, including households, government, organizations, trading companies and others (Meyfroidt et al 2008). Our study was guided by the hypothesis that drivers of forest-cover transition are space- or time-dependent and that knowledge of past drivers in a certain landscape cannot be directly extrapolated into the future yet there may be predictability in the succession of drivers. The study was implemented in Bac Kan Province, in Northeast Viet Nam as one of pilot provinces for REDD+.

Forest gain and forest loss in Bac Kan province were identified by using spatial analysis, surveys, and focus group discussion. There are various factors, such as agricultural expansion or governmental policies, which have affect the cover of forests. Those factors can be categorized into underlying factors or proximate factors. The proximate factors provide a direct link

with the changes of forests while underlying drivers made their own impacts through proximate factors.

Forest restoration and reforestation policies in Viet Nam (1990-2010)

Viet Nam's forests are divided into three categories: 1) special use; 2) protection; and 3) production forests. The function of special-use forests is to preserve natural forest resources and to protect ecosystems, biodiversity, sources of species, natural beauty for ecotourism, and sources of livelihoods. Protection forests' main purpose is to protect and enhance landscape functions, such as water regulation, control of soil erosion, and mitigation of natural disasters. Both special-use and protection forests are managed by the Community People's Committees at sub-provincial level, the Department of Agriculture and Rural Development (DARD) at the provincial level or the Ministry of Agriculture and Rural Development (MARD) at the national level. Production forests, which include planted and natural forests, are expected to address the demand for timber and are allocated to households, individuals, state forest enterprises and private concessionaires (MARD 2012).

Forest policies began in 1986 with Đổi Mới, a program that aimed to reform the economy, followed by a number of forest and land laws (Table 1). Based on these provisions, forest and agricultural land was allocated to smallholders. Decree 327 focusing on barren land restoration (Government of Viet Nam 1995), Program 661 supporting 5 million hectares of forests (Government of Viet Nam 1998) and Decree 147 (Government of Viet Nam 2007) about improving natural and planted forest are the three main forest policies and programs. Through those programs, the government provided credit and distributed seedlings to stimulate the establishment of plantation forests as well as improvement of the quality of existing natural forests with native timber tree species. Other stakeholders-such as provincial, district and commune governments, village leaders, military, forest management boards, non-governmental organizations and forest enterprises-also engaged in the process. Many overseas development assistance funds, such as from Germany and Belgium and international organizations, were mobilized for both restoration and reforestation. As a result of all these efforts, the area of planted forest increased from 425,504 hectares in 1990 to 3,218,388 hectares in 2010 (MARD 2010).

Table 1. Summary of land and forest policies in Viet Nam (1990-2010)

Year	Policy	Key provisions
1986	Renovation program (Đổi Mới)	Economic reform was implemented, which led to substantial development in agriculture and rural livelihoods (Kerkvliet and Porter 1995)
1991	Forest Protection and Development Law	Allocation of forestland and uplands to farmers

1992	Decree 327	Reforestation initiative with the aim of increasing tree cover on barren land and enhancing agricultural production. The program introduced contracts between government and households to protect forests (Clement 2009)
1993	Land Law	Land in agricultural, forestry and aquacultural sectors was allocated through contract to organizations, households and individuals (Tan et al 2008). The law provided more detail for the process of forest land right allocation
1994-1995	Decree 01-CP, Decree 02-CP	
1998	Decision No. 661-CT/1998	Also known as the Five Million Hectare Restoration Program, objectives were to enhance forest protection and to plant 5 million hectares of forest: 2 million of production forest; 2 million of protection and special-use forest; and 1 million of fruit and industrial trees
2002	Decision No. 78/2002/QD-BNN (Ministry of Agricultural Development)	Forest tenure was classified into several groups 1. State enterprises 2. Management boards for special-use forest 3. Management boards for protection forest 4. Joint-venture companies 5. Households and individuals 6. Collectives 7. Armed forces 8. Commune people's committees
2003	Land Law (modified)	Communities were recognized in forest-land tenure
2004	Forest Protection and Development Law (modified)	Provided more detail on forest rights, ownership and development of the forestry sector but did not mention the presence of communities in the list of legal forest owners (Tan et al 2008)
2007	Decision No. 147/2007/QD-TTg	Approved the development plan for forests until 2015, with supporting polices. The plan included forest protection and development, that is, afforestation, zoning for regeneration, plantations of scattered trees, rehabilitation of critically-poor natural forest, and improved quality of forests Decision 147 also encouraged the allocation of forestland to communities, households, individuals, organizations and enterprises and allowed the conversion of poor-quality natural forest to forest plantation

Figure 1 shows the forest transition in Viet Nam over 60 years, linked with the key forest policies described above. In 1943, forests accounted for almost half the total land area. Forest cover was at its lowest from the late 1980s to the early 1990s, with a total area of just 27.2% in 1990. With Decree 327 in 1992, and forestland allocation policies, the percentage of forest cover increased rapidly from to 33.2% in 1999. Following this, forest cover gradually reached 39.5% of total area in 2010 with support from Program 661 (1998–2007) and Program 147 (2007–2010) (de Jong et al 2006, Viet Nam Forestry 2007, 2008, 2009, 2010, 2011).

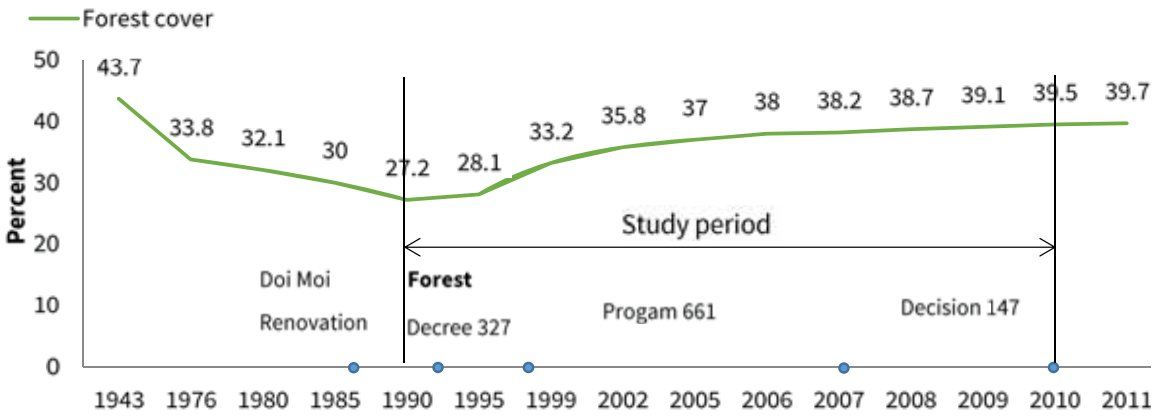

Figure 1. Percentage of forest cover in Viet Nam and key forest policies, 1943–2011

2. Methodology

Study site

Bac Kan is a mountainous province in the Northeast region of Viet Nam, with more than 60% of its area covered by forests in 2010 (Figure 2). The main ethnic groups in Bac Kan are Tay, Dao and Nung. In 2009, the province had the highest poverty rate in the country, with an average monthly income per capita of VND 669,000 (approximately USD 35) (GSO 2010). Only 5% of the land is arable and water shortages are common. Income is mainly derived from small-scale agricultural production.

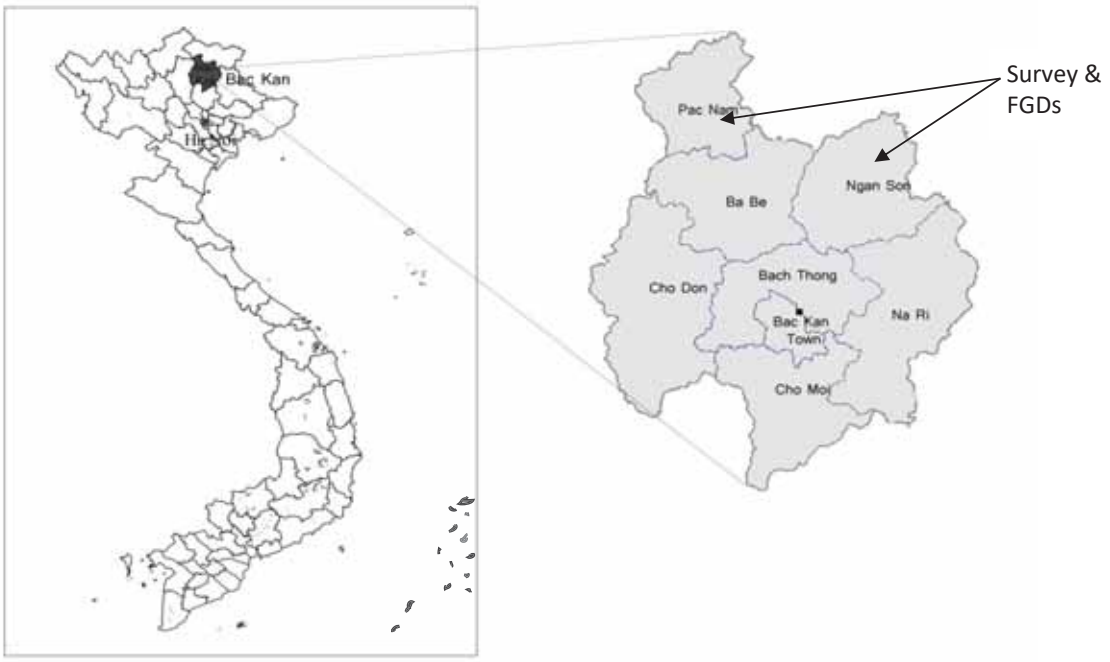

Figure 2. Bac Kan Province and study sites

Methods

Figure 3 displays our analytical framework. The spatial analysis included two data sets: 1) land-use-change data with the status of forest volumes for 20 (1990-2010) years as well as the spatial distribution of forest owners and forest-management types; and 2) supporting data, such as roads, hydrology and settlements. Overlaying time-series maps provided a broad characterization of forest-cover change along with identification of the different actors and proximate drivers.

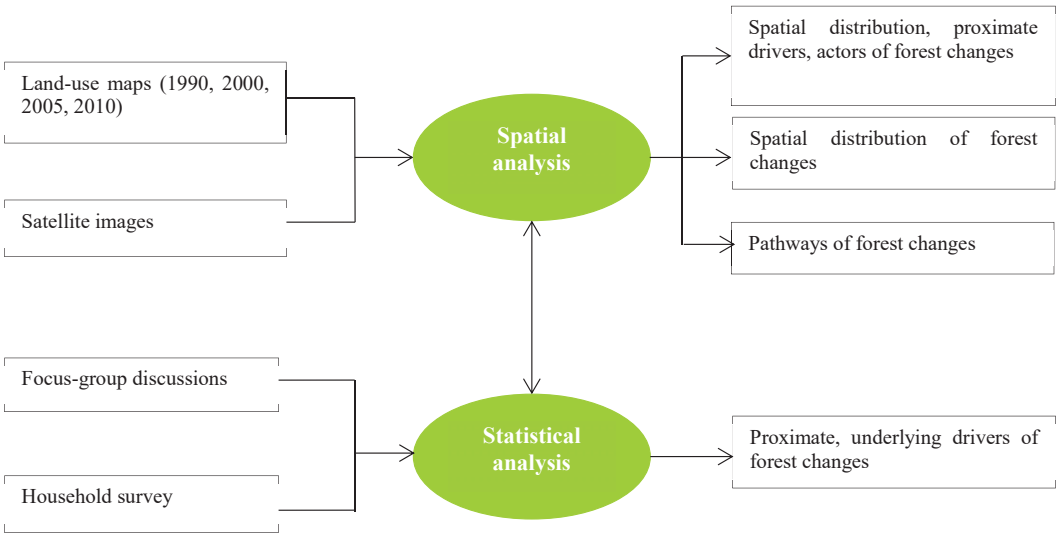

Figure 3. Analytical framework of the study

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After examining the spatial changes in forest cover, links with proximate drivers and other GIS layers, the next step was to examine these in relation to the data obtained from household surveys, focus-group discussions (FGDs), and interviews with government officials. Based on the forest-change analysis, the areas of forest gain and loss were identified. Four villages in two communes in the districts of Ngan Son and Pac Nam, which had significant forest gains and losses, were selected for household surveys.

The FGDs at the provincial, district and commune levels helped to clarify land-use types and better understand forest-cover changes and their drivers. FGDs at the district and commune levels were carried out with partners and at the village level with farmers and village leaders. The general information gathered from the FGDs at all levels was used to design the household survey. The survey focused on the underlying factors of forest changes during 2000–2010. Interviews with commune and district officials focused on the impact of both internal and external factors on identified forest changes up to 2000. Survey data were analysed using a correlation test to identify the relationship between changes in forest cover and the drivers of those changes. Multivariate linear regression was also used to further understand the contribution of different land uses and factors to forest-cover change.

A final workshop at the provincial level was organized to evaluate the findings with the participation of 30 representatives of district people's committees, policy makers and forest-plantation companies.

3. Data

Spatial data

We developed consistent time-series, land-cover maps for 1990, 1995, 2000, 2005 and 2010 at the scale of 1:100.000 based on the forest maps of MARD and land-use maps of the Ministry of Natural Resources and Environment (MONRE). Forest maps were overlaid with forest planning map of Bac Kan province (DARD 2009) to see the trend in forest cover in the future. SPOT images were used to correct the differences between the two mapping systems. Our map classification covered a wide range of forest types and non-forest land uses. Additional layers included road and settlement distribution, forest-management boundaries and forest ownership.

Survey data and FGD information

We surveyed four villages in Ngan Son and Pac Nam districts in 2013 with a total 256 respondents-30% of the village populations-and held FGDs in communes. At each meeting, we presented a land-use map with figures of forest changes. The land-use maps showed no village boundaries because the commune is the smallest administrative unit in Viet Nam. Village heads delineated their villages' boundaries on the maps during the FGDs. Village boundaries are important for understanding what occurs on each plot of forestland. Through the FGDs, the impact on reforestation, afforestation and deforestation of forest policies and support programs, and village accessibility (road network and quality to the village and distance from the village to the district capital), were better understood.

Secondary data

To further understand the causes of forest changes in Bac Kan, we reviewed forestry policies and laws promulgated since the 1990s. Relevant information on forest fires, illegal logging, forest conversions, forestland allocation status, and forest protection were also generated. These data made it possible to analyse the relationships between the forest-cover changes, the identified factors and the political, social, and economic conditions of the province over two decades.

4. Results

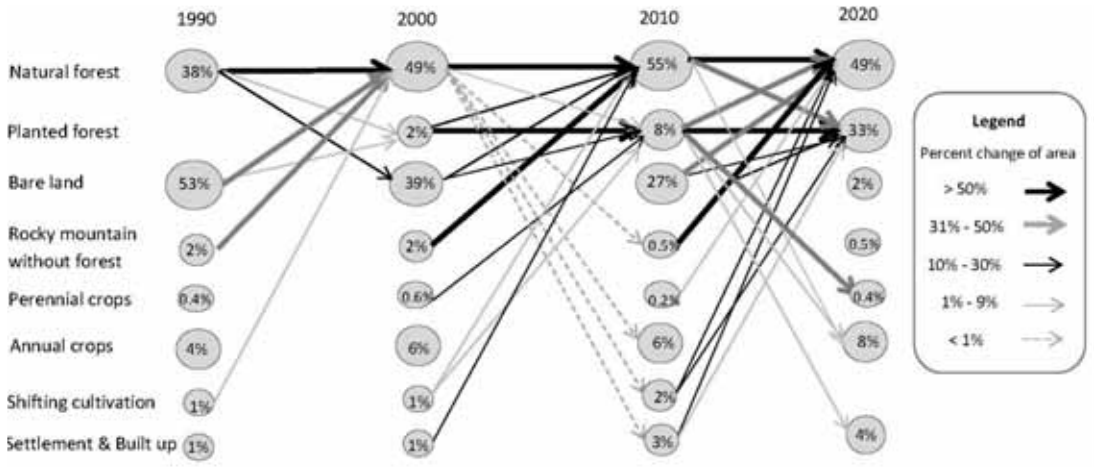


Figure 4. Pathways of land-use changes in Bac Kan Province, 1990-2020

Figure 4 shows the pathways of forest changes in Bac Kan over the 30 years between 1990 and 2020 as a result of overlaying land-use maps of 1990, 2000, 2010 and the land-use planning map toward 2020. There was little change over the period 1990–2000. Natural forest, which accounted for 38% of the total area of the province, increased rapidly, reaching 49% in 2000. Primary trends during that time included 1) the growth of natural forest by regeneration from existing natural forest and bare land; 2) planted forest increased by gaining 2% from natural forest and 2% from bare land; 3) forest was lost through conversion to bare land.

By 2000, the majority of land use was natural forest, 48%, and bare land, 39%. Planted forest accounted for only 2% and tree-based, or agroforestry, land was 1%.

After 10 years, natural forest had increased to 55%, of which 88% was existing natural forest and from 26% of bare land and 7% of rocky mountain, respectively. Those conversions represented regeneration of natural forest. Simultaneously, 3% of natural forest was converted to other land-use types, such as shifting cultivation. Projections until 2020 showed that 31% of the natural forest area of 2010 will have been converted to planted forest and less than 1% to agricultural, settlement and infrastructural land. Only 63% of natural forest from 2010 will remain after ten years.

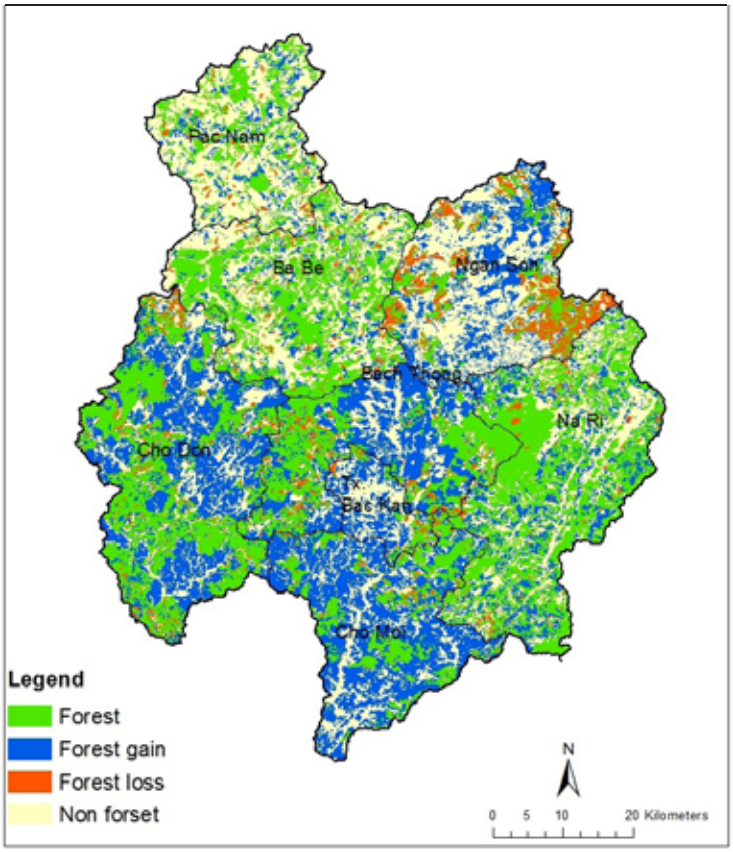
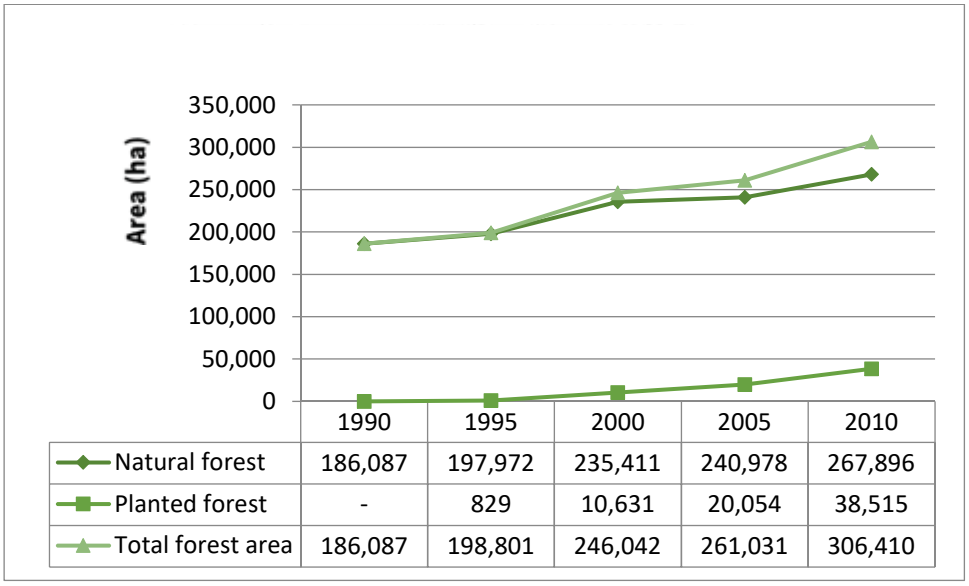


Figure 5. Spatial distribution of forest changes in Bac Kan, 1990-2010



	1990	1995	2000	2005	2010
Natural forest	186,087	197,972	235,411	240,978	267,896
Planted forest	-	829	10,631	20,054	38,515
Total forest area	186,087	198,801	246,042	261,031	306,410

Figure 6. Forest transition in Bac Kan, 1990-2010

Figure 5 shows the spatial distribution of forest-cover changes in Bac Kan from 1990 to 2010. Results of spatial analyses of land-cover data showed remarkable changes over 20 years. Forest cover in Bac Kan increased significantly by approximately 120,000 hectares, accounting for 65% of the province's land area in 1990. Of the two forest types, planted forest changed the most dramatically, with a staggering increase from almost nothing in 1990 to 38,537 hectares in 2010. Simultaneously, natural forest grew by 44 % from its total area in 1990 (see Figure 6). It is notable, however, that while there was a dramatic increase in area, forest quality fluctuated.

Changes in high and low carbon-stock forests

To assess the change in quality of forests in Bac Kan, those that had above 150 m^3 per hectare average standing volume were categorized as high carbon stock and, therefore, good quality from a carbon perspective; lower than this average were considered to be of poorer quality. The carbon values of each forest type can be found in the report of the forest inventory project carried out by the Japan International Cooperation Agency and the Forest Inventory and Planning Institute. Figure 7(a) shows that between 1990 and 2000 there was a substantial decline of 1) high carbon-stock (defined as rich or medium) timber forests; and 2) forests on rocky mountains. After 2000, high carbon-stock forests experienced a recovery and increased to the original area of 1990. There was a contradictory trend in low carbon-stock forests. These included poor-quality timber, bamboo, mixed bamboo with timber, and recovered timber forest types. Recovered forest was defined as young secondary forest that naturally regenerated from bare land in forest areas. It can be seen from Figure 7(b) that the area of low carbon-stock natural forests, except for recovered timber forests, fluctuated around 1990. By 1995, the area of poor-quality timber forests had almost doubled from 1990 but gradually decreased in subsequent years. However, recovered timber forests increased significantly from 57,251 hectares in 1995 through 134,546 in 2000 to 151,387 in 2010.

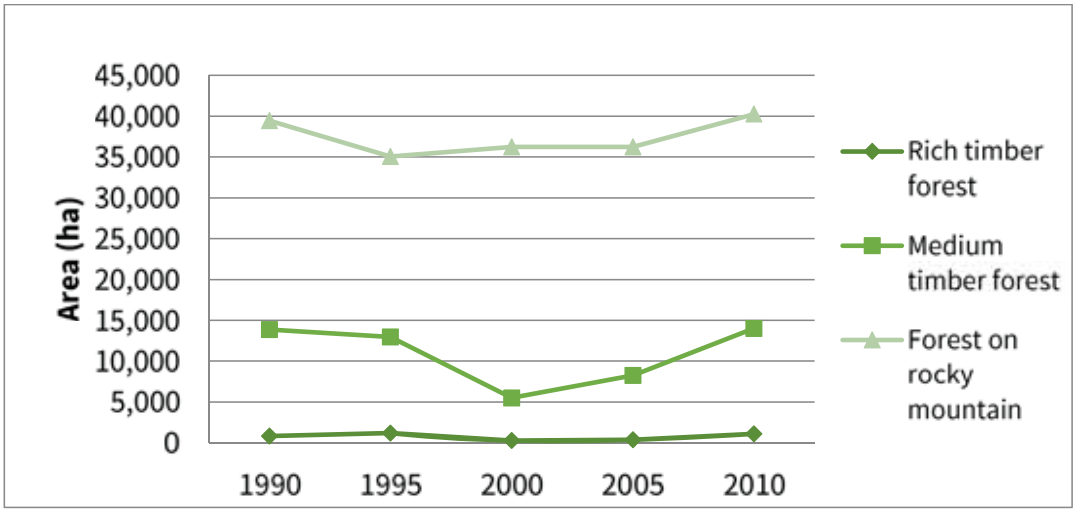


Figure 7 (a). Changes in high carbon-stock natural forests in Bac Kan, 1990–2010

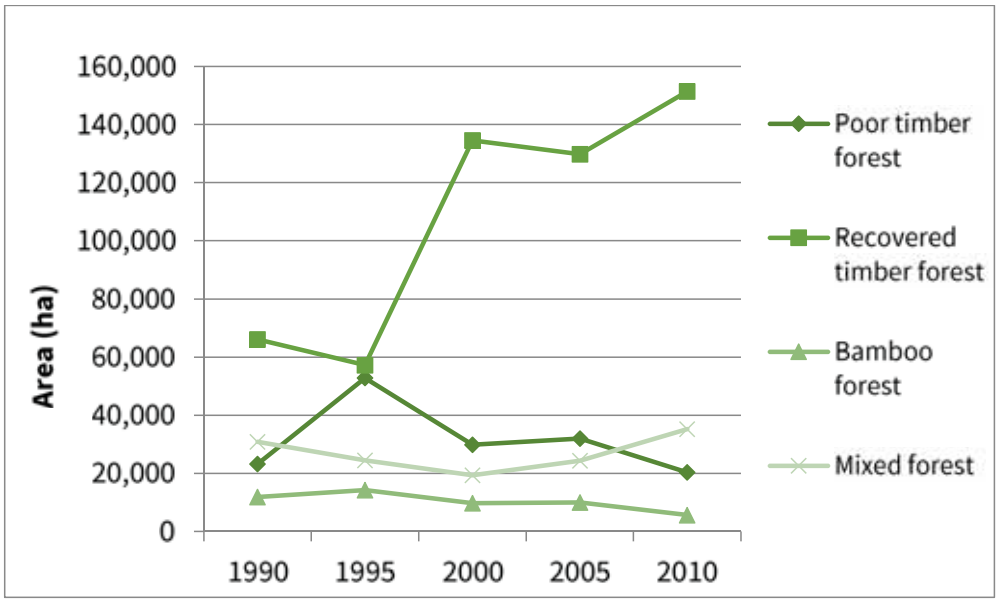


Figure 7 (b). Changes in low carbon-stock natural forests in Bac Kan, 1990–2010

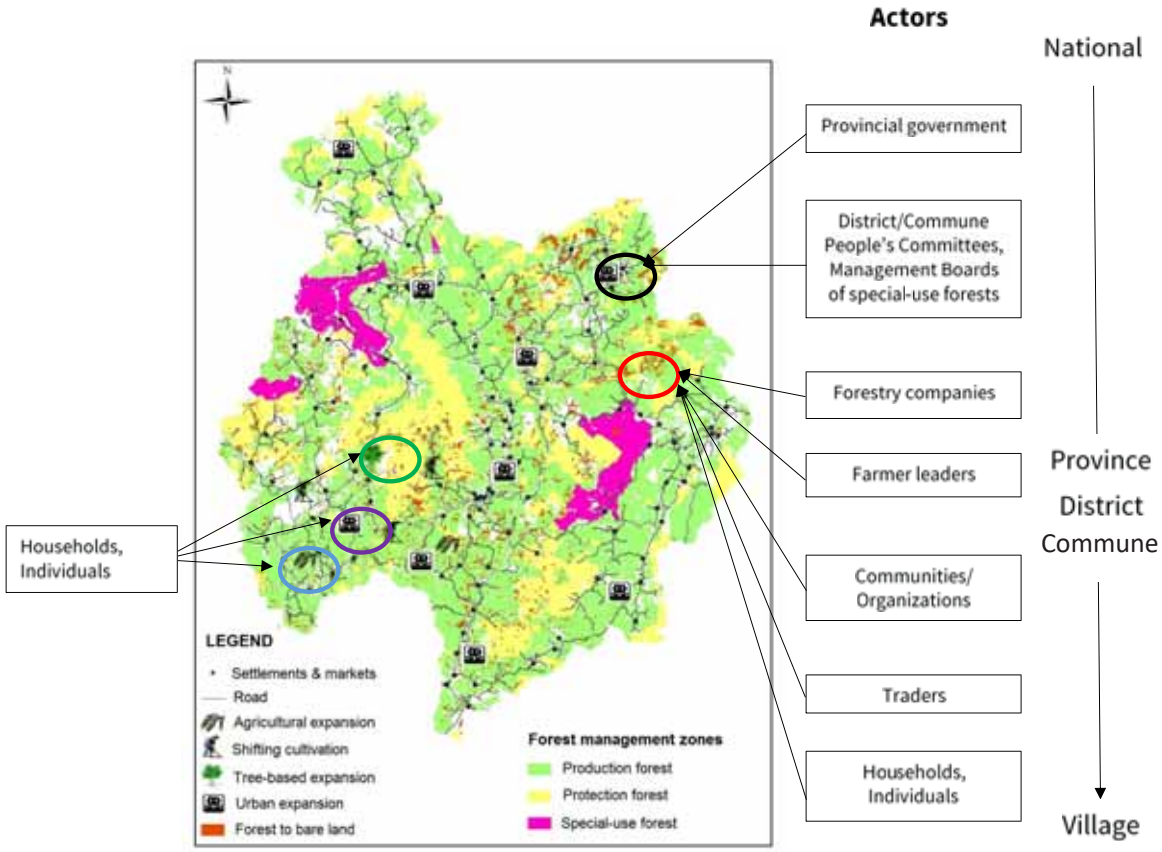


Figure 8. Spatial distribution of deforestation during 2000-2010, its proximate drivers and actors

According to Nguyen (2009), there were eight major groups involved in forest activities. During FGDs in communes, we verified those groups with farmers and categorised generally, as shown in Figure 8. The majority of lost forest area was from natural and production forests. The conversions listed in Table 2 include direct drivers and related actors as found during the spatial analysis and FGDs. The most dominant trend was abandonment of forest land or conversion from forest to bare land, which accounted for 94% of the deforested area. The conversions from forest to bare land occurred primarily in easy-to-access forest areas near roads, settlements or markets.

Second, the area of forest converted to agricultural land was 168 hectares, 0.8% of the deforested area; and to shifting cultivation 246 hectares or 1.1%. These conversions were caused by agricultural expansion to meet demand for food, indicating that the underlying factor was the growth of population in the province. According to the FGDs, farmers had converted poor-quality forest to upland rice or other annual crops long before the conversions were recorded by the provincial government. Further, the demand for settlements and infrastructure had been increasing, which led to conversion of forest land for these purposes as per land-use plans responding to the pressure of a growing population.

Table 2. Proximate drivers and actors of deforestation

No.	Conversion	Area (ha)	%	Drivers	Actors
1	Forest to agriculture	168	0.7	Agricultural expansion, population increase	Households, provincial/ district people's committees
2	Forest to infrastructure and built-up area	152	0.7	Urban expansion, land-use planning, population increase	Provincial/district people's committees
3	Forest to settlement	551	2.5		
4	Forest to rocky mountain	106	0.5	Natural factors	
5	Forest to bare land with scattered trees	20,997	94.3	Illegal logging, legal concessions, natural deforestation, conversion of natural forest to planted forest, timber market demand	Households, traders, timber companies
6	Forest to shifting cultivation	246	1.1	Traditional cultivation, economic benefits	Households
7	Forest to tree-based/agroforestry	36	0.2	Economic benefits, timber market demand	Households
Total deforested area:		22,259 ha			

Underlying factors

The conversion of forests to bare land with scattered trees was the most significant process, accounting for 94.3% of the deforested area. This process was partially clarified through surveys and statistical analysis (Pearson correlation and multiple regression) to determine the underlying causes. The regression model showed that the area of natural forest converted to plantation forests and annual crops under Program 147 strongly explained the change in natural forests (Table 3). A p value less than 0.001 indicates that the variable has a significant influence to the decrease of natural forest.

Table 3. Underlying factors of deforestation (n = 42)

Variables	Decrease in natural forest	p value
The area of poor-quality natural forest and agroforestry converted to plantation forest and annual crops under Program 147	1.11	<0.001
Household size in 2000	0.112	>0.05
Constant	-0.531	
R^2 adj	0.373	

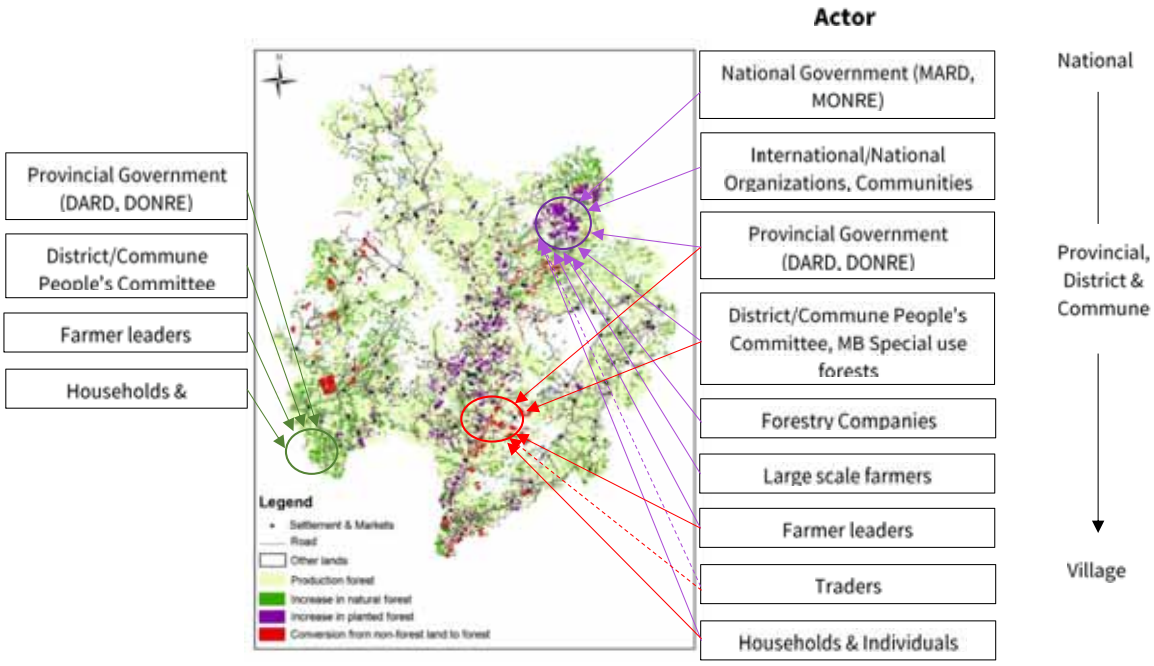


Figure 9. Spatial distribution of reforestation and actors in Bac Kan province, 2000-2010

Spatial distribution of reforestation and actors

The amount of forest cover in Bac Kan since 1990 saw a reversal of the trend compared to previous decades. The most significant period was 2000–2010. For that reason, we focused on reforestation, drivers and actors in that ten-year period.

As mentioned above, the net forest area in Bac Kan increased by 61,000 hectares while total forest area rose by 82,628 hectares, owing mainly to natural forest regrowth (60.2%) under the forest protection policies of the government (Table 4). This was a result of the reforestation programs (summarized in Table 1), which financially supported households to protect forests. Figure 9 shows that most of the naturally regenerated forests are in the production-forest category, management of which was allocated to households. Nearly 30% of the reforestation area in 2010, which was mostly production forest, was bare land in 2000 (Table 4).

Table 4. Reforestation process, drivers and actors, 2000–2010

No.	Conversion	Area (ha)	%	Drivers	Actors
1	Non-forest land to production forest	10,687	12.9	Land-use planning; policies	Government, provincial/ district/commune people's committees, households
2	Bare land (with scattered trees) to natural forest	49,780	60.2	Natural forest regrowth; land-use planning; Program 661	Provincial/district/ commune people's committees, village leaders, households
3	Bare land to planted forest	22,160	26.9	Programs 661, 147 and 135; NGO activities	Government, provincial/ district/commune people's committees, NGOS, village leaders, households
Total reforested area:		82,628 ha			

Area of planted forest and drivers

To identify the cause of the dramatic increase of planted forests in Bac Kan, we conducted household surveys in the districts of Ngan Son and Pac Nam. Pearson's correlation coefficient (Boslaugh 2012) was used to analyse the linear relationship between the increase of planted forest and other factors (Table 5). Positive value shows same trend of the increasing planted forest and factors. Among the different factors tested, the area of natural forest converted by household to plantation forest under Program 147 provided the highest contribution to the increase of planted forest. Other factors such as household income from rice negatively correlated with the areas of planted forest.

Table 5. Pearson's correlations between the increase in the area of planted forest and the drivers in Bac Kan

Variables	Pearson's R	p value
General policies		
Area of natural forests converted by households to plantation forests under Program 147	0.861	<0.001
Total land allocated to households	0.442	<0.001
Total land owned by households in 2012	0.405	<0.001
Amount of money provided by the government for planted forests since 2000	0.298	<0.001
Number of seedlings provided by the government since 2000 for planted forests	0.255	<0.001
Accessibility, physical aspects and infrastructure development		
Proximity from home to the closest urban area	-0.276	<0.01
Proximity from home to the closest tree nursery	-0.223	<0.001
Agricultural intensification		
Household income from growing rice, 2012	-0.261	<0.001
Household income from growing rice, 2000	-0.188	<0.01

Results from multiple regression analysis (Table 6) show that Program 147 was the strongest factor determining the increase of planted forests in comparison to distance from home to urban area).

Table 6. Multiple linear regression of increase in planted forests, with driving factors

Variables	Decrease in natural forest	p value
Area of poor-quality natural forests and bare land converted to planted forests under Program 147	0.831	<0.001
Proximity from home to the closest urban area	-0.053	<0.05
Constant	0.707	<0.05
R^2 adj	0.47	
N	30	

Forest transition trend

Several transitions occurred simultaneously in Bac Kan during the study period: reforestation, deforestation, and forest degradation. Forest degradation was represented by the change in area of high carbon-stock forests. Between 1990 and 2000, forest quality and area had opposite trends. While forest area was increasing, forest quality declined. During the following ten years, the trend reversed, with forest quality recovering remarkably since 2000 and the forest area continuing to grow steadily. Both forest quality and forest area were planned to maintain the same trend until 2020 (Figure 10).

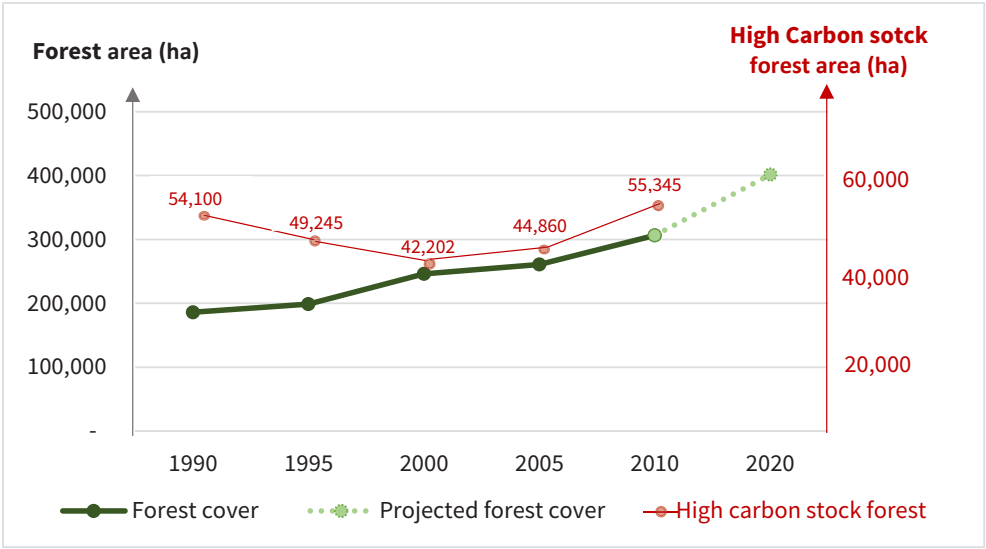
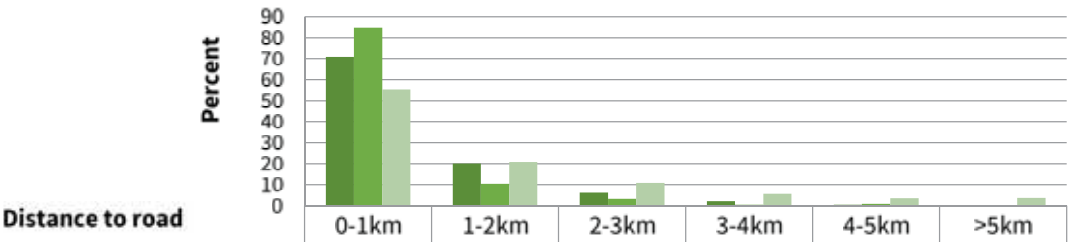


Figure 10. Forest transition curves in Bac Kan

Forest cover change and accessibility

The results of FGDs at a provincial workshop in Bac Kan showed that forest-land allocation played an important role in protection by prohibiting use of forests for shifting cultivation, illegal logging, and plantations. The more land that was allocated to households, timber enterprises and organizations, the more natural forests were protected and new plantations were planted. Households' perceptions about forest protection had an impact on forest-cover changes as well. From 1990 until the present, farmers' knowledge and information about forests, carbon, climate change, and markets have been improving through the reforestation programs of the government and other organizations. Accessibility to forest plots had a high ranking with participants of the provincial workshop when they were asked to choose the most important factors. To examine the relationship between accessibility, reforestation and deforestation, a forest-changes map was combined with roads and settlements' maps. A strong correlation between accessibility and changes is presented in Figure 11.



Distance to road	0-1km	1-2km	2-3km	3-4km	4-5km	>5km
Reforestation	71	20	6	2	1	0
Natural forest conversion	85	10	3	0	1	0
Deforestation	55	21	11	6	4	4

Figure 11. Forest changes by accessibility in Bac Kan, 1990–2010

Policy-makers' perspective on drivers of forest change

During the provincial workshop, the drivers of forest gain and loss over 20 years were examined and evaluated. The participants were asked to choose the five most important drivers and score them from 1 to 5, with 1 indicating the most importance. Table 7 shows the results. Only three factors of deforestation were picked and the most important one was shifting cultivation before 2000, owing to poor economic conditions. Forest gain, including afforestation and reforestation, was driven by the reforestation programs from 1994 until the present. Factors receiving equally high rankings are demarcated by 1a and 1b, and 2a and 2b.

Table 7. Most important factors driving forest changes, according to policy makers

Forest loss		**Forest gain**	
Ranking	Drivers	Ranking	Drivers
1	Shifting cultivation owing to poverty and low agricultural production	1a	Financial and seedlings support from reforestation programs (327, 661 and 147; overseas development assistance)
		1b	Accessibility (distance to roads and settlements)
2	Allowance of natural forest harvest before 2000	2a	Forest development program of province and district
		2b	Farmers' knowledge increase through training and workshops
3	Weakness in forest management before 2000	3	Forest-land allocation since 1994

5. Discussion

Owing to the lack of forest-cover statistics before 1999, our results were compared with trends reported in a study conducted by the Forest Inventory and Planning Institute related to forest cover and greenhouse-gas emissions in Bac Kan in 1990, 1995, 2000, 2005 and 2010. The Institute concluded that forest volume—represented by area of medium forests, rich forests, and recovered forests—declined remarkably from 1990 to 1995. Similar to our findings, in the next decade, from 1995 to 2010, they witnessed the reversal of the trend. The areas of recovered forests, including planted forests, increased dramatically.

Our study indicates that deforestation and degradation of natural forests between 1990 and 2000 were mainly caused by shifting cultivation and illegal logging. Based on their study in Bac Kan province, Castella et al. (2002) reported similar results that farmers were among the actors, and they claimed that the farmers in the province were actually conscious of the need for forest protection, and they were aware on the rapid deforestation and forest degradation that occurred in their area along with potential risk to their livelihood. The farmers also witnessed a declining abundance of forest wildlife that was important part of their livelihood. Thanks to the implementation of land allocation policy, farmers claimed that they could now protect their lands including from forest degradation and resource deterioration caused by other forest dwellers, and they felt more secure in cultivating the lands, including under the

support of forest plantation programs.

In Bac Kan province, above all other factors and under the period of analysis, government reforestation programs such as 327, 661 and 147, or forest-development policies were the most important factors resulting in forest protection and plantation expansion in the province. Thanks to these, naturally regenerated forest contributed to 60% of the total reforested area. As indicated by local people, governmental project management units at the local level provided technical support to farmers on trees and plantations and, therefore, facilitated planting by households and improved their knowledge of the role of forest protection and development.

The reversal trend from forest loss to regrowth took place generally in the country from 1990s due to the major changes in environmental and socio-economic policy (Cochard et al 2017). There has been a disparity, however, among regions in the trend of forest transition curve. For example, Cochard et al 2017 who studied changes of forest cover that took place in Viet Nam between 1993 and 2013, reported that, especially between 1993 and 2003, reforestation was clearly apparent in northern mountainous areas, while deforestation continued to prevail in the Central Highlands and Southeast region of the country. The authors claimed that the continuing deforestation in the Central Highlands and Southeast region was particularly driven by an expansion of commercial crops such as coffee and rubber plantation, along with immigration and population growth.

A similar pattern of forest policies with afforestation campaigns and devolution of forest land-use right was also found in many tropical countries (Clement and Amezaga 2009). This resulted in a trend of reforestation led by smallholder households and particularly apparent in some countries of the Asia-Pacific region particularly Viet Nam and China (Sandewall et al 2010) that have similar reforestation policy. For Viet Nam's case, based on the reports from FAO (2005, 2006) and MARD (2006), Sandewall et al (2010) stated that the annual increase in area of productive forest plantation in the country reached 5% between 1990 and 2005, and there had been a substantial increase of farm-based plantations.

The trend of forest regrowth in the country has continued in the 2010s. For example, the General Directorate of Forestry reported that forest encroachment had decreased by 9 percent between 2015 and 2016; and by 2016, up to 222,000 hectares of forestland had been afforested and 58 million trees planted in different areas. The country's target is forest coverage of about 42 percent by 2020, both for production and protection purposes.

The strategy of developing smallholder's forest plantation as part of forest protection program, is also apparent in the Viet Nam's 2006–2020 National Forest Protection and Development Strategy that has formulated targeted contribution from smallholders' forest plantations in different regions, including the northern mountainous areas like Bac Kan province. In addition to forest protection's purpose, the Strategy targets contribution from productive forest plantations to meet national demand for materials such as paper, woodchips, pit props, and furniture.

The success in promoting sustainable smallholder's forest plantation along with the protection of natural forests will move Bac Kan province further along the forest transition curve, as expected to take place in a pilot province of REDD+. Do and Mulia (2018) emphasized however that smallholder farmers generally have to face constraints in tree planting either in 'input', 'knowledge', or 'output' domain. For the 'knowledge' domain, lack of knowledge in tree management practice was still found in Bac Kan province, including to tree species promoted by afforestation programs. Therefore, the targeted contribution from smallholder's forest plantations should be accompanied by improvement in extension service, especially in mountainous and remote areas like

many of communes in Bac Kan province. Furthermore, while the province targets 82% of forest coverage by 2020, it's important to reconcile the forest protection and livelihood purpose. The study presented in the next chapter (Chapter 3) explored different alternative systems of acacia forest plantation that can potentially provide higher carbon stock as an ecological objective without compromising farmer's livelihood.

6. Conclusion

Analyses show that deforestation and degradation of natural forests between 1990 and 2000 were caused by shifting cultivation followed by illegal logging. In the next period, the main causes were conversion from poor-quality natural forests to planted forests under Program 147 and to agriculture, settlements and other land-use types. While Program 147 was the driving factor behind the loss of natural forests, it was also one of the main reforestation programs during 1990–2010. Thanks to financial and seedlings support from reforestation programs, planted forests rapidly increased from 2% of total land area in 1990 to 27% in 2010. Forest-land allocation was also one of the driving factors of reforestation in Bac Kan.

The spatial analysis of historical and planning maps found that planted forest is continuing to increase and that the area of forest cover for the whole province will reach 75% by 2020. In this context, development activities should place greater focus on farmers' livelihoods. Not all forest conversion is bad. If natural forests provide little economic value and their carbon stock is typically less than planted forests, it is recommended they be transformed. Approximately 4,000 hectares of rich- and medium-timber forests will be allocated to households under forestry plans. These types of forests—which 2020 are the core of natural forests—located near roads, markets and settlements are 'vulnerable' because they are easily encroached upon for conversion to planted forests. On the other hand, the results of overlaying a forest-ownership map of 2010 with land-cover maps from 2010–2020 show that around 49% of forest gain and loss was, and will likely be, on land owned by households and individuals. Around 45% of this is under the management of district and provincial people's committees. Thus, individuals, households and the committees are likely to continue to be the most important actors making changes to forests in Bac Kan in the next 10-year period.

This chapter provides understanding of what caused changes to forests in terms of both quality and area in Bac Kan over 20 years and provides a projection for the next 10 years. The results support the hypothesis that changes to forests are dependent on time and spatial location. Drivers of changes are temporal and they change accordingly at certain periods of time. Prediction of the trend is possible but drivers in the future might be different from those in the past. Government policies and programs are always the most important and leading factor. Our research results could be improved by using high-resolution satellite images to examine changes to forests, especially quality. Moreover, the drivers and actors of the processes were identified but the correlation among the factors is the limit of this study. The next challenge will be to determine the impact of each factor on the others as well as livelihoods' options that can maintain a balance between environmental and economic benefits for the sustainable development of the province.

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