Research article

Impact Assessment of Land Use Change on Ecosystem Services and Livelihood Security of Rural Highland Communities in Saysathan District, Sayaboury Province, Lao PDR

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Abstract It is widely recognized that land use changes are affecting provision of ecosystem services as well as people's livelihoods, especially in rural areas where people are highly dependent on local ecosystem services. This study developed an integrated methodological framework by combining a diversity of corresponding frameworks and concept, such as Driver-Pressure-State-Impact-Response (DPSIR), Ecosystem Services (ES), Sustainable Livelihood Framework (SLF) and Agro-Ecosystem Analysis (AEA). This integrated framework was used together with a combination of Participatory Rural Appraisal (PRA) method and spatiotemporal analysis. The objectives of this study aimed at detecting land use change and identifying its drivers; and assessing the impact on provisioning ES and livelihood security of rural highland communities in Saysathan district, Sayaboury province, Lao People's Democratic Republic (Lao PDR). Land use change analysis highlighted a large decrease in forest areas during the past decade. The reduction of forest cover was associated with significant decline of provisioning ES, and the decline in provisioning ecosystem services also influenced the state of livelihood security of the local communities, especially natural capital. By taking the trajectory of forest cover change and the importance of provisioning ES into account, it is essential for stakeholders to integrate ES indicators into land use management planning as well as socio-economic development to maximize benefits from natural resources to the communities.

Keywords land use change, ecosystem services, livelihood security, integrated methodological framework, rural highland communities, Lao PDR

INTRODUCTION

In the Lao PDR land use change has been recognized for several decades which mostly driven by related government policies, such as Land and Forest Allocation (LFA), land concession, and others (Thomas, 2003; Saphangthong and Kono, 2009; Baird, 2010). Consequences of land use change have resulted in degradation of natural resources i.e. changes in ecosystems causing negative impacts not only on agricultural land and livelihood but also on forest covers and long-term environmental degradation (PEI, 2012). For instance, a reduction of shifting cultivation land and shortened fallow period, increased weed population, depleted soil fertility, and reduced crop productivity as well as

labor productivity (Takahashi and Liang, 2010), and a continuous reduction of forest cover from 70% of the national land in 1940 to 64% in the 1960s, to 49.2% in 1982, to 47.1% in 1992, 41.5% in 2002 and 40.29% in 2010 (UNEP, 2001; World Bank, 2001; Bouahom, 2009; DOF, 2003; 2005; 2011).

Although impacts of land use changes have been widely studied, there is still a need to investigate drivers that have led to change in land use, and how ecosystem services (ES) and livelihood security (LS) are affected by land use change, especially at local level in rural context.

OBJECTIVE

This study aimed at (1) detecting land use change and identifying its drivers during 2005 to 2014; and (2) assessing the impacts of land use change on provisioning ecosystem services and livelihood security of local community.

METHODOLOGY

Study Site

Saysathan is a rural highland district of Sayaboury province, located in the north-central part of the Lao PDR between latitudes 19°13'12"N and 19°33'15"N and longitudes 101°11'11"E and 101°31'47"E, with elevations ranging from 324 to 2,061 meters above sea level. In order to get insight information of this area, two villages (Doykao and Paklong) with a diversity of agroecosytem and livelihood contexts (traditionally relying on shifting cultivation and natural resources as for maintaining their livelihoods; being in the transition of land use, natural resources and livelihood, and facing land use management problems; and others) were selected for this study.

Data Collection

This study developed an integrated methodological framework from various frameworks and concepts, such as DPSIR, ES, SLF and AEA, which have been effectively applied in rural research perspectives. This integrated framework was used to support the data collection process so that all activities could be conducted systematically and logically. PRA method with a series of activities, for example, key informant interview, focus group discussions (FGDs), resource mapping, livelihood analysis, historical profile, etc., and spatiotemporal analysis were also used to conceptualize, diagnose and synthesize the interconnectedness of land use change, ES and livelihood security of the local communities.

A total of thirty-three indicators of livelihood security (ten of provisioning ES, the italicized texts) were collectively developed and categorized into five main groups as follows:

- Human capital: (1) health; (2) children's school enrollment; (3) adult literacy; (4) labor availability
- Natural capital: (5) land holding size; (6) soil fertility; (7) *rice yield*; (8) *timber*; (9) *bamboo*; (10) *firewood*; (11) *broom grass*; (12) *bamboo shoots*; (13) *wild mushroom*; (14) *wild vegetables*; (15) *wildlife* (e.g. bird, rat, squirrel, etc.); (16) *aquatic species* (e.g. fish, frogs, crab, etc.)
- Financial capital: (17) household income; (18) land ownership; (29) cattle holding; (20) house quality; (21) access to credit
- Physical capital: (22) access to clean water; (23) access to road; (24) access to school; (25) access to hospital/healthcare center/dispensary; (26) access to electricity; (27) access to market; (28) access to information and communication services
- Social capital: (29) capacity of village authority; (30) community participation; (31) woman' role in village organization; (32) woman' role in household decision-making; (33) traditional worshiping

The majority of indicators were determined using critical values representing three different degrees, including 0.33, 0.66 and 1 to replace, for example, "Poor", "Average" and "Good", respectively (Muangkaew and Shivakoti, 2005). Another form of "Yes" and "No" answers, the values of 1 and 0 were used respectively. Two temporal Landsat images, including Landsat 5 Thematic Mapper (TM) and Landsat 8 Operational Land Imager/Thermal Infrared Sensor (OLI/TIRS) acquired on February of 2005 and 2014 respectively were used for land use change analysis. In addition, household survey with a total of 70 sampled households (purposively selected using on a quota sampling method), were also conducted in December, 2014.

Data Analysis

Landsat imageries were classified, analyzed and visualized using a combination of remote sensing (RS) and geographical information system (GIS) techniques. The developed indicators were standardized into the values ranged from 0 to 1 using the min and max normalization method. Ranking and scoring methods were applied to reflect the importance of indicators. The capital index values were also aggregated for the "Composite Index" which was used to imply states of livelihood security of the studied communities. The normalized and weighted data were then analyzed, and the asset pentagon (DFID, 1999) was created to visualize various aspects of livelihood assets. Finally, the aggregated capital values as well as the composite index were interpreted using the rating scale of "0-0.33", "0.34-0.66" and "0.67-1" for "Poor", "Average" and "Good" conditions, respectively.

RESULTS AND DISCUSSION

Changes in Land Use between 2005 and 2014

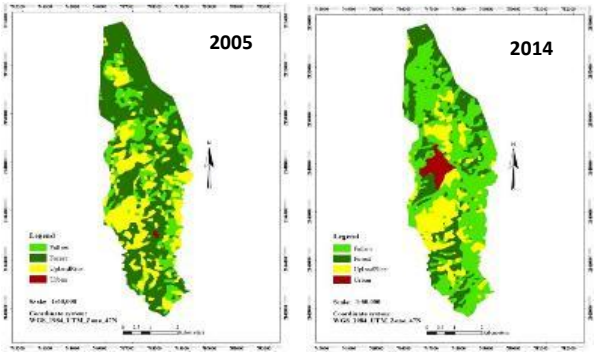

Fig. 1 Land use classification of Doykao village in 2005 and 2014

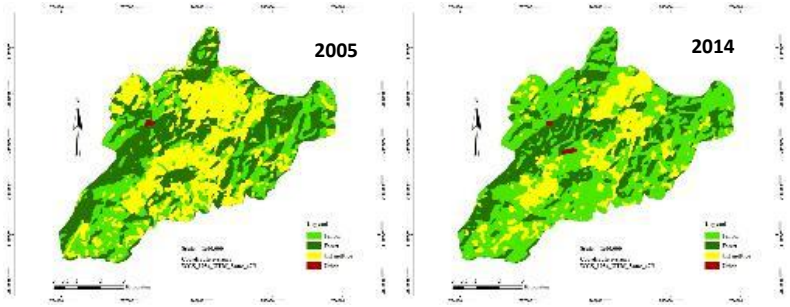

Fig. 2 Land use classification of Paklong village in 2005 and 2014

The results of this study (Tables 1 and 2) assert that, in both Doykao and Paklong villages, forest area and upland rice field were obviously decreased between the year 2005 and 2014. In contrast, the results also reveal significant increases in fallow and urban areas similarly in the two villages (Figs. 1 and 2).

The decreases in forest area are consistent with the study of Eickhoff et al., (2012) that highlights a continuous reduction of forest cover in this area. However, when considering with a reduction of upland rice field, these results seem to disagree with other findings which mostly reveal that upland rice agriculture is the major cause of deforestation. Nevertheless, the results are consistent with CPI (2005) which notes that a reduction of shifting cultivation and a decrease in forest area occurred concurrently.

In this regard, the finding from the Focus Group Discussions (FGDs) addressed that a reduction of upland rice field was mainly related to recognition of village boundary which encourages farmers to cultivate specifically in their village areas unlike years ago that anyone could farm anywhere they preferred. The decrease in forest area was associated with upland rice farming. The forest was transformed into upland rice field (at the time the upland rice area increased), then most of them was left fallow due to the land use policy particularly LFA, and the farmers had to cultivate in the limited allocated land.

Table 2 Land use change matrix for Doykao village from 2005 to 2014

From land use 2005 (ha)		Into land use 2014 (ha)				Loss into 2014 (ha)	Land use 2014 (ha)	Area net changes		Type change rate (%)
Total	2,629.26	Fallow	Forest	Upland rice	Urban			(ha)	(%)	
Fallow	524.09	402.09	2.34	110.91	8.75	122.00	1,330.11	806.02	59.11	23.28
Forest	1,388.34	571.77	615.84	167.12	34.01	772.91	670.66	-717.68	-52.63	55.67
Upland rice	712.19	356.25	52.99	248.21	54.85	463.98	530.87	-181.32	-13.30	65.15
Urban	4.64	-	-	4.64	-	4.64	97.61	92.98	6.82	100.00
Gain into 2014 (ha)		928.02	55.23	282.67	97.61	1,363.53	2,629.26			

Source: Data analysis

Table 3 Land use change matrix for Paklong village from 2005 to 2014

From land use 2005 (ha)		Into land use 2014 (ha)				Loss into 2014 (ha)	Land use 2014 (ha)	Area net changes		Type change rate (%)
Total	5,753.63	Fallow	Forest	Upland rice	Urban			(ha)	(%)	
Fallow	1,667.47	1,359.07	28.32	279.56	0.52	308.40	3,012.99	1,345.52	60.87	18.50
Forest	2,069.92	609.19	1,353.02	107.03	0.69	716.91	1,511.24	-558.69	-25.28	34.63
Upland rice	2,006.74	1,041.58	129.11	825.70	10.36	1,181.04	1,212.29	-794.45	-35.94	58.85
Urban	9.50	3.15	0.79	-	5.55	3.95	17.11	7.62	0.34	41.56
Gain into 2014 (ha)		1,653.92	158.22	386.59	11.56	2,210.30	5,753.63			

Source: Data analysis

Responses from the FGDs and the household survey (Fig. 3) indicate that these changes in land use have been primarily driven by the government's policies, increasing population and forest fire which actually caused by human's activity, specifically upland rice farming.

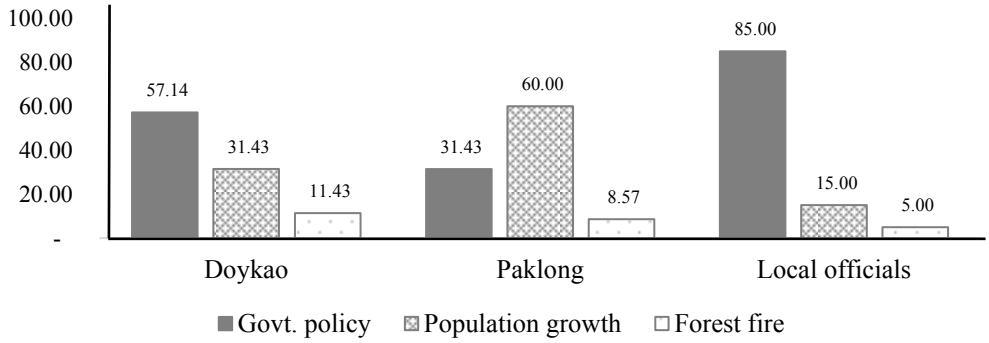

Fig. 3 Drivers of land use change in the study area given by different stakeholders

Changes in Provisioning ES and Livelihood Security

Index Values of Provisioning ES

Figure 4 illustrates an obvious decline of provisioning ES in both Doykao and Paklong villages from an overall index value of 0.921 and 0.892 in 2005 to 0.426 and 0.450 in 2014 respectively. The broom grass was considered with a slight increase only in Paklong because villagers have gradually maintained and planted this grass in their upland fields.

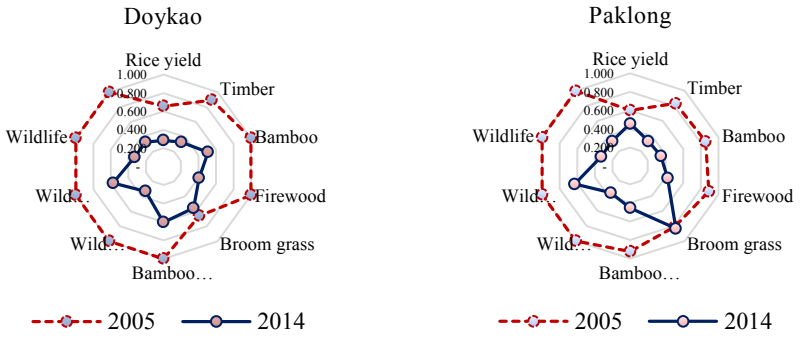

Fig. 4 Index values of provisioning ES of the selected communities

Index Values of Provisioning ES

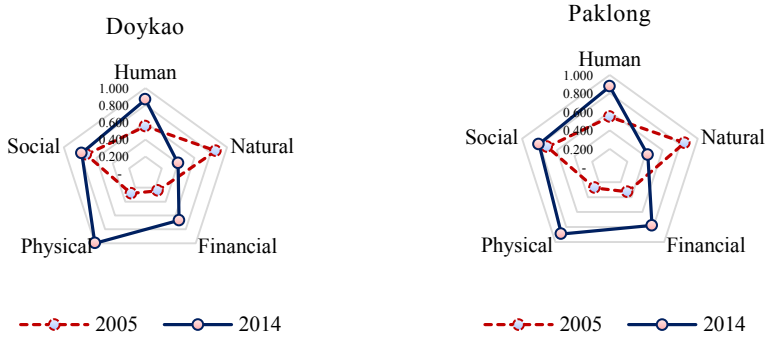

Fig. 5 Index values within five capitals of the selected communities

The results illustrated in the Figs. 4 and 5 indicate that in 2005 both studied communities had good states of natural and human capitals but poor in financial and physical accesses, while social assets were at average condition. By 2014, there were predominant increases in physical, financial and human capitals in both communities. However, natural capital was significantly decreased, while social capital was not much changed. These results reveal that the five livelihood capitals of the selected communities were changed in a similar direction.

Composite Index of Livelihood Security

Table 3 illustrates that composite indices of both villages were slightly increase from 0.567 and 0.579 in 2005 to 0.757 and 0.740 in 2014, respectively. In general, the results indicate that the condition of livelihood security of the selected communities have considerably improved from "Moderate" to "Good" during the past decade.

Table 3 Composite indices of livelihood security of the selected communities

Capitals	Doykao		Paklong	
	2005	2014	2005	2014
1) Human	0.563	0.882	0.533	0.894
2) Natural	0.779	0.357	0.737	0.394
3) Financial	0.305	0.676	0.384	0.728
4) Physical	0.367	1.000	0.510	0.942
5) Social	0.742	0.854	0.721	0.834
Composite index	0.567	0.757	0.579	0.740

Source: household survey, 2014

CONCLUSION

Results from land use change analysis and household survey reveal that land uses in both studied communities have highly changed during the past decade. The main drivers of this change were government policies together with population growth and forest fires. Land use change, specifically a decrease in forest area which is the fundamental stock of ES, has led to a dramatic degradation of provisioning ES. The decline of provisioning ES highly influenced the condition of natural capital which also contributed to an alteration of livelihood security of the local communities. Although the status of livelihood security of Doykao and Paklong villages have improved from "Moderate" to "Good", natural capitals which are mainly made of provisioning ES have dramatically declined during 2005 to 2014. By taking the trajectory of forest cover change and the importance of provisioning ES into account, it is essential for stakeholders to integrate ES indicators into land use management planning as well as socio-economic development to maximize benefits from natural resources to the communities.

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