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Land Cover Changes and Resource Use Patterns of Selected Communities in Phou Phanang National Protected Area, Sangthong District, Vientiane Capital, Lao PDR

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ABSTRACT

The study determined the relationship of land cover changes and resource use patterns from 1989-2011 of the selected three villages in the Phou Phanang National Protected Area (PPNPA) located in Sangthong District, Vientiane Capital, Lao PDR. It adopted the concept of co-evolution of the communities and the ecosystem for its framework. It is a process in which human communities with their social-system exert selective pressure on the natural-resource base and biodiversity of a given ecosystem and how the resulting changes and alterations within this ecosystem in turnexerts pressure over the given community in terms of the quality of livelihood.

The study had shown the positive relationship between population growth rate and land cover change. The positive population growth rate was attributed more on voluntary resettlement induced by the economic opportunities brought about by the government support to lowland agricultural intensification. This condition contributed to decline of the communities' dependence on forest resources. Without the corresponding technical expertise and budget, the national government failed to regulate resource access in the area resulting to widespread illegal occupation and resource extraction. The result had enumerated six recommendations that may contribute to the development of the management strategies for the conservation of Phou Phanang National Protected Areas.

Key words: *land cover, resource use pattern, community*

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INTRODUCTION

There is no doubt that forest provides the raw materials for the economic and livelihood activities around the world. It also plays a very significant role in mitigating the numerous effect of climate change by sequestering amount of carbon in the atmosphere to prevent or minimize the effects of climate change such as high temperature and flood.

However, some of the factors that contribute to loss of forest land cover include increasing demand for agricultural land, unsustainable logging, and inefficient soil conservation and urbanization process. The same driving forces have been attributed to the deforestation and forest degradation in Lao People's Democratic Republic (Lao PDR). The country is generally rural with the beginnings of a rural-to-urban shift, primarily attributable to the resettlement of villagers from the highlands to lowland areas. The resettlement policy has also brought with it challenges not only to the culture of the villagers but also to the stability of the environment. The unfamiliarity with, and lack of preparation in this new farming environment, combined with prohibition to access forest resources, has contributed to deterioration of forest land cover.

Livelihood of the communities in these resettlement areas are generally associated and dependent on the forest resources and services that are provided by the protected area. Striking the balance between production and consumption has become a major challenge in the areas of policy planning for the sustainable management of the protected areas.

In determining the long term strategies for the sustainable conservation and protection of the protected areas, the study has looked into the dynamic interrelationships that exist between spatial and temporal dimensions of land cover change and resource use pattern of those communities living in the protected area. This interaction between the people and the resources forms resource utilization patterns that could be used to determine the future state of the forest's biophysical and social environment. Thus, the study was conducted to analyze the land cover changes in Phou Phanang National (PPN) Protected Area from 1989 to 2011 in relation to resource utilization patterns of the selected communities in PPNPA Protected Area.

Considering the proximity of Phou Phanang National Protected Area to Vientiane Capital- the main entry point of tourists to the country both by air and land, the site serves as the nearest nature haven for tired metropolis folks and adventurists to enjoy the mystique beauty and serenity of the place. Likewise, its rich biodiversity resources combined with the colorful local culture may offer both good technical

and social laboratories for academic and research institutions, the National University of Laos (NUoL) in particular.

However, this strategic distance of the park from the capital city has a negative bearing on the sustainability and integrity of the natural resource-base in the long run. The increasing urbanization alongside with population growth in Vientiane Capital City poses growing demographic pressure on the nature park. This is exacerbated by the rapid transformation of the natural landscape to varied land uses, the most serious is the increasing size of concession areas for industrial forest plantation and high value crops, which in many cases have even encroached the fringes of the natural forest.

Conceptual Framework of the Study

The state or current condition of the natural and social systems is the result of their interaction with the policy and institutional environment. Natural systems is described in terms of climate, forest resources, water and soil while the social system includes population, economic activities, knowledge, awareness and perception on protected area policies. On the other hand, policy and institutional environment comprise of the regulating institutions and the policies issued (**Figure 1**).

The linkage between the natural and social systems and their components involve flows of energy, materials and information. The framework likewise suggests that these interactions determine the community's resource use patterns that may lead to the land cover and resource degradation. Understanding these interrelationships may contribute to the formulation of conservation efforts and sustainable resource management plan for the communities around the PPNPA.

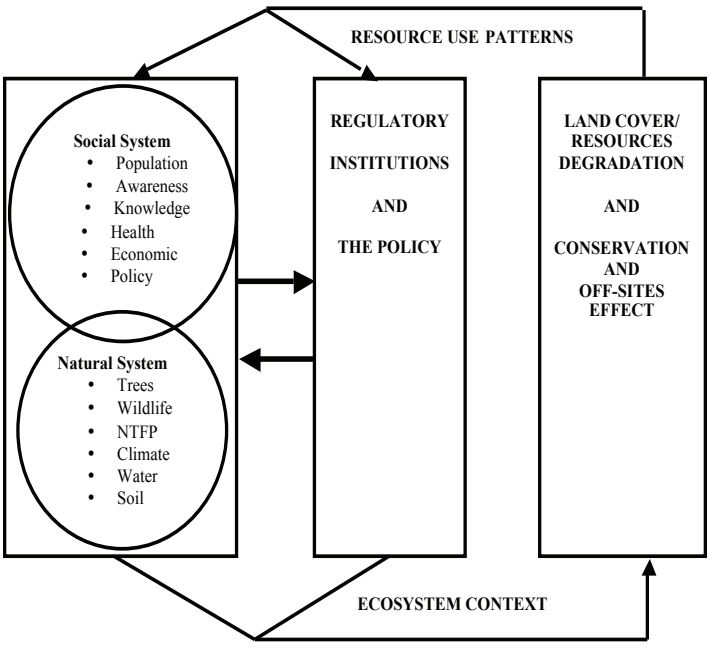

Figure 1. Conceptual framework of the study.

METHODOLOGY

Location of the Study

The study was conducted in Phou Phanang National Protected Area (PPA) which covers Vientiane Province and Vientiane Capital. It is geographically located between 18° 05' and 18° 34' N, and 102° 13' and 102° 25' E. It occupies total land area of 70,000 ha with 19 villages around the PPNPA. For the analysis of resource utilization patterns and land cover change, the study focused on three villages, namely Nahoi, Thana Sanghin and Hinlup (**Figure 2**).

The gender disaggregated population of the three villages for three period 1989, 1999 and 2011 showed that the growth rate of Thana Sanghin village is the at 0.14% from 1989 to 1999 and 0.14% from 1999 to 2011. Nahoi village registered the highest growth rate particularly during the period 1989 to 1999 at 31%. This declines to 1.55% from 1999 to 2011. Growth rate of Hinlup is 2.1% from 1989 to 1999 and 0.55% from 1999 to 2011 (**Table 1**).

Physical Characteristics of Study Area

In the 20-year period (1989-2009) monthly observation of the minimum, mean and maximum temperature, the hottest month is April. The month has the highest maximum temperature (34.6°C), highest average temperature (29.5°C) and highest minimum temperature (24.5°C). The coldest month in the area is December having the lowest maximum temperature (28.6°C) lowest mean temperature (23.1°C) and minimum temperature (17.7°C).

The rainfall data from a twenty-year observation showed that the area has experience seven to ten-year cycle of wettest periods as indicated by the amount of rainfall. The twenty year observations indicated three peaks of rainfall above 2000 mm: 1992, 1999 and 2009. On the other hand, the volume of rainfall was at lowest in 1991, with less than 1,500.00 mm, to about 1,500.00 mm in 2009.

The five soil types of Phou Phanang National Protected Area comprised of clay loam, loam, loamy sand, sand and sandy loam. The dominant soil type at the middle to southern portion of the reserve is sand while the northern part is dominated by loam. Loamy sand soil type is also found in the southern portion and in some north eastern part. Small patches of sandy loam soils are located near the rivers and water bodies.

Data Collection Procedure

The present study on the analysis of the impact of resource utilization in Pho Phanang National Protected Area (PPNPA) is descriptive in nature. Respondents of the study

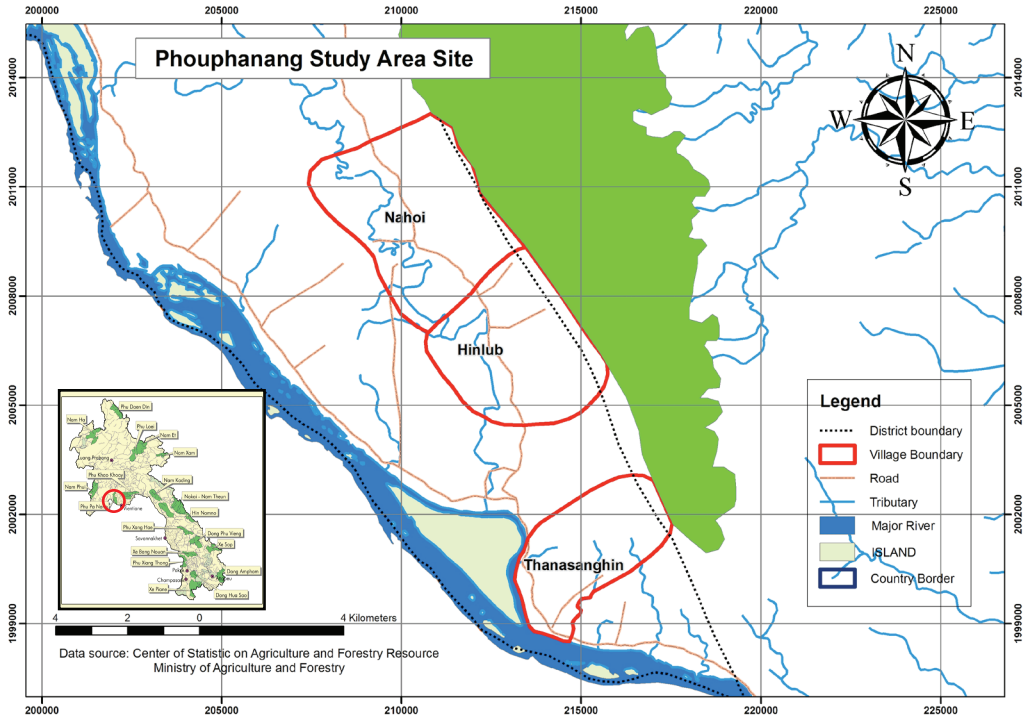

Figure 2. Map of the study areas in Phou Phanang National Protected Area, Sangthong District, Vientiane Capital, Lao PDR (Source: Center of Statistic on Agriculture and Forestry Resource Ministry of Agriculture and Forestry, 2011).

Table 1. Population of the selected villages in 1989, 1999 and 2011.

Gender	Nahoi			Thanasanghin			Hinlup		
	Year								
	1989	1999	2011	1989	1999	2011	1989	1999	2011
Men	100	340	425	169	172	176	125	185	214
Women	80	400	453	178	180	182	196	205	202
Total	180	740	878	347	352	358	321	390	416

Source: Personal Communication with the Heads of the Three Villages.

were randomly selected from three communities who relies on the natural forest resources of PPNPA. The final numbers of households were determined using Slovin's formula with desired margin of error at 0.1 or 90 % confidence level. About 43 respondents were considered from Thana Sanghin, 42 from Hinlup and 61 from Nahoi, for a total of 146 respondents. Primary and secondary data were collected. Descriptive statistics such as frequency counts, percentages, and averages were used.

The parameters covered in the study included socio-economic, bio-physical and policy/political aspects. Variables collected to describe the socio-economic aspects include population and demographic profile, source of livelihood and forest-based resource consumption pattern. Variables under bio-physical aspects included wildlife population and spatial information on various land uses. For the policy/political aspects, the variable collected included the various policy and the political agenda under the different administration. Considering the causal relationships of the interactions between variables, the study adopted the DPSIR framework to describe the interactions. The DPSIR was applied to the analysis and to show how the variables affected forest cover changes and resource consumption pattern.

RESULTS AND DISCUSSION

Socio-economic Profile of the Respondents

In the summary of the respondents' profile, about 80 to 90 percent of the respondents from the three villages are male. The average ages are 47 at Hinlup, 48 at Nahoi and 49 at Thana Sanghin. About 51% of respondents from Thana Sanghin village, and 43% from both Hinlup and Nahoi villages belong to a household with 3- 4 members, although a significant number of respondents also belong to household with 5-6 members. Likewise, majority of the respondents are also married. In terms of educational attainment, majority of the respondents (79%) from Thana Sanghin, 74% from Hinlup and 51% from Nahoi have attended only primary school. As expected, farming is the major sourceof income for almost all respondents (**Table 2**).

Extent and Patterns of Resource Use

Agriculture–Based Livelihood: Only about 19% of the respondents from Hinlup, 14% from Thana Sanghin and 5% from Nahoi Village claimed ownership over the lands they use for farming while the remaining majority of the respondents are only leasing the lands they farmed (**Table 3**). There were two types of farming system, rain-fed and irrigated farmlands (**Table 2**). Eighty-eight percent of the respondents from the village of Thana Sanghin have between 1 to 5 ha of rain-fed farm unlike in the two other villages where there are more than 6 to 15 ha of rain-fed farms.

The area for paddy farming is much smaller than the rain-fed farms. Majority of the respondents from Thana Sanghin and Nahoi villages cultivates between 1-2 ha, while some respondents from Hinlup and Nahoi cultivates between 3 to 6 ha.

Forest-Based Livelihood Resources: The study identified the major forest resources that contributed to the communities' livelihood and well-being. These are flora, water, wildlife, non-timber and fishery resources. Respondents from the three villages utilized the forest's flora for domestic consumption, energy and shelter. Few respondents claimed to use it for medicinal purposes or for trading. Water resources of the forest are used for domestic and agricultural purposes, while only few respondents from the three villages claimed that they use the water resources for fishery purposes (**Table 4**).

Majority of the respondents from the three villages used wildlife resources for domestic consumption, while about 10% to 37% claimed that they trade the wildlife for other resources, and less than 10% of the respondents sell wildlife. Similarly, majority of the respondents also use non-timber forest products for their own consumption while about 11% from Hinlup, 15% from Thana Sanghin and 27% from Nahoi villages use it for trading. Again, less than 10% admitted selling non-timber resources.

Fish resources from the water bodies inside the forest are use for their own consumption as claimed by about 88%, 70% and 61% respondents from Hinlup, Thana Sanghin and Nahoi, respectively. Less than 20% of the respondents use it for trading and less than 11% retail fish resources.

Participation in Natural Resources Conservation Activities

Majority of respondents are members of community

Table 2. Demographic profile of respondents from selected communities in 2011.

Characteristics	Nahoi		Thana Sanghin		Hinlup	
	Freq	%	Freq	%	Freq	%
Average age	48		49		47	
Gender						
Male	55	90	38	88	34	81
Female	6	10	5	12	8	19
Total	61	100	43	100	42	100
Household Size						
1-2	2	3	4	9	3	7
3-4	26	43	22	51	18	43
5-6	25	41	12	28	15	36
7-8	6	10	3	7	4	10
No answer	2	3	2	5	2	5
Total	61	100	43	100	42	100
Civil Status						
Married	59	97	33	77	37	88
Single			9	21	4	10
Divorced	2	3	1	2	1	2
Total	61	100	43	100	42	100
Educational Attainment						
Primary	31	51	34	79	31	74
Secondary	17	28	7	16	7	17
High	4	7	-	-	2	5
No answer	9	15	2	5	2	5
Total	61	100	43	100	42	100
Occupation						
Farmer	52	85	40	93	37	88
Non-farmer	9	15	3	7	5	11
Total	61	100	43	100	42	100

Table 3. Types of land ownership of the respondents in selected villages.

Characteristics	Nahoi		Thana Sanghin		Hinlup	
	Freq	%	Freq	%	Freq	%
Ownership						
Owner	3	5	6	14	8	19
Tenant	58	95	37	86	34	81
Total	61	100	43	100	42	100
Cultivated Areas						
1-5 ha	38	62	38	88	27	64
6-10 ha	12	20	1	2	6	14
11-15 ha	6	10	-	-	1	2
Non-farm	5	8	4	9	8	19
Total	61	100	43	100	42	100
Paddy Areas						
< 1 ha	1	2	4	12	1	5
1-2 ha	32	60	22	67	7	37
3-4 ha	13	25	7	21	6	32
5-6 ha	7	13	-	-	4	21
> 7 ha	-	-	-	-	1	5
Total	53	100	33	100	19	100

Table 4. Purpose of getting/utilizing of resources from the forest.

Response	Nahoi		Thana Sanghin		Hinlup	
	Freq	%	Freq	%	Freq	%
Flora resources						
Domestic consumption	59	26	40	31	39	27
energy use	59	26	37	29	34	24
Medicine	39	17	7	6	26	18
Shelter	53	24	31	24	38	27
Trading	14	6	12	9	6	4
Water resources						
Domestic consumption	58	41	40	52	39	52
Irrigation	57	40	30	39	33	44
Fishery	27	19	7	9	3	4
Wildlife resources						
Domestic consumption	52	65	23	53	27	64
Trading	20	25	16	37	4	10
Sell	8	10	4	9	2	5
Do not collect	-	-	-	-	9	21
NTFP (Leaf and vegetable)						
Food	58	62	41	76	40	87
Trading	25	27	8	15	5	11
Sell	10	11	5	9	1	2
Fish resources						
Domestic consumption	57	70	27	61	37	88
Trading	16	20	11	25	4	10
Sell	9	11	6	14	1	2

organization active in resource conservation and protection, as mentioned by 74%, 62% and 51% of the respondents from Thana Sanghin, Hinlup and Nahoi village, respectively. However, about 29% from Hinlup, 20% from Nahoi and 12 % from Thana Sanghin are not members (**Table 5**).

Village Land Characteristics (Land allocation)

Thana Sanghin village demonstrates the least or almost no significant change in the sizes of the various land uses from 1989 to 2011 (**Table 6**). This could be attributed to a very insignificant 0.14% population growth rate of the village for the twenty-year period (**Table 1**). The increase in population size did not require expansion of agricultural production area and just a minimal expansion of resettlement land. There were no data recorded for the ares of upland farm.

On the other hand, land uses in Nahoi village showed

Table 5. Membership in community organization of the three selected villages.

Response	Nahoi		Thana Sanghin		Hinlup	
	Freq	%	Freq	%	Freq	%
Yes	31	51	32	74	26	62
No	12	20	5	12	12	29
No response	18	30	6	14	4	10
Total	61	100	43	100	42	100

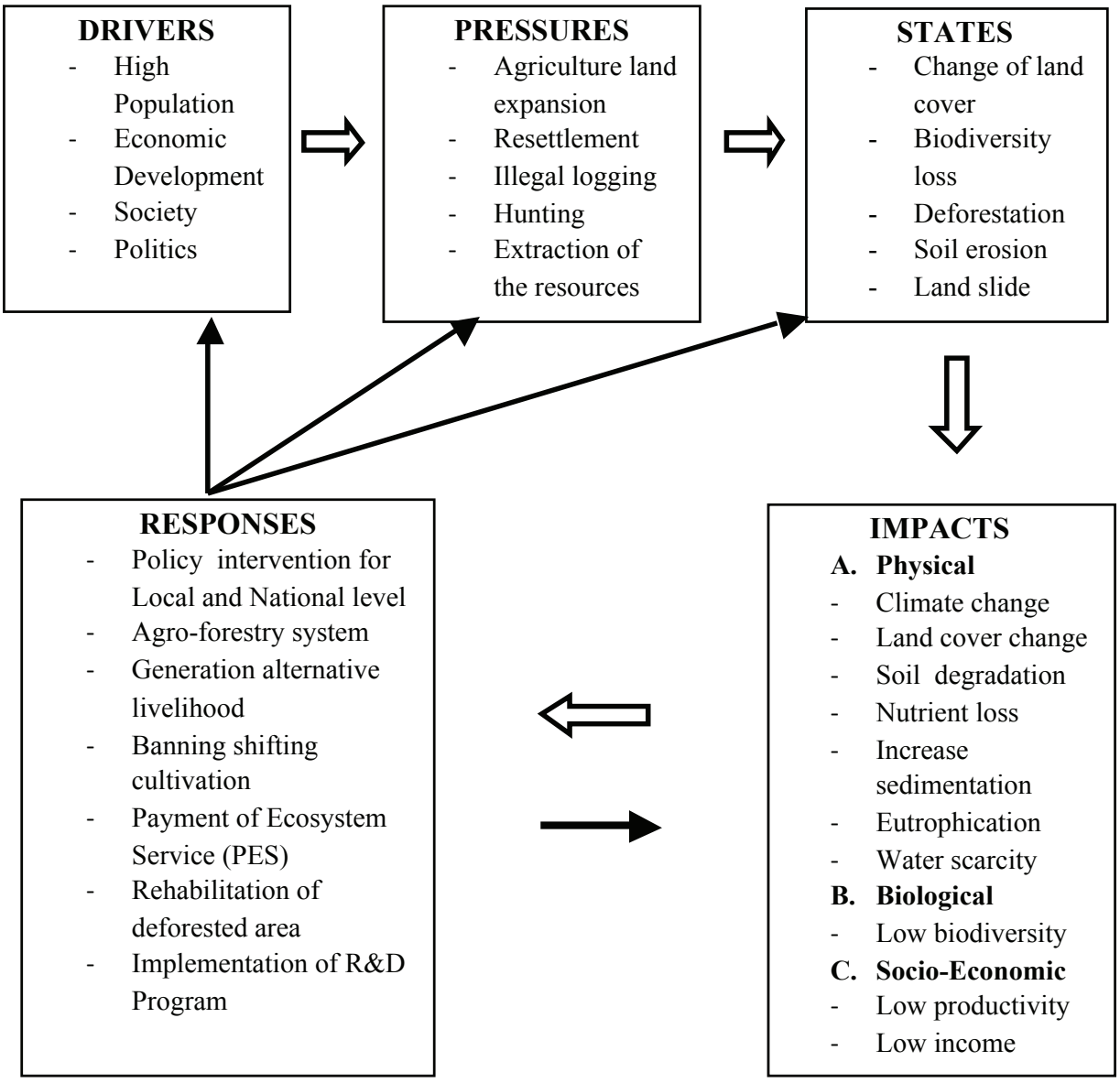

Figure 3. Analyses of land cover change and resource utilization patterns with DPSIR Model.

the most significant changes in terms of size particularly those related to food production. Area of rain-fed farms decreased by 5 ha from 1989 to 1999 and another 19 ha from 1999 to 2011, while upland cultivated paddy farms increase by 5 ha from 1989 to 1999. There was also a decrease of 2 ha in the area of garden/crop areas from 1999 to 2011. However, despite the differences of the population growth rate for the two periods (31% for 1989 to 1999 and 1.5% for 1999 to 2011), the increase in the area of the resettlement inNahoi village remains constant at 4 ha from 1989 to 1999 and another 4 ha from 1999 to 2011. Nahoi village started its tree planting activity in 1999. The tree planting area increased by 15 ha to 30 ha from 1999 to 2011. The same trend could be observed in Hinlup village particularly those related to food production and resettlement.

Application of the DPSIR framework to land cover change and resource use pattern

The DPSIR framework can be amply described through

Table 6. Land allocation in Nahoi, Thana Sanghin and Hinlup Villages from 1989 to 2011.

Gender	Nahoi			Thanasanghin			Hinlup		
	Unit (ha)								
	1989	1999	2011	1989	1999	2011	1989	1999	2011
Paddy land									
Rain-fed	160	155	136	190	180	171	50	49	44
Upland	15	20	25	-	-	-	10	12	15
Gardening (crop area)	9	7	5	80	87	91	30	25	24
Pasture land	5	3	2	50	45	35	5	4	4
Forest land (tree planted)	10	15	25	5	8	15	6	8	10
Fruit tree area	5	2	2	4	4	4	-	-	-
Settlement area	6	10	14	5	10	18	8	11	12
Fishpond	1	1	1	2	2	2	0.8	0.8	0.8
Public land	2	1	1	0.2	0.2	0.2	1	1	1
School	-	0.1	0.1	0.4	0.4	0.4	0.1	0.1	0.1
Temple	1	1	1	2	2	2	1	1	1
Total	214	214.1	214.1	338.6	338.6	338.6	111.9	111.9	111.9

the issue on forest cover changes in the selected villages (**Figure 3** and **4**). Forest cover changes occur when tracts of forest lands are converted into other uses to meet the needs of the growing population.

Driving Forces

The present study identifies the population growth as the driving force that lead to changes in the forest cover. The study attributed the population growth pattern in the study sites to both voluntary and involuntary migration. Involuntary migration was a result of the transfer of the affected population to the resettlement sites as a result of the delineation of the Phou Phanang protected area. However, the study attributed the significant increase in population particularly in Nahoi village to growing economy of the village in connection with the increasing demand for agricultural crops wherein it registered a 31% increase in population from the period 1989-1999. The demand for agricultural crops is another driving force that also contributed to the changes in forest cover. This resulted to the expansion of areas devoted to agriculture both in the upland and lowland. This is best illustrated in the changes in the sizes of areas devoted for agricultural production in the village of Nahoi.

Other driving forces that were likewise identified include the prevailing political agenda and economic policies as described under the topic on the effect of political and socio economic policies.

Pressures

Growing population coupled with the development of the agricultural sector as supported by policies and programs implemented by the government led to the expansion of agricultural areas and conversion of forest areas into food production areas. The driving forces also resulted to the modification or development of resource utilization pattern that exerted pressures to the forest resources including forest lands in the three villages. Other resource utilization pattern that also exerted pressures to the forest resources in addition to state-owned logging operations were illegal timber and non-timber extraction and wildlife poaching.

State

Changes in resource utilization pattern affected the state of the environment both in quality and quantity in relation to their functions. The immediate consequence of agricultural area expansion is the decrease and fragmentation of the area of forest lands as graphically illustrated in the various maps in **Figures 5**, **6** and **7**. The changes in the area of the five major land use from 1989 to 2010 shows the quantitative effect of the changes in resource utilization pattern as a consequence of the population growth and agricultural development (**Table 3**).

Socio-Economic and Environmental Impacts

The impact associated to the decrease and fragmentation of forest cover can be described under the following components of the environment:

Physical: Impacts under the physical component of the ecosystems include the alteration of the physical and chemical properties of the soil due to its exposure to the elements. Surface run-off removes organic matters resulting to the deterioration of the soil fertility. Turning forest soils into arable land could increase the mineralization of soil organic matter. The loss of the permanent land cover will increase the high risk of soil erosion or even landslides. Intensified soil management might also cause soil compaction. Moreover, since the amount of impervious surface increases, rainstorm runoff increase in volume, increase the risk of flooding and

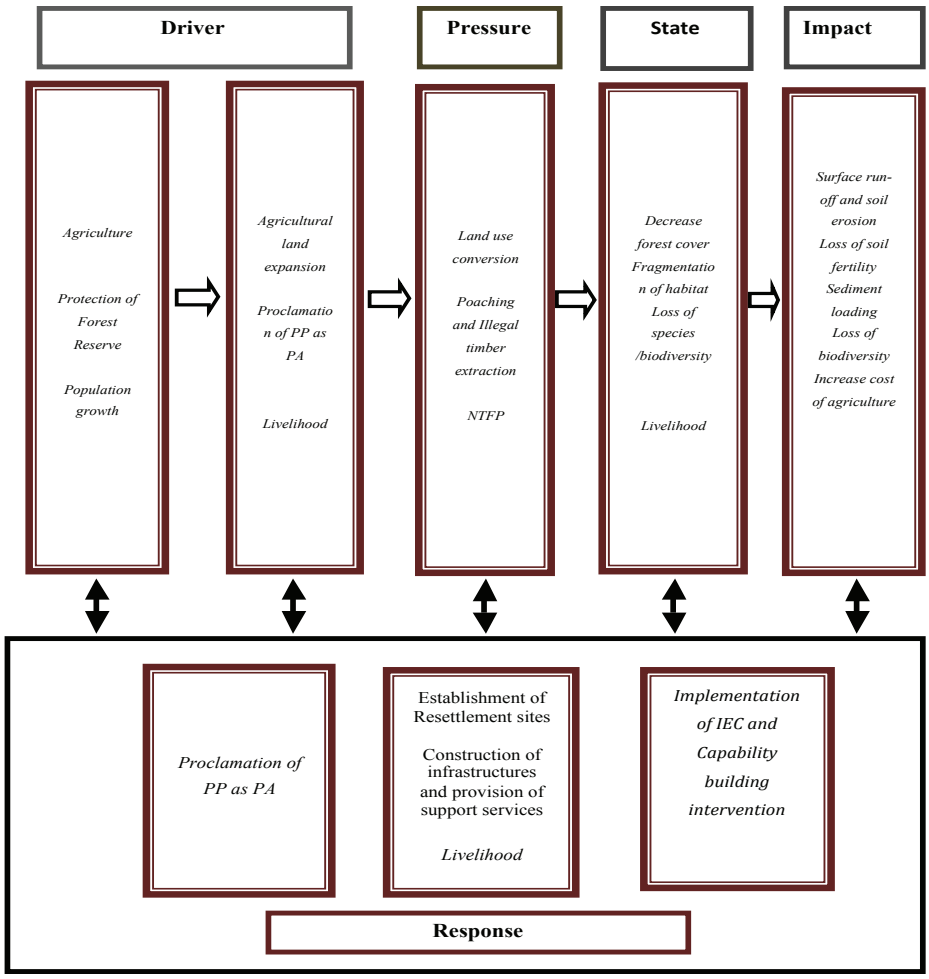

Figure 4 . DPSIR Framework of Phou Phanang Protected Areas.

also sediment loading of the streams, lakes and dams.

Biological: In addition to loss of habitat, fragmentation of habitat will also have a negatively impact on biodiversity. Fragmentation of habitat as a result of different patterns of land use as well as the various sizes and shapes of landscape will have an effect to the behavior of the wildlife. Although some species of plant and animal behave better in fragmented environment, others need large and uninterrupted areas.

Socio-economic: Socio-economic impact can be attributed to the effect of surface run-off and soil erosion on the agricultural production. The deterioration of soil fertility will require additional inputs such as fertilizers and pesticides to maintain the productivity of the area to achieve high yield. This could lead to reduce the net income of the people and also food insecurity at the regional level. This could remove opportunities for education and better health and nutrition.

Responses

The study identified several courses of actions to respond to the issues at different links of the framework. Foremost among the responses that were implemented is the declaration of the Phou phanang as one of the Protected areas. This response is to protect the area from further exploitation and rampant resource extraction.

The second response was the establishment of the resettlement area outside the protected areas and the designation of areas for the various land use requirements of the communities. This was designed to relieve pressure on the protected areas.

The third response includes the construction of infrastructures and provision of support services to the expanding agricultural production. These were aimed to shift livelihood to agricultural production to further remove dependence on forest resources.

The fourth response was the active implementation of IEC and capability building interventions to the members of the villages. These have increase the environmental awareness of the members of the communities on the importance of resource conservation and implementation of livelihood activities.

CONCLUSION

Changes in the forest cover as indicated by the

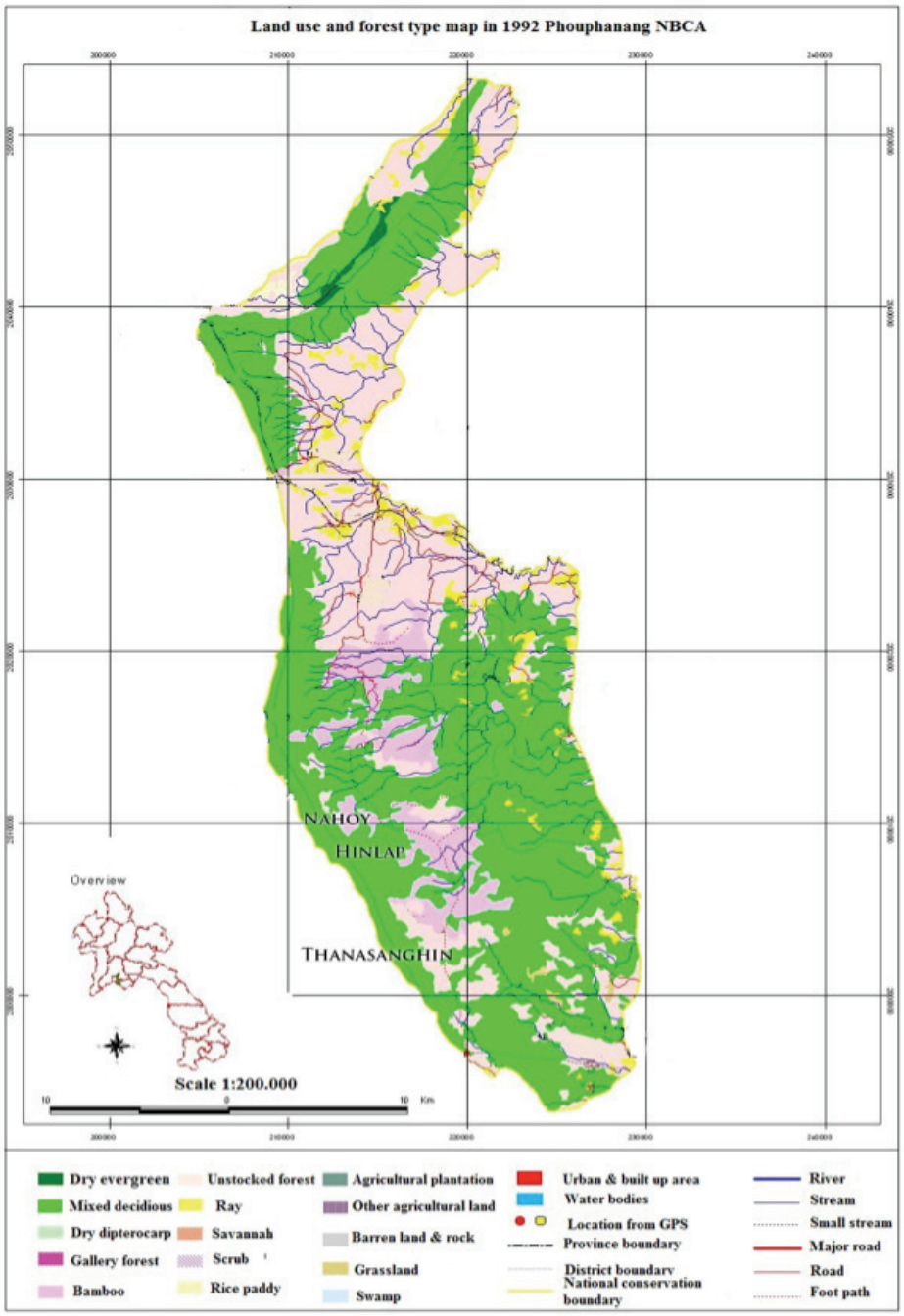

Figure 5. Land use and Forest type Map of Phou Phanang Protected Area in 1992. Source: National Geographic Department (NGD), GIS Unit, Lao, PDR. 2011.

degradation of the forest and deforestation are attributable to a complex interactions of the socio-economic, cultural and government policies. The socio-economic factors include the population growth as affected by voluntary resettlement or in-migration. Population growth, particularly in Nahoi village, could be attributed to the opportunities for economic improvement brought about by the integration of the market economy and the construction of support facilities and infrastructures for agricultural production.

RECOMMENDATIONS

To address the problem of forest degradation inside the national park, which has direct impact on biodiversity loss, the study recommends the following:

1. Organize an "on-site villagers" surveillance and monitoring team to conduct a routine patrolling with para-legal authority to arrest illegal activities inside the park;
2. Provide incentives (cash or in kind) and necessary gadgets, such as vehicles, motorbikes, flashlights, patrolling gears and other support system to "on-site" monitoring team;
3. The management (PAFO of Vientiane Capital and DAFO of Sangthong Distirct) should define and promote a strong "selling point" of the National Park to attract the business sector to invest in developing the sites as ecotourism destination;

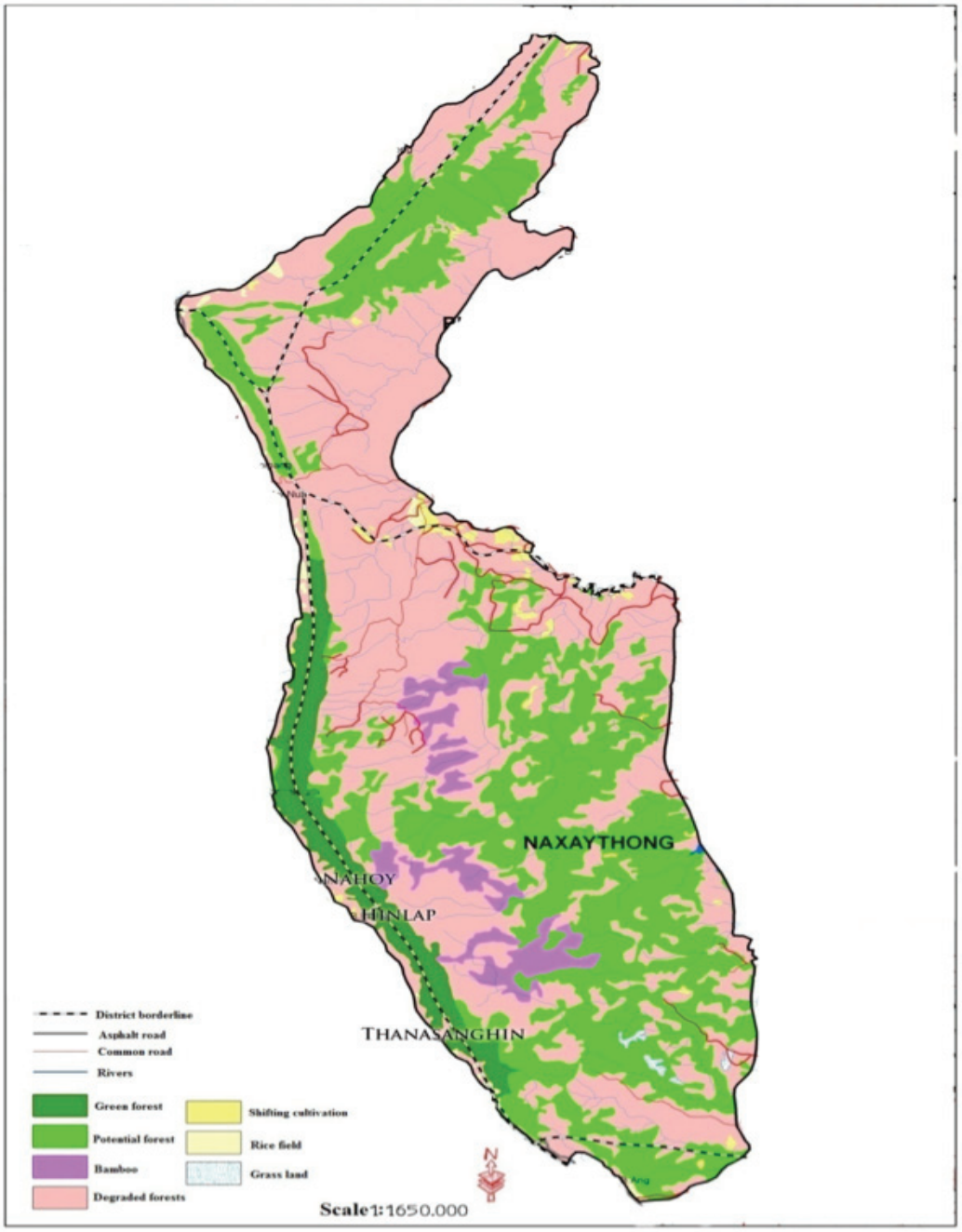

Figure 6. Land use and Forest type Map of Phou Phanang National Protected Area in 2002. Source: National Geographic Department (NGD), GIS Unit, Lao, PDR. 2011.

4. Encourage the Sangthong District Government to have "buy in" for the development of the site as tourist area in partnership with the private sector,
5. The Park Management should explore tying up with the NUoL and other research institutions for certain part of the Park to be developed as scientific and social laboratories for students and researchers; and
6. The Park Management should conduct intensive, massive and sustained public education and information campaign for the protection and conservation of the National Park.

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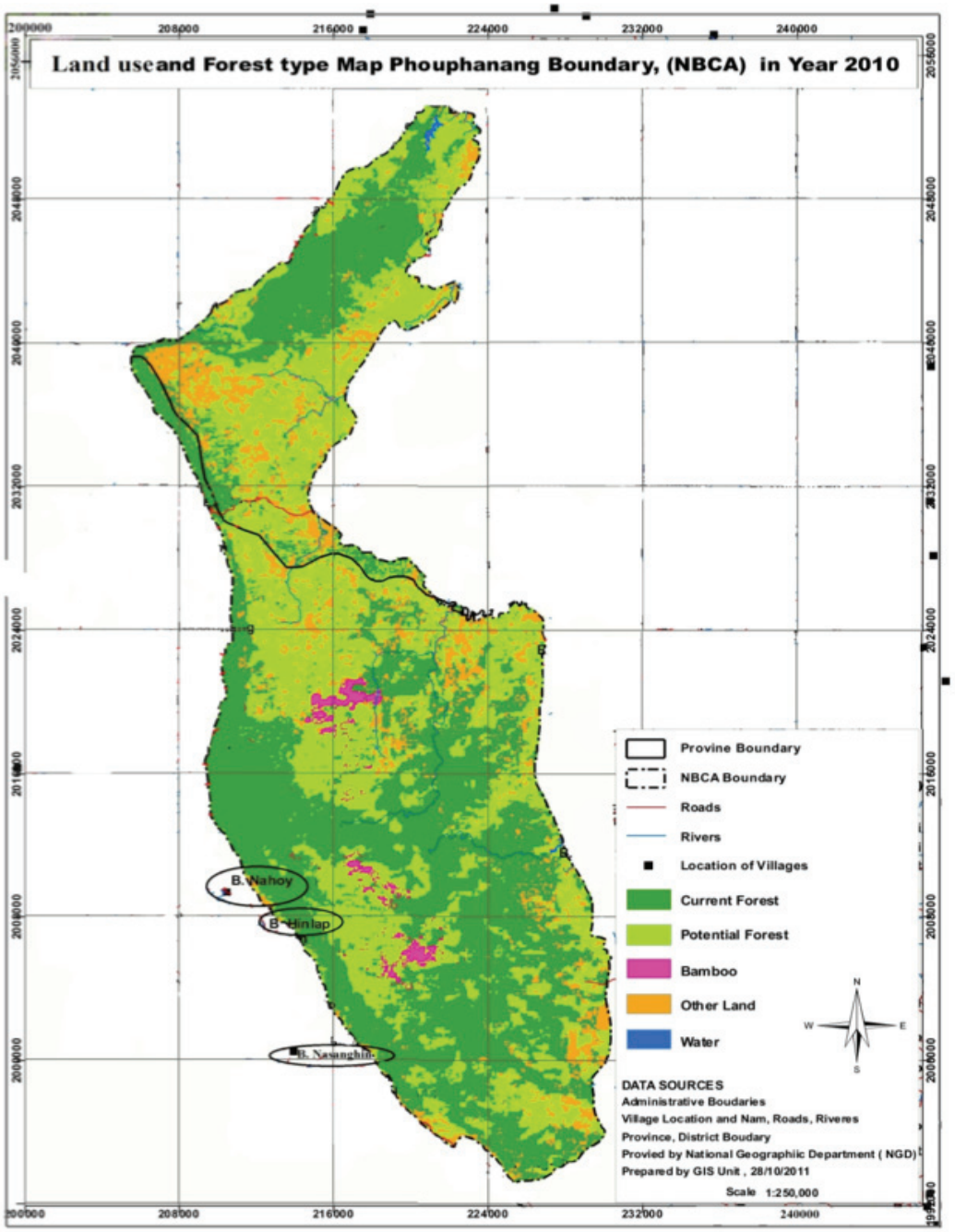

Figure 7. Land use and forest type Map of Phou Phanang National Protected Area in 2010. Source: National Geographic Department (NGD), GIS Unit, Lao, PDR. 2011.

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