CatchUp Program

Comprehensive Analysis of Trajectories of CHange in the Uplands

Understanding the diversity of land use change trajectories in Northern Lao PDR

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Abstract

Since the opening of Lao PDR to market economy, the agricultural sector has engaged in a rapid shift from subsistence to commercial production. In the northern uplands, this shift has translated into a diversity of local land use change trajectories. This study aims at capturing the diversity of land use dynamics and understanding their driving forces and their impact on livelihoods and forest resources. For that purpose, we conducted a meta-analysis of case studies based on a review of scientific papers and grey literature. Inspired by state of the art meta-analyses of land use change, we developed an original framework based on a limited set of first-hand case studies. We selected a series of indicators of change in agriculture, livelihoods and natural assets which were coded according to various modalities. All reviewed case studies were then described through such ordinal variables and statistical analyses were conducted in order to build a typology of case studies and capture the main driving forces for land use change. As expected, physical accessibility of the study sites constitutes the single most important factor explaining local variations in land use and livelihoods. Population density, tenure rules and ethnic diversity also play important roles. Three main development trajectories emerge from the meta-analysis: a mainstream trajectory which reflects market integration and a gradual diversification of the land uses and livelihood activities, and two alternative pathways which differentiate farm investment and land use intensification in the lowlands and in the uplands.

Key words: land use change, livelihoods, forest resources, meta-analysis, uplands, Lao PDR.

Content

I. Capturing the diversity of land use change trajectories in Northern Lao PDR

1. The need for a systematic characterization of the agrarian transition

Since the economic reforms of the late 1980s, considerable changes have occurred in Lao PDR. Agriculture, which remains the main livelihood activity in rural areas, has experienced a shift from subsistence to market orientation (Cramb et al. 2009; Schmidt-Vogt et al. 2009). This transition has led to improved socio-economic conditions but constitutes a threat to sustainable use of natural resources. In the northern uplands of Lao PDR, this trend combines with a diversity of biophysical and socio-economic environments and leads to various land use change dynamics.

The Catch-Up Project (Comprehensive Analysis of Trajectories of Changes in the Uplands, NAFRI-IRD-CIFOR) aims at capturing the diversity of these local trajectories. From 2008 to 2010, a large number of case studies have been conducted across the northern mountains of Lao PDR. They systematically included several methodological components of landscape and livelihood analysis such as agro-ecological zoning of the study site, land use and land use change maps from remote sensing data, farm household surveys, etc. These case studies cover a large range of ecosystems and development situations. Developed in partnership with local institutions, they highlight locally–specific trajectories of change and provide guidance to development interventions. However, they need to be placed in a larger, more holistic perspective in order to support the processes of decision making and policy formulation at the regional level.

Several research initiatives have been developed recently in Lao PDR with a similar goal. Relying on data collected at the village level, they attempt to draw conclusions about patterns of land use change at higher scales, up to the national level. They focus on different themes and combine different methods both qualitative and quantitative.

One example is the Socio-Economic Atlas of the Lao PDR. This Atlas presents statistical and spatial analyses of data derived from the national census conducted in 2005 at village scale. It draws conclusions on a large range of topics, including demography, agriculture, education, health, ethnicity and poverty (Messerli et al., 2008).

Rigg (2005) developed more qualitative analyses of land use change trajectories and their impact on poverty in Lao PDR. Based on a combination of first hand field data and a review of literature, his analysis focuses on poverty and its driving forces. Combining qualitative and quantitative data from case studies, he develops explanatory narratives about livelihood changes.

Based on grey literature and published papers, two BSc students from the Centre for Development and Environment (CDE) of the University of Bern developed a more quantitative approach under the supervision of Peter Messerli. In 2009, they studied the impact of two selected drivers, policy and market driving forces on changes in land use (Sonderegger and Sommer, 2010). Their meta-analysis method consisted in reviewing and coding local case studies according to the drivers mentioned, then conducting frequency analyses. From qualitative data (influence of a driver on land use changes), they obtained quantitative results.

Our study aims to complement this series of meta-analyses from a different perspective. We chose to cover a larger range of indicators of the agrarian transition, including some of the 2005 National census data and on a large set of case studies containing qualitative and quantitative data. We selected in priority research reports with first-hand data (19 case studies). Secondary data were obtained mainly from student reports who had conducted detailed investigations over long periods (from 4 months to 2 years) in a given area. Our quantitative analysis aimed at capturing the diversity of on-going trajectories of land use changes and quantifying their intensity at the scale of the northern

uplands. The research also aims to better understand the driving forces of the agrarian transition and its impact on livelihoods and forest resources.

On the longer term, the study should enable the scientific community involved in Reducing Emissions from Deforestation and Forest Degradation (REDD+):

- To better understand past trajectories of LUCC, to rank their drivers according with their relative importance at the regional level,
- To develop a reference scenario of LUCC under "business as usual" condition and to explore potential scenarios in relation with external interventions (e.g. payment for environmental services),
- To integrate heterogeneous, incomplete data sets acquired from different sources into a regional monitoring framework of land use changes

2. Overview of existing methodological frameworks for meta-analyses

A literature review was conducted prior to the development of our own methodological framework. This state of the art aimed at characterizing the existing methods and determining how the scope of the study and materials available (i.e. number and quality of case studies and secondary data) can influence the selected methods for meta-analysis. The reported methods, below, differ by many aspects: i.e. how the literature review is conducted and the case studies are selected for inclusion? Which sources of information are used to document the case studies' context? How the case studies are characterized and quantitative and qualitative data are code? What kind of statistical analyses are conducted on these attributes? We propose a categorization of the experiences reported in the literature depending on how data are managed and/or analyses performed.

Effect of a treatment: binary response

A meta-analysis of case studies aims at combining the results of a collection of independent studies, in order to integrate them at a larger scale. This approach was for the first time developed in the field of medicine; researchers attempt to know if a treatment leads to significant benefits to a certain group of patients, by combining the results of independent experiments. They respond to a binary question: effect or no-effect of the treatment and conduct frequency analyses comparing an intervention group and a control group.

Frequency analysis on drivers of change

Further methods have been developed to analyze drivers of change in socioecological systems. First, a binary approach is used to assess the existence of a particular change in a case study. Then, context attributes are characterized and statistical analyses are performed to identify the drivers of change among these attributes.

This kind of approach has been developed to analyze the impact of community resource management worldwide (Pagdee et al., 2006, Oldekop et al., 2010). Having defined success as a combination of ecological, social and economic factors, the authors coded management results as a binary outcome, namely success or failure. Their conceptual framework also includes the description of internal community attributes, such as tenure security, accessibility, local leadership, technological changes and infrastructures, as well as external factors, e.g. market conditions and financial assistance from external institutions. These attributes are coded by presence, absence or not discussed. The main drivers of success are first identified among the community attributes through frequency analysis. Then, statistical tests are performed to analyze the association between community attributes and success.

Meta-analyses of land use/cover changes (LUCC) provide a relevant methodological framework for our research. Geist and Lambin (2002, 2004); Lambin et al (2003); Rudel (2005, 2008) have conducted systematic inventory of land conversion types and their drivers in relation with desertification and deforestation processes worldwide. For instance, Geist and Lambin differentiate

between proximate causes of deforestation on one hand, such as agricultural activities, increasing aridity, infrastructure extension and wood extraction, and underlying driving forces on the other hand, e.g. climatic, technological or demographic factors. This method has also been applied in Lao PDR by Sonderegger and Sommer on two driving forces, policy and market, and in Mexico by Rudel (2008). Missehorn (2005) has applied a similar approach to the issue of food insecurity in Southern Africa. There are two steps within this method: (i) the definition of main drivers through the overview of the selected case studies and (ii) the quantification of these drivers' influence through the systematic coding of case studies and a frequency analysis.

These studies use binary data (presence/absence of a driver), then conduct frequency analysis to quantify the predominance of the element. Our study aims at describing land use change trajectories and their impacts, which cannot be simplified into binary data. Therefore, we reviewed further meta-analyses that used different methods for case studies' characterization.

Analyze of drivers of change as metric variables

Umemiya et al (2010), Azadi et al. (2010), Vedeld et al. (2004) further develop this approach by quantifying the studied process, as well as the drivers. As a result, they do not process binary data anymore, but metric variables. The authors focus respectively on deforestation, quantified through deforestation rate, agricultural land conversion (ALC) and forest dependence, assessed by the share of forest income in total income. The first two focus only on given drivers that they quantify directly (GDP growth, urban population) or through a combination of indicators (governance quality). Veldeld et al. (2004) analyze the impact of a larger range of case studies' attributes, such as household-level variables (wealth, age, ethnicity, education) and contextual factors (market access, legal frameworks, type of forest). Azadi et al. (2010) go further by differentiating the case studies into types, namely less developed, developing and developed countries.

These quantitative meta-analyses are based on metric data. However, homogenous quantitative data are rarely available in case studies selected from a literature review. Without simplifying the data into binary variables like experiences presented above, other meta-analyses create a typology of case studies based on a series of indicators and parameters that combine quantitative and qualitative data.

Typologies of case studies

Valbuena et al (2008, 2010), Erout and Castella (2004) study LUCC at farm level, building a households' typology in order to simulate farmers' decisions. They use the classification and regression trees growing method (CRT) and multivariate analysis, basing the typology on a series of qualitative information from surveys (Valbuena et al., 2008, 2010) or quantitative data (Erout and Castella, 2004). They use then different analysis methods to test the differences between agent types and analyze the relation between the different parameters.

Tallis et al. (2009), Belcher and Ruiz-Pérez (2001) focus on the drivers of processes' emergence, respectively conservation projects focusing on environmental services and forest product development. The authors use a combination of attributes to describe their case studies and classify them into a typology, using CRT method. Belcher and Ruiz-Pérez (2001) code the case studies through a set of descriptors in order to develop a matrix of attributes by cases and perform exploratory data analysis. The attributes are absolute variables of several types: nominal and categorical variables (animal or plant as source of forest product), ordinal or ranked variables, interval variables, ratio variables (i.e. ratios of two measurement variables) and trend variables (e.g. changes in income contribution).

Oldekop et al. (2010) conduct also quantitative analysis of common resources management regimes (see above) in order to reflect the data complexity. They convert continuous values into ranked data to conduct ordinal logistic regressions.

By developing typologies of case studies based on a series of indicators, quantitative and qualitative data are combined and statistical analyses are performed to understand the relations between indicators. In order to select the most appropriate indicators for our analysis, we reviewed several frameworks for analysis of livelihoods and resource management systems.

Indicators and organizing frameworks

The Sustainable Livelihood Framework (SLF) provides a logical organization of the assets necessary to achieve sustainable livelihoods (Scoones, 1998). “A livelihood comprises the capabilities, assets, and activities required for a means of living; a livelihood is deemed sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities, assets, and activities both now and in the future, while not undermining the natural resource base” (Chambers and Conway, 1992). These assets are gathered in five categories. Human capital refers to people’s skills, aptitudes, knowledge, experience, ability to labor, and good health. Natural capital encompasses natural resources, such as land, water, wildlife and biodiversity as well as the related environmental services. Financial capital includes cash-based assets, such as savings, credit, remittances, and pensions. Physical capital is human-made capital; it includes transport, shelter, water, energy, and communications. Social capital includes networks, groups, trust, mutual understanding, shared values, and access to institutions.

Elinor Ostrom has developed a predictive model of socio-ecological systems (SES) that includes many variables identified as affecting the systems. The framework aims at analyzing how attributes of a resource system (e.g., fishery, lake, grazing area), the resource units generated by that system (e.g., fish, water, fodder), the users of that system and the governance system jointly affect and are affected by interactions and resulting outcomes achieved at a particular time and place. The whole system may also affect and be affected by socioeconomic, political and ecological contexts. The framework lists a large range of variables that describe in detail each part of the system (Ostrom, 2007).

The aim of our study is to build upon this large range of meta-analysis methods in combination with other classification approaches for case studies (Castella and Erout 2002; Ostrom 2007; Valbuena et al. 2008) to understand the main trajectories of land use change in northern Laos and the drivers involved.

3. Justification of the selected meta-analysis method

Our analysis framework should be able to: (i) describe the parallel evolution of livelihood assets, agrarian systems and forest resources at village level, (ii) allow the comparison between different study sites in Northern Lao PDR and (iii) generate a database for statistical analyses. Building such a framework is challenging. First, the comparison of different areas of Northern Lao PDR relies on the multiplicity of environmental, socio-economic and cultural contexts. Therefore, we had to find a balance between a series of indicators that would allow the comparison of diverse case study sites and a range of specific indicators used to describe the diversity and the complexity of local situations. Second, this diversity of situations has been studied by different research teams with various methods and scopes of research, which leads to several kinds of data and measurements. Therefore, the selected indicators have to capture different types of information, both quantitative and qualitative, from different sources.

In order to conduct statistical analysis on this large range of data types, we decided to code them into ordinal data (Pagdee, 2006; Belcher, 2001; Oldekop et al., 2010). By using ranked data, we ran the risk to put a value judgment on case studies, and to classify them from ‘well developed case’ to ‘less developed case’ (Belcher, 2001). To avoid this, we assumed that a trajectory of land use and livelihood changes at a local level could be represented by a limited number of indicators evolving in parallel (Kasperson, 1995).

Using a series of first-hand field studies that draw contrasted pictures of land use and livelihood patterns in the northern uplands of Lao PDR as well as theoretical frameworks (Ostrom, 2007; Scoones, 1998), we selected a number of relevant indicators for comparison between case studies. For each of them, we created an index that describes various stages in an evolutionary pathway. We hypothesized that different case studies may represent different stages along the same evolutionary pathway or may characterize divergent pathways. The diversity of local trajectories can be captured by the multiple indicators included in the framework. We progressively parameterized the indexes by selecting, for each indicator, objective criteria both quantitative and qualitative that would help us categorizing a case study as representative of a given stage along the evolutionary pathway and defining thresholds between successive stages.

Our first-hand field studies were used to develop the comparative framework that would be further used to select relevant case studies from our document database. We selected research papers and consultancy reports from our project database and documented these case studies in our framework. With the resulting matrix of attributes per cases, we performed exploratory data analysis to outline patterns of changes, gradients of variability and typologies of case studies (Belcher 2001, Ruiz-Pérez 1999).

The original purpose of our meta-analysis is to describe the local trajectories of land use and livelihood changes and compare them into a common framework for analysis. Our work consisted in the following main stages: the development of a framework for analysis through the in-depth study of a limited number of first-hand documents, the selection of case studies among primary and secondary sources of data, their integration into the comparative framework and finally statistical and spatial analyses to understand the drivers of change and the distribution of local trajectories across the Northern Lao PDR.

II. A comparative framework to analyze case studies of land use changes

1. A comparative framework grounded in detailed empirical knowledge

The parameterization of the comparative framework, namely the selection of indicators and the description of their hypothetical evolution, was based on empirically grounded case studies conducted by the CatchUp program between 2007 and 2010 as well as PhD theses from partners (Appendix 1).

All these studies entail a long period of field work and include an historical dimension, participatory mapping of land use as well as land use change analysis based on time series of remote sensing data. Some of the study sites have been visited at different dates. For example, Lestrelin (2009) presents data from Ban Lak Sip and Ban Done Kang in 1990 and 2003. Both villages are roadside villages under the influence of the provincial capital. Both villages face a very high population pressure, which led to a rapid diversification: access to land is restricted for a large part of the population, due to lack of available land and a low quality. In order to meet their needs, people have oriented their livelihoods towards off-farm activities. These re-studies allow us to follow the evolution of indicators and contribute to the temporal dimension of the comparative framework. We describe these ‘first-hand’ case studies below (Figure 1).

Ban Samlang in Phongsaly district, Phongsaly province, is in 2003 a remote village where traditional farming systems and local institutions are still predominant. The landscape is composed of steep slopes and narrow valleys, with settlement near the summit and dense forest on the summit and in the valleys. The mono-ethnic village faces a large out-migration, especially from young people who move to the city to look for a job, which reduces the already low population (Ducourtieux 2006).

Ban Yapong in Phongsaly district, Phongsaly province, is a roadside village where population density has increased recently. It is located 6 km from the provincial capital. The farming systems and social organization of the village are similar to Ban Samlang. However, some differences exist. Dense forest covers a smaller area and agricultural land is fragmented. Fallow length has been reduced, which could explain the need for more labor to cultivate land and a resulting lower return to labor (Ducourtieux 2006).

Ban Huay Yen and Ban Nongdi in Xieng Ngeun district, Luang Prabang province, are located in the Nam Khan watershed. Ban Huay Yen is located near the province capital and along the road, which stimulates trade and migrations. Furthermore, tours are organized around the village, which reflects the touristic influence of the city of Luang Prabang. Several ethnic groups share the village territory after successive waves of in-migration from neighboring villages that were successively relocated. The increasing population density has led to more pressure on agricultural land and changes in land tenure; fallow land tends to be privatized and people secure land ownership by planting trees. Although traditional upland rice cropping is still important from cultural and subsistence points of view, it faces constraints related to a decreasing land quality and insecure land tenure. Farmers have recently introduced cash crops (e.g. job's tear, sesame) on the hillsides. Ban Nongdi is a riverside village only accessible by boat. Farmers' livelihood activities are less diversified than in Ban Huay Yen and population density is lower (Sany 2007).

Ban Muangmuay, Ban Bouammi and Ban Phadheng, in Viengkham district, Luang Prabang province are three villages located along a gradient of accessibility and population density. Ban Muangmuay is located on a national road, whereas Ban Bouammi is accessible by a semi-permanent road and Ban Padheng has no road access. Situated at increasing distance from the Nam Et – Phou Loey National Park the three villages are characterized by different agroecological conditions. different agroecological conditions. Villagers in Muangmuay cultivate paddy rice in the alluvial plain whereas there is no sufficient lowland in the other villages. The three have adopted cash crops; however restricted access to market limits the commercialization in Phadheng (Fitriana 2008).

Natong cluster in Xieng Khor district, Huaphanh province, recently experienced a shift to cash crops that even led to a specialization in maize cultivation. The former paddy cultivation system remains important for subsistence and cash income generation. However, pressure has been rapidly increasing on upland fields where permanent cultivation led to a degradation of land quality, with erosion and landslides. However, land rent has increased as well as farmers' income, and living standards have improved within the cluster, even though investment in new crops led to increased debts for most villagers (Viau 2009).

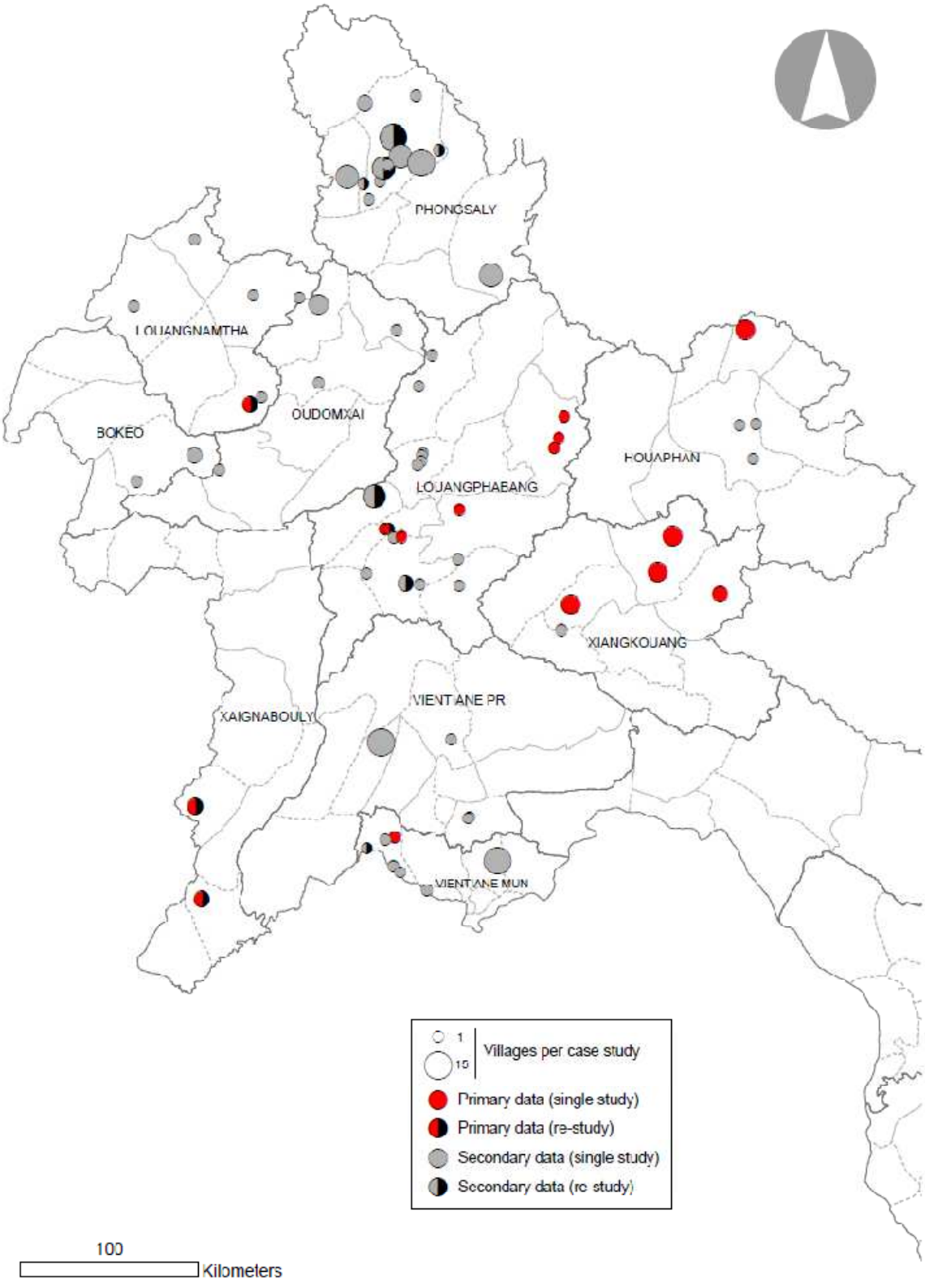

Figure 1: map of the case study location

As they describe contrasted situations across the northern uplands of Lao PDR, these case studies enable us to build a comparative framework that is relevant to the whole region and can support

generalization of household and village level data to a regional level. This framework focuses on changes in livelihood assets, agrarian systems and forest resources and includes variables that link these three groups in order to analyze the causal relations between them.

2. Characterization of agrarian changes at village level

Three main strategies were identified to characterize agrarian changes that our study villages experienced, i.e. diversification / specialization; intensification / extensification and market-orientation / subsistence. These strategies do not exclude each other.

Diversification of livelihood activities

Accessible villages along the main road, such as Muangmuay or Huay Yen, enjoy a good exposure to market which led to a gradual **diversification of agricultural productions**. This process was also pushed by the increasing population pressure in these villages as more remote villages were relocated along the road. With the reduction of agricultural land available per capita, villagers have to innovate through diversification of agricultural products and off-farm activities (Fitriana, 2008; Sany, 2008). In more remote villages such as Natong, cash crops have often been introduced recently by foreign investors or development projects. In Natong cluster, after testing a range of income diversification options, the great success of hybrid maize led to a crop specialization in upland areas. This phenomenon can be captured by a diversity index based on the share of village cultivated area covered by each crop. We tested different coefficients in order to select the more appropriate to characterize the different case study sites. The Simpson's Index of Diversity (SID) was finally selected (Appendix 5, Table 11). SID is computed using the number of crops and their respective areas and is therefore affected by the availability of data. In order to draw a comparison between villages, we have to define several crop categories that should not be too narrow to avoid the problem of the lack of precise information in further documents (Douangsavanh 2004).

We differentiate four main land uses, i.e. rice production, garden and vegetables, other annual crops and plantations. We chose not to separate lowland rice from upland rice; even though these are different agricultural system, with different practices, yields and investment levels. However, it remains the same kind of product for household consumption or commercialization. The stages in the diversification process have been defined, using the following villages (Table 1). Ban Samlang's traditional system is based on upland rice production on the hillsides with small garden around the houses. Various vegetables are cultivated in the upland fields, such as pumpkin, marrow, peanut, cassava, sweet potato and chili, nonetheless this only counts for one land use in our calculation, because it remains traditional crops for family consumption. Ban Nongdi villagers have diversified their productions with the introduction of cash crops such as Job's tear and paper mulberry. Endowed with greater market opportunities because of its proximity to Luang Prabang city, Ban Lak Sip has a higher diversity of productions with a predominance of teak plantations. Natong cluster specialized in maize production after trying various cash crops.

	Lak Sip	Nongdi	Natong	Samlang
%garden	0,09	0,02	0,00	0,006
%rice	0,31	0,65	0,76	0,87
%annual crop	0,18	0,26	0,24	0,02
%plantations	0,42	0,07	0,00	0,10
SID	0,69	0,50	0,36	0,23

Table 1: SID calculation for first-hand case studies

Based on these case studies, we differentiate between traditional farming systems relying on upland rice cultivation (SID<0,30), farming systems undergoing a process of diversification with introduction of cash crops (SID<0,60), diversified farming systems (SID>0,60) and specialized farming systems, which have a low SID (>0,60) and have large areas covered by one type of cash crops.

In addition to this horizontal diversification (Douangsavanh 2004), some villages experience a **vertical diversification** into non-agricultural activities. We chose to assess their importance through the share of off-farm income in the village total income. Along a hypothetical pathway of changes, Samlang is representative of the traditional mountain livelihood system, with 40% of village income coming from gathering and hunting, 36% from crops, 18% from livestock and 5% from off-farm activities. At the end of the evolutionary pathway, Ban Done Kang draws 64% of its income from off-farm activities, which represent 75% of the workload. Viengkham villages show contrasted situations. The main income source is agriculture and livestock farming for the three villages; however, Muangmuay villagers have engaged into off-farm jobs, while Bouammi and Phadheng still depend heavily on forest products (Table 2).

Rank in income sources	Samlang	Bouammi	Muangmuay	Done Kang
Gathering	1	3	3	3
Crops	2	1	1	2
Livestock farming	3	2	2	4
Off-farm activities	4	-	4	1

Table 2 : Diversity of income sources in selected villages

As we study the impact of land use changes on forest resources, it is essential to analyze the relation between villagers' livelihoods and forest. **Forest dependence** is a complex notion that encompasses several questions (Vedeld 2004, Byron 1999), e.g. how much time and labor force people invest in forest activities, what role have forest products in livelihood strategies (supplementation or food security strategy, cultural importance), are there any potential alternatives to forest uses in case of restricted access, how will forest be used in the future? As our work aims at contributing to future REDD+ projects, the impact that a forest use restriction could have on people livelihoods is important to assess to define the type and level of compensation that should be provided to forest dependent people. We differentiate for example villages like Samlang, where forest has a multiplicity of roles and functions in culture, medicine and subsistence and Done Kang, where people have developed off-farm activities along a deagrarianisation strategy (Rigg 2005). Lak Sip villagers remain highly dependent on forest, but they collect only for a limited set of products that they can sell in order to meet their subsistence needs (Bouahom et al 2004). Huay Yen represent an intermediary situation along the pathway of forest dependency reduction. Non-timber forest products (NTFP) are collected in fallow land for both consumption and sale or are grown in gardens when they can contribute to the household revenue. Villagers are less dependent on forest resources and use them only as a supplementation strategy. Domestication of NTFP helps responding to the market demand in the most accessible villages where forest resources have been depleted by unsustainable NTFP gathering practices (i.e. low regeneration potential due to high collection pressure or uprooting of forest products when harvesting).

With this indicator, it was difficult to define a metric variable that could precisely identify stages along an evolutionary pathway. Except for the share of forest products in the total income; we relied on narratives to understand the village situation. In addition, it was hard to systematically assign a stage to a study village because of the great diversity that exists between households within the same village. Poor households depend much more on forest resources to meet their subsistence needs than rich households. The main point is to capture the general village trend. Therefore we took into account the percentage of the different household types in the villages and in some cases we focused on the richest households to identify the stage in the trajectory of agrarian change. However, the income disparity indicator was used to characterize the diversity of livelihood systems within the villages that despite recent economic growth still face poverty issues (see Characterization of livelihood assets).

Market orientation

One key element of the agrarian transition is the shift from subsistence agriculture to market-oriented activities. In remote villages such as Samlang or Phadheng, accessing markets requires walking several hours and occupies labor force that cannot be employed in the fields anymore. In these

villages, agriculture is mainly for subsistence and only small livestock or rice surplus are exchanged within the village to get daily consumption products. In the villages of Lak Sip, Bouammi or Nongdi, where access to land is restricted because of political, environmental or demographic reasons, people tend to produce or collect specific products that they can sell to buy the rice they cannot produce. This coping strategy can be explained by the lack of options for rice production that would be the first choice of rural communities. In villages like Natong, Muangmuay or Huay Yen, people have achieved food sufficiency through agriculture and gathering and start to diversify their livelihoods into market-oriented activities in order to improve their living conditions, e.g. housing and children education. In some villages where considerable opportunities for off-farm activities or new crops exist, people were reported to even stop rice cultivation, but we did not observe this pathway in our first-hand case studies.

The same difficulty appears as for forest dependence. In some villages, the sale of forest or agricultural products is a very limited income source for farmers, and is mainly used to pay for children education. Furthermore, many households are not yet in a livelihood improvement strategy, and some of them are still struggling for subsistence. In these cases, market orientation and diversification has to be considered as a 'distress strategy' (Rigg, 2005) rather than a supplementary strategy.

Intensification of land use

Just as for the indicators described above, the comparison of contrasted village situations and trajectories allowed generating indicators of land use intensification. Samlang is characterized by traditional extensive farming systems while agricultural practices have slightly changed in Yapong under increasing population pressure, and agricultural income opportunities in relation with the rapid spread of maize have completely changed the land use systems in Natong cluster.

Pressure on agricultural land is assessed as the total number of inhabitants on cultivable land area. The latter can be difficult to define. This area depends on several factors, namely the area suitable for cultivation from an agronomic point of view, the area that villagers are allowed to use according to land policies and tenure system; and land accessibility (i.e. distance to the residential area). Indeed, pressure on agricultural land is not only a question of land suitability. In Ban Done Kang for instance, despite important land resources, land use planning and land allocation policy (LUPLA) has led to a very high pressure on land available for rotational shifting cultivation which threatens the rice sufficiency of poor households (Lestrelin, 2009). Availability of agricultural land also depends on demographic trends and existence of alternative livelihood opportunities. For example, in Ban Napho, Sang Thong district, Vientiane Municipality, the number of villagers per area of cultivated land is very high with 115 inhabitants/km². However, population density (on total village area) is only 15 inhabitants/km². The author of the case study argues that pressure on agricultural land is low, because people use for agriculture only a small part of the total village area (Darr, 2003). For instance, there is 1205 ha of unstocked forest, which is not classified as cultivable land in the village land use plan and would be suitable for agriculture. In that case it is not the high pressure on agricultural land that is responsible for changes in land use systems but the availability of off-farm activities that divert local people from agriculture. This case illustrates the deagrarianization trend described by Bouahom et al. (2004) and Rigg (2005) which is at work in Lao PDR. People prefer engaging in off-farm activities, the village being very close to Vientiane, rather than cultivating all the land available. As a result, the definition of what is cultivable land depends on indications given by the authors on local regulations and natural constraints. The results from our first-hand case studies are presented in Table 3.

Samlang	Phadheng	Yapong	Bouammi	Muangmuay	Natong	Done Kang 2003	Nongdi	Huay Yen	Lak Sip 2003
12	12	20	26	48	73	80	114	200	370

Table 3: Pressure on agricultural land (people/km²) in the first-hand case studies

Other indicators of land use intensification are **land rent** and **technological level**, which give information about agricultural practices. Both indicators usually evolve in the same direction. New crops and new practices are often adopted because they give more value to the land. However, the definition of thresholds between stages justifies referring independently to the two notions. Many crops or innovations can exist or be known within a community, but it does not necessarily translate into an increased return on agricultural land if the innovation does not spread largely to the whole village.

We also distinguished the values of these two indicators in the uplands and lowlands of each case study site, to see which part of the landscape is the most important for livelihoods. For instance, in Natong cluster, farmers used to rely heavily on lowlands when paddy rice was the most profitable crop. With the development of new roads in 2003, the improvement of market access and introduction of hybrid maize varieties, the focus shifted towards the uplands where they could generate much higher income. This shift in interest is captured by changing land rent. This movement can also go the opposite direction, from upland to lowland, when people invest in terracing (with or without the help of development projects) and increase their village lowland area. Finally, we assess the total land rent, at the landscape scale, combining the land rent values from different components of the landscape and the percentage of lowland. Regarding technological levels, we used separate indicators for the lowlands and the uplands in order to account for differentiated patterns and timing of innovation adoption between flat lands (i.e. practical advantages for mechanization) and sloping lands.

Traditional systems in the uplands, as they exist in Phadheng and Samlang, represent the first stage for both indicators, namely a low land rent but swidden practices with hand tools and manual weeding that optimize return to labor. In Muangmuay, Bouammi and Yapong, fallow length in upland rice systems has been reduced, which induces a relative and temporary increase in land rent (i.e. until the yield decrease because of fertility loss due to weed infestation and erosion). In Viengkham villages, cash crops are cultivated by a few households to compensate for productivity losses in rice-based swidden systems. Many villagers in Huay Yen and Nongdi have shifted to permanent cultivation of annual crops and perennial plantations, which represent a higher technological level. However, unlike Lak Sip and Done Kang, cash crops do not cover a large share of the landscape and plantations were too recent at the time of the study to be profitable and consequently to translate into increased land rent. While they are at the same technological level, Huay Yen and Nongdi stand at an earlier stage in the pathway of land rent change.

In lowland, the major innovation so far has been the use of hand tractor instead of buffaloes for land preparation. In a few sites, villagers may develop an irrigation system that allows producing in dry season. This happened in most cases with the support of an external development project. In other sites, farmers are now using chemical inputs for pest control and fertilization as well as new practices like direct seeding instead of transplantation.

Regarding **return to labor**, some decades ago, villagers in Yapong used to grow rice on upland slopes under a slash and burn system with long fallow period, as people did in 2003 in Samlang. This traditional extensive farming system optimized return to labor, as labor force is the limiting factor for agricultural production. When pressure on agricultural land increases within shifting cultivation systems, people tend to maintain their level of production first by shortening fallow length, or changing cropping practices within the swidden system. These changes aim at reducing labor requirement, which is the limiting factor in traditional systems. Changes in cropping practices first tend to decrease the return to labor, for example by investing more time in manual weeding, then increase it through the introduction of crops or activities that require less work (e.g. use of herbicide for weed control). When the population pressure on agricultural land is so high that negative environmental consequences (e.g. erosion) prevent sustainable production under swidden system, then it is converted into a different livelihood system. Land scarcity is replacing labor scarcity as the main driver of farmers' strategies. Villages such as Huay Yen, Lak Sip or Natong developed cash crops cultivation or plantations that increase labor productivity. In Done Kang, villagers focused on off-farm activities, which offer them an even higher return to labor, while disconnecting their livelihoods from the land.

3. Characterization of livelihood assets

To assess the impacts of agrarian change on livelihood and forest resources and the interactions between these different variables, we followed the same method of indicators' selection and characterization. We organized our framework around changes in different livelihood assets (Scoones, 1998) to make sure all aspects would be addressed.

Natural changes

Since livelihoods in the northern uplands widely rely on agriculture, they are directly linked to the natural assets, i.e. physical context and natural resources, in terms of quantity (e.g. forest cover) and quality (e.g. soil quality).

Land degradation issues have been reported in the case study of Yapong, where the reduction in fallow length induced a rise in pest invasions and workload for weeding. In Natong cluster, the shift towards permanent cropping led to soil erosion and landslides. Many villagers in Done Kang even diverted from agriculture because their land had become unsuitable for cropping. These three contrasted situations form a gradient of decreasing **land quality** that we included in our framework. As we did for indicators of agricultural practices, we distinguished between uplands and lowlands.

Regarding forest resources, our case studies exemplify several stages along the **forest transition.** Forest cover in Phadheng is decreasing slowly with a slight extension of upland fields. Yapong and Natong encounter a higher deforestation rate due respectively to increasing population and continuous spread of cash crops. Muangmuay's forest cover remains stable as plantations' development counterbalances reduced natural forest. Finally, reforestation occurs by two different means in our study sites: in Lak Sip because of land regulation and tree plantation and in Samlang by spontenous regeneration due to massive out-migration.

The indication of the stage in forest transition was completed by an estimate of the share of **forest cover**. When the information was not given in the case study, we used data from the moderate-resolution imaging spectroradiometer (MODIS) sensor. Data from the MODIS 'Vegetation Continuous Fields' collection (Hansen et al. 2006) was used to estimate forest cover values (2005) and deforestation rates (2000-2005) for each village / case study. This data was then used to verify and/or complement the information on forest cover and transition derived from the case study.

The diminution of forest cover is not the only indicator of forest resources' depletion. In Lak Sip, Muangmuay and to a lesser extent in Yapong, diversification of land uses and changes in land tenure tend to increase forest fragmentation. In Natong cluster, the implementation of LUPLA induced a segregation of land use types and a delimitation of protection forest. The resulting **land use patterns** can be used to understand agricultural and environmental changes within a study site.

The landscape structure gives information about the initial potentialities of a study site in terms of land use. Villages such as Samlang, with steep slopes and narrow valleys, cannot develop large areas of paddy fields and reach a massive rice production through irrigation and mechanization like some villages in Xayabury province. An easily available proxy of this initial geo-physical landscape structure is the **percentage of lowland** in the village area. However, this indicator can also vary if villagers invest in terracing, e.g. in Yapong, or abandon terraces due to a lack of irrigation structures, e.g. in some villages in Phongsaly (Roche, 2006).

Financial changes

Market integration induces an improved **access to credit** but also increasing **indebtness** among villagers, as seen in Natong cluster. In remote villages that have no access to bank, villagers have developed rice loan system, e.g. in Bouammi. In Natong cluster, Vietnamese middlemen give credit to villagers with high interest rates. In villages closer to Vientiane, people can access bank credit with lower interest rates. Remote villages often share resources and labor and therefore incur no debt. In most case studies, rice is borrowed and must be reimbursed at the next harvest time. However, in

study sites such as Natong cluster, villagers incur long term debts, which can threaten their livelihood sustainability in case of varying agricultural prices.

Regarding **savings**, big livestock such as buffalos and cattle are the traditional means of capitalization in rural areas. We chose to assess this capitalization by computing the average number of large ruminant units (LRU) owned by households. Villages such as Samlang and Bouammi experience poor capitalization, i.e. less than 2 LRU by households. Nongdi and Phadheng form a gradient of increasing capitalization through livestock, whereas Huay Yen villagers rather invest their savings into plantations, which require less workload.

Human changes

Most indicators are assessed at village level. However, a measurement of intra-village variations is necessary to capture the diversity of situations**. Income disparity** is such a measurement. Samlang and Phadheng are villages where income disparity is very low. Economic differentiation appears with the introduction of market-oriented productions and increasing competition for land, e.g. in Yapong or Bouammi. Income disparity is high in villages such as Muangmuay, Huay Yen or Lak Sip, when a share of the population cannot produce its own food and relies entirely on wage employment while others become richer and reinvest their surplus in production means.

Improved accessibility, increased pressure on land and off-farm job opportunities tend to attract villagers outside their village boundaries. We differentiated between different types of **out-migrations**. In Lak Sip and Done Kang in 1990, some villagers worked regularly in Luang Prabang. As production conditions within the village have become harder, many people send their children to live and work in the city for several years. In Nongdi, population is also decreasing, as villagers leave their house permanently with the hope of a better life to find lowlands or off-farm jobs in other villages or cities. Since people can follow these different migration strategies within the same village, we rely on the narratives of the case study to understand the causal relation behind the observed trend.

Human assets such as poverty, education and literacy, health and age structure of the population, are linked to land use and forest resources as well. As these themes were rarely reported in our case studies, we developed indicators using the census data.

Physical changes

Accessibility and roads play an essential role in livelihood changes as it determines access to market, health centers, schools, development projects and governmental authorities. The three villages in Viengkham district follow a gradient of accessibility in term of transportation structure. Reaching Phadheng requires three to four hours walk from the main road. Bouammi is only accessible by motorcycle and Muangmuay is located along a national road. Natong cluster can be reached by car during the dry season, therefore is ranked between Bouammi and Muangmuay in term of accessibility.

Presence of electricity network and water infrastructures has an impact on livelihoods, e.g. health or agricultural practices with the development of an irrigation system. However, this kind of information was rarely available in the case studies and was completed using the census data.

Social changes

An indicator of social cohesion within the village is **mutual help**. In traditional agricultural systems as it still exist in Samlang, Phadheng or Lak Sip, people perform community work or help each other in time of labor peak, such as harvest or weeding. In Natong, Muangmuay and Yapong, some villagers employ others as daily workers in their farms and pay them with money or rice.

Mutual help is sometime difficult to assess within a village as in Chicho, Pongsaly. Some households use wage labor, however work exchange is still developed within the village, among relatives. There are also rice share without interests among relatives. If we compare the situation in Chicho with those of Kiou, they both have work exchange for upland rice and wage employment; however the latter is

more developed in Kiou (Roche, 2006). The value definition depends then on the comparison with other villages. In this case, it is necessary to justify the value selection in the database from objective elements read in the case study document.

An indicator of social capital in a village is the presence of **conflicts** and the way they are resolved. In traditional villages such as Samlang or Phadheng, conflicts are generally resolved at the village level by local authorities. When resources become scarce, e.g. in Nongdi, conflicts break out about livestock management and resulting damage on crops, village boundaries and natural resources management, e.g. gathering of forest products. An increasing competition for land use engenders conflicts about land in villages such as Natong or Huay Yen. At the time of land reforms, conflicts can come up against government representatives.

Traditionally, decisions about land use and daily regulations are taken at village level. When conflicts arise or with the arrival of new habitants from remote areas or even from other ethnic groups, local leadership can be threatened and **rule enforcement** at village level less effective, e.g. in Natong or Nongdi. For most accessible village, rules are imposed by government representatives who can be corrupt or face villagers' resistance, e.g. in Lak Sip. Finally, in Done Kang or Huay Yen, very close to Luang Prabang and provincial authorities, villages' life is influenced by governmental projects and incentives.

Land tenure systems vary among our case studies. Traditionally, land belongs to the people who clear it and use it; even though the uplands are recognized as common property. When land is not used anymore, i.e. under extended fallow period, land returns back to the community, e.g. in Samlang, Yapong and Nongdi. However, when land become scarce, villagers tend to privatize fallow land, build fences around their plots and plant trees, e.g. teak, to ensure the ownership of the land. This occurs in Natong, Muangmuay and Huay Yen. In some villages close to the administrative centers, like Lak Sip and Done Kang, land ownership has become official through land certification.

Another indicator of social capital is the cultural diversity within a village, assessed by the share of different ethnic groups. As women education and emancipation are likely to have an impact on natural resource management, we also studied gender equity in the villages. However, few case studies deal with this theme. Therefore, we chose to use census data to objectively assess this indicator.

Use of 2005 census data

The Population and Housing Census carried out in March 2005 by the Department of Statistics of the Ministry of Planning and Investment is a source of socioeconomic data systematically collected at village level. We used an extract from the census database for our 43 target villages to complete the missing data from the case studies. Under the condition that the date of the case study was close enough to the year 2005, the census data provided valuable information to derive our indicators.

We first selected a number of variables that would complement our framework. Then, like for the other indicators, we defined intervals and thresholds by assessing the variability of the indicator's values between the selected case studies. We validated these choices by looking more closely to village which situation is known from the first-hand studies to check that the categorization based on the census would be consistent with the one based on the meta-analysis.

As regards **Services and Infrastructures**, we built a combined variable using access to electricity, access to water and type of toilet. This information was often missing from the case studies that focused on land use changes. The presence of a water supply and electricity network in the village would yield the value 3 to the index. In case only one infrastructure is present, the index value is 2. If none, the value 1 is assigned to the index. If more than 50% of households have toilets, we add 1 to the index value, which reaches the fourth stage of the index.

Dependency ratio, i.e. ratio of dependent people to labor forces, plays an essential role at household level, as the number of labor forces evolve along circles of wedding and births and often determines the level of food production in traditional systems. At village level, dependency ratio evolution could follow the demographic transition. It is computed as the ratio of dependent people (i.e. people with age 0 to 14 and 65 and older) to non-dependent people (i.e. people with age 15 to 65). Research reports rarely give information about village population age structure. They sometimes mention the average number of declared labor forces per household; however, this value might be voluntary underestimated by villagers since they pay taxes accordingly. Therefore, we often relied on census data to compute it. In villages such as Natong or Muangmuay, where living standards improve steadily, women tend to have fewer children than in more remote villages, which brings about a low dependency ratio. In Yapong, out-migrations of young adults that look for a job in the city have impact on villages' age structure and increase dependency ratio. We decided the following thresholds: a very high dependency ratio is superior to 1.5, which means less than 40% of people are active within the village; an average ratio is in-between 1 and 1.5 and a low ratio is less than 1, that is more than half of the villagers are active people.

In order to assess the importance of **education** in a village, we computed the percentage of 10 years old children, male and female, who attend school. If the share is less than 50%, the index value is 1. If the share is between 50% and 90%, we give 2, if more, 3. In Huay Yen, as people have improved their wealth, more expenses were allocated to children education. As often reported in villages, it is the first expenditure when people achieve food sufficiency. In Padheng, a Hmong village, children often work in the fields instead of going to school. School attendance is lower.

In order to assess **gender equity**, we computed the sex ratio (male to female) of people with age 6 and older who completed primary school. If this ratio is more than 1.2, disparity is high; if it is between 0.8 and 1.2, it is low; if the ratio is inferior to 0,8, with more girls than boys having completed school, disparity is very low. This measure can be biased by the low number of people having completed primary school and should be reinforced by other calculations.

Ethnic groups in a village are an indicator of cultural heterogeneity. We computed this diversity using the census on ethno-linguistic families and calculation of Simpson Index. The main ethnic groups we selected are: Tai Kadai (Lao Loum, Tai), Mon-Khmer (Khamu, Ksing Moul), Tibeto-Burman (Akha, Ho) and Hmong-Mien (Hmong). We differentiate between villages encompassing one ethnic groups, such as Samlang or Phadheng; villages with one main group and one minority, e.g. Huay Yen and Done Kang; villages with one main group and several minorities, e.g. Muangmuay and Lak Sip and villages with two main groups and minorities, such as Souan Luang in Xieng Ngeun district (Gabeloux, 2007; Guemas, 2007).

To assess **poverty** within a village, we used the poverty rate of the census as percentage of households living below the national poverty line (NSC 2004). If it is less than 30%, the index value is set to 3: the village is quite wealthy. If between 30 and 60%, we give 2, and if more than 60%, we give 1, the village is poor. When use of census data is not relevant and such quantitative data are not present in the case study, we assessed poverty as follows: when majority of villagers are not rice sufficient and have no house equipment, village is described as poor, e.g. Nongdi; when people are able to spend money for children education, village is intermediate, e.g. Samlang, Muangmuay; when most households are self sufficient during the whole year, own a good house equipment in concrete houses, village is better off, e.g. Done Kang or Huay Yen.

To assess **health** status at the village level, we used child and infant mortality. Infant mortality is the ratio between the number of children who died during their first year and the number of life births. Child mortality is the ratio between the number of children who died before the age 5 and the number of population with age 4 and younger.

The values computed from Census data were not automatically used. We combined census data with data from case study documents in order to give the most accurate value possible, especially when data were not collected at the same date.

This empirical approach allowed the comparison of diverse socioecological systems at village or village cluster level. By using such indexes, the comparative framework can address a large range of case studies that had different scopes and methods and therefore generated heterogeneous datasets. Finally, all these case studies could be incorporated into the same statistical analyses to compare and classify them or to test the relative influence of different drivers of change. Table 4 displays the list of indicators and related modalities. The matrix case studies by indicators corresponding to our first-hand case studies is presented in Table 5.

	Indicators	Stages in evolutionary pathway
Agricultural changes	Diversification of income sources	1. Gathering/fishing/hunting is the biggest income source in the village 2. Agriculture or livestock is the biggest income source in the village and gathering remains an important income sources 3. Agriculture or livestock is the biggest income source in the village 4. Off-farm income is the biggest income source in the village
	Diversity of agricultural productions	1. Low diversity of agricultural productions, farming system based on upland rice with or without associated annual crops and vegetables. (SID < 0,3) 2. Introduction of new crops, diversification of agricultural productions (0,3 < SID < 0,6) 3. Farming system based on several different agricultural productions (SID > 0,6) 4. Loss of diversity, specialization in one cash crop
	Forest dependence	1. High dependence (traditional forest-based livelihoods), high diversity of products, good knowledge, mainly for self-consumption 2. High dependence (distress strategy), low diversity of products, loss of knowledge, important contribution to revenues and/or food security 3. Low dependence (supplementation strategy), very specific products, limited contribution to revenues and/or food security (safety net or complementary incomes) 4. Very low dependence (deagrarianisation strategy), no contribution to revenues or food security
	Land rent in lowland	1. Rain season paddy rice, no mechanization or inputs 2. Mechanized paddy rice 3. Dry season crops with high value, plantations 4. Two seasons mechanized paddy rice, and high value crops in dry season
	Land rent in upland	1. Extensive farming system based on low value/ha/year crops like upland rice with long fallow period 2. Intensification of land use due to land scarcity, decreasing fallow length 3. Introduction of high value crops (cash crops) and decreasing fallow length, land rent increases in most accessible areas (roadside) 4. Intensive farming systems based on high value crops like teak and fruit trees, maize, eaglewood and sesame, permanent cropping
	Market integration	1. Main production is for self-consumption, main exchanges without money 2. The village is rice deficient, other productions are sold in order to buy rice that cannot be produced: distress diversification (sell of labour, livestock, NTFPs, other crops, handicrafts), monetization of exchanges, achieving subsistence remains the main purpose 3. Surplus production or cash crops sold in order to improve their livelihoods 4. Cash crops, main production is sold, rice is mainly bought

	Indicators	Stages in evolutionary pathway
Agricultural changes	Pressure on agricultural land	1. Very low density < 15 inhab./km.sq 2. Low density: >15 & < 30 inhab/sq.km 3. Average density: >30 & < 50 inhab/sq.km 4. High density: >50 & < 100 inhab/sq.km 5. Very high density: > 100 inhab/sq.km
	Return to labor	1. Rice-based subsistence system optimizing the return on labor (upland rice provide superior return to labor than paddy rice) = sustainable extensive farming systems -> return to labor = higher than daily agric. Wage 2. Labor intensification of subsistence system because of land degradation or land restrictions (increased time spent on weeding, lower yields) -> return to labor tend towards daily agric. Wage (incentive to stop farming, migrate, diversify productions or to change farming practices) 3. Introduction of market oriented products (annual and/or perennial crops) and/or new practices (e.g. pesticides and chemical fertilizers, mechanization) that increase labor productivity (return to labor higher than daily wage but mainly family labor) 4. Increased reliance on off-farm activities to generate income. Reference is not agricultural daily wage but industrial daily wage. Reliance on hired labor for agricultural activities. Family return to labor higher than agricultural return to labor.
	Technological level in lowland	1. Paddy rice with no technical inputs, use of family labor and animal force (buffalo) 2. Use of hand tractor 3. Irrigation system, dry season rice 4. Use of chemical inputs, new techniques like direct seeding
	Technological level in upland	1. Shifting cultivation of upland rice with hand tools 2. Introduction of new upland crops like maize, sesame 3. Permanent upland crops or plantations 4. Permanent cropping with mechanization, use of chemical fertilizer and herbicide
	Total land rent	1. Extensive farming systems based on low value/ha/year crops like upland rice with long fallow period, no mechanization 2. Intensification of land use, decreasing fallow length, mechanization in lowland 3. Introduction of high value crops (cash crops) and plantations, decreasing fallow length, land rent increases in most accessible areas (roadside) 4. Intensive farming systems based on high value crops and permanent cropping (two seasons paddy rice, plantations, permanent upland cropping)
Financial changes	Credit system	1. Village credit fund with mutual trust 2. Local middlemen with high interest rates 3. Access to bank with low interest rates with land mortgage
	Indebtness	1. No debts in the village, share of rice, land borrowed. 2. Debts with less than one year reimbursement period. Debts < one year household production 3. Long term debts > one year household production
	Living savings	1. Poor capitalization (<2 LRU/hh) 2. Medium capitalization through livestock (2-4 LRU/hh) 3. Large capitalization through livestock (> 5 LRU/hh) 4. Capitalization through other means (plantations…)

	Indicators	Stages in evolutionary pathway
Human changes	Dependency ratio	1. Very high dependency ratio (>1.5), age structure in pyramid, more than 60% of the population is less than 15 or more than 60 2. Dependency ratio>1 but <1.5 3. Dependency ratio<1
	Education	1. No expenditure for school, no secondary school in the village, high child involvement in farm work, frequent absences of teacher, less than 50% children with age 10 attend school 2. Children go in other villages for secondary school, between 50% and 90% children with age 10 attend school. 3. More than 90% children with age 10 attend school
	Health	1. Very high child mortality: >1/3 2. High child mortality: 20-30% 3. Medium child mortality: 10-20% 4. Low child mortality: <10%
	Income disparity	1. Low disparity 2. Medium disparity 3. High disparity
	Migrations	1. No migration 2. Temporary migration to find off-farm jobs 3. Long term migration to find off-farm jobs 4. Definitive out-migration to find new land or off-farm jobs
	Population density	1. Very low density < 10 inhab./km.sq 2. Low density: >10 & < 20 inhab/sq.km 3. Average density: >20 & < 50 inhab/sq.km 4. High density: >50 & < 100 inhab/sq.km 5. Very high density: > 100 inhab/sq.km
	Poverty	1. Poor: majority of poor households, non sufficient in rice, bamboo house, low income 2. Medium: intermediary level = just enough to send children to school and cover family expenditures but not enough to accumulate capital, construct concrete houses, etc. 3. Better off: majority of households self-sufficient in rice, good house equipment

	Indicators	Stages in evolutionary pathway
Natural changes	Forest cover	1. > 70% 2. 50 – 70 % 3. 20 – 50 % 4. < 20%
	Forest transition	1. High forest cover declining slowly 2. Rapid decrease in forest cover 3. Stabilization of forest cover – agroforestry systems 4. Increase in forest cover after a decrease period (natural forest regeneration + plantations)
	Land quality in lowland	1. Fertility maintained, no pest invasion 2. Increase in workload/inputs/mecanization due to pest invasion and low fertility, declining yields 3. Stop cropping due to land degradation in some village area, lowland flooding 4. Large share of village lowland degraded
	Land quality in upland	1. Fertility maintained, no pest invasion 2. Increase in workload/inputs/mecanization due to pest invasion and low fertility, declining yields 3. Stop annual cropping due to land degradation in some village area, lowland flooding, land slide 4. Large share of village upland degraded (with broom grass or not cultivable anymore)
	Land use patterns	1. >90% natural land, large fields of upland rice or concentration of paddy in valley bottom, low fragmentation 2. 70% natural land, fragmented cultivated land (small cropping areas), field houses 3. Patchy landscape mosaic 4. Segregated agricultural and natural land use types; e.g. dense forest delimited for protection, cash crops and/or plantations near the road or river
	Percentage of lowland	1. No lowland 2. 0-10% lowland 3. 10-30% lowland 4. >30% lowland
Physical changes	Accessibility	1. Walk to access facilities: school/market/next village or non-farm employment opportunity 2. Access by motorcycle only (track) 3. Difficult access to facilities by river or road (semi-permanent road) 4. Roadside village, permanent road
	Services and infrastructures	1. Water from river or well / no latrine / no electricity or from water turbine / no phones 2. Collective water tap/ no electricity/ no phones 3. Collective water tap / electricity from national grid / difficult availability of signal - few phones 4. Individual water tap / use of latrines generalized / electricity from national grid / good phone signal – many households equipped with phones

	Indicators	Stages in evolutionary pathway
Social changes	Conflicts	1. no conflict (solved at the village level) 2. conflicts about livestock (damage on crops), wildlife gathering and hunting, village boundaries 3. land conflicts 4. conflicts involving government representatives
	Ethnic groups	1. one ethnic group (SID=0) 2. two ethnic groups, one main group (90%) and one small minority (SID=0,20) 3. one main group(80%) and one or two minorities (SID=0,25-0,30) 4. two main groups and one or two minorities (SID=0,50)
	Evolution of tenure rules and tenure security	1. open access to natural resources 2. traditional right of first opener 3. privatization of the fallow, presence of fences around plots, use of perennial crop to mark property 4. full land privatization, land certification
	Gender equity	1. high disparity in primary school completion 2. no disparity in primary school completion 3. more girls than boys have completed primary school
	Mutual help	1. mutual aid, traditional community work 2. mutual aid, individual 3. individually paid labor (or rice)
	Rule enforcement	1. high community control of rules and regulations - no governmental representatives in the village 2. fair community control 3. non-compliance with national laws, passive resistance / presence of governmental representatives, but corruption 4. high governmental control / governmental projects and incentives

Table 4: List of indicators and their evolutionary pathway

Indicators	Natong 2009	Lak Sip 1990	Lak Sip 2003	Done Kang 1990	Done Kang 2003	Muangmuay 2008	Bouammi 2008	Padheng 2008	Huay Yen 2007	Nongdi 2007	Samlang 2003	Yapong 2003
Diversification of income sources	3	2	2	2	4	3	2	2	3	2	1	3
Diversity of agricultural productions	4	3	3	3	2	3	3	2	3	2	1	1
Forest dependence	3	2	2	2	4	3	2	1	3	2	1	3
Land rent in lowland	2	1	1	1	1	1	0	0	1	0	0	1
Land rent in uplant	3	2	3	2	4	2	2	1	2	2	1	2
Market integration	3	1	2	2	2	3	2	1	3	2	1	2
Pressure on agricultural land	4	4	5	3	4	3	2	1	5	5	1	2
Return to labor	3	2	3	3	4	2	2	1	3	2	1	2
Technological level in lowland	3	1	1	1	1	2	0	0	2	2	0	1
Technological level in upland	2	2	3	2	3	2	2	1	3	1	1	2
Total land rent	3	2	3	2	4	3	2	1	3	2	1	2
Accessibility	3	3	4	3	4	4	3	1	4	3	2	4
Conflicts	3	3	2	4	2	2	1	1	3	2	1	4
Credit system	2	2	2	2	2	2	1	1	2	1	1	1
Dependency ratio	3	2	3	2	3	3	3	2	2	2	3	2
Education	3	2	3	2	3	2	2	2	3	3	3	2
Ethnic groups	2	3	3	2	2	3	2	1	2	1	1	1
Tenure rules and tenure security	3	3	4	3	4	3	2	2	3	2	2	2
Forest cover	3	3	2	3	2	2	2	1	4	4	1	3
Forest transition	2	4	4	4	4	3	3	1	3	4	4	3
Gender equity	2	1	2	1	3	2	1	1	1	1	1	1
Health	3	3	3	3	3	1	1	2	3	3	3	3
Income Disparity	1	3	3	2	2	3	2	1	3	3	1	2
Indebtness	3	2	2	2	2	2	1	1	2	2	2	2
Land quality in lowland	1	1	1	1	1	1	0	0	2	0	0	1
Land quality in upland	3	2	3	2	4	2	2	1	2	2	1	2
Land use patterns	4	3	3	3	3	3	3	2	3	2	1	2
Living savings	3	2	2	2	2	1	1	3	4	2	2	1
Migrations	1	2	3	2	3	1	1	1	3	4	3	3
Mutual help	3	1	1	1	1	3	1	1	3	2	1	3
Percentage of lowland	3	3	3	2	2	2	1	1	2	1	1	2
Population density	3	4	5	3	4	3	2	1	5	1	1	2
Poverty	2	2	2	2	3	2	2	2	3	1	2	2
Rule enforcement	2	2	3	4	4	2	1	1	4	2	1	2
Services and infrastructures	2	1	3	1	4	2	2	1	2	1	1	1

Table 5: Matrix of attributes by cases for our first-hand case studies

III. Data processing and analysis

1. Selection of case studies

The knowledge base of the Catch-Up project includes a large number of reports and documents (2402 files including students reports and dissertations, grey literature and published materials) related to land use change in northern Laos. From the original database, 52 documents were selected that related to case studies relevant to the meta-analysis (Figure 2).

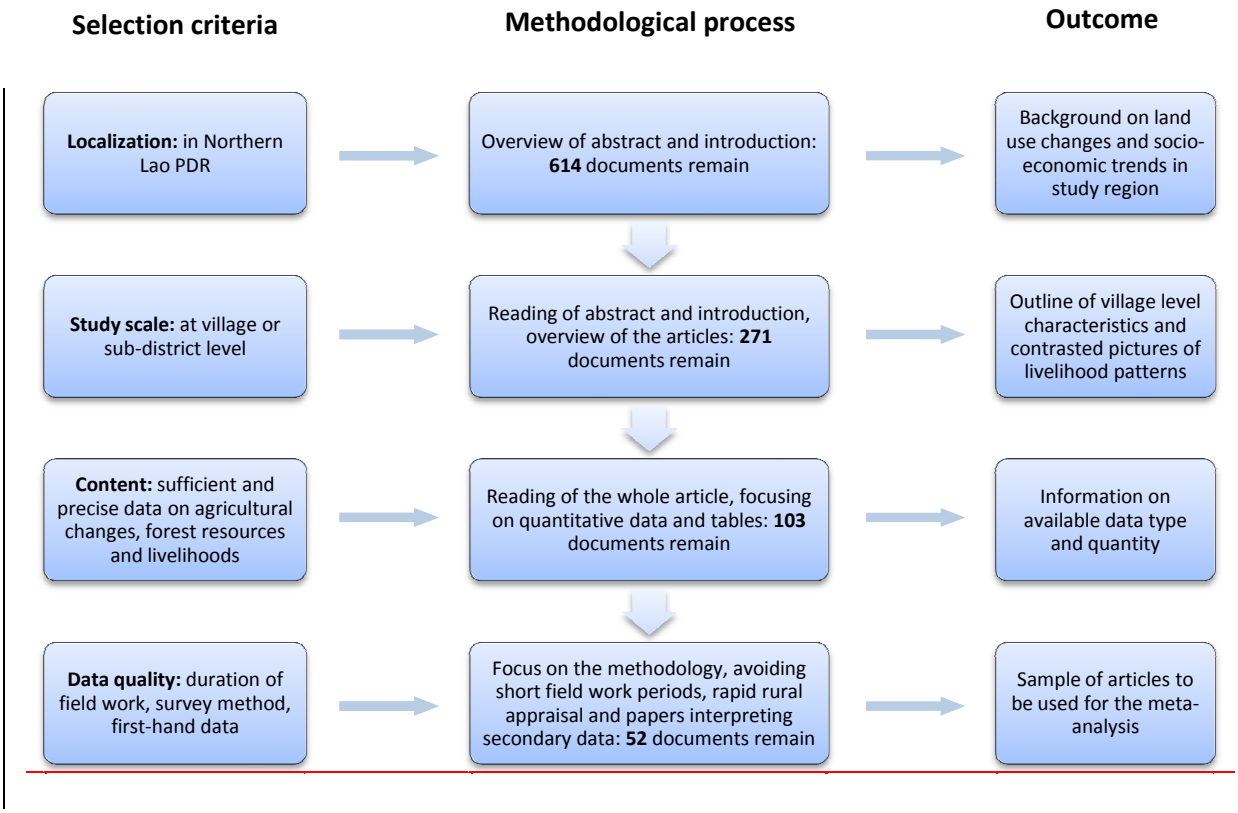

Figure 2: Method for selection of documents

The first criteria for case study selection were the localization of the study and the presence of empirically derived conclusions about land use changes and their impact on forest resources and on livelihoods at village level. Unlike meta-analyses based on published literature as a criterion of quality (Vedeld et al 2004; Padgee 2006), our literature review is mainly based on grey literature, namely on reports from MSc or PhD students from which detailed pictures of agrarian systems and livelihood assets can be drawn. The large range of interdisciplinary knowledge that is required for our study can only be found in this type of documents, and much more rarely in shorter journal articles. Documents were selected based on the quality of the field work. The data and results reported in the document should be firsthand. Many consultancy reports rely on data already reported elsewhere that they tend to re-interpret and synthesize according to their own objectives. We tried not to use such second hand reports, but instead to always select the original work, in order to get more abundant and less biased information. The study must entail a long field work, of several months if possible. Results from Rapid Rural Appraisals were not selected for the meta-analysis. In case the document covers only partially our topics of interest, we tried to couple it with another document from the same area. If no other document is available to complete the required information, the first 'incomplete' document was excluded.

Having defined which document could give us sufficient information in order to complete our framework of analysis, we still had to define what a case study is. One document can include several

case studies, and one case study can be documented by several papers. In the same way, one village can be documented by several case studies, i.e. at different dates, and one case study can entail several villages. Finally, a case study is defined as the description of the status of local land use and livelihoods at a certain date in a given locality. It can focus on one village or on a group of villages that share some agroecological characteristics or have a common history (e.g. Natong village cluster). Appendix 1 lists the references that were used to document these case studies and some that were not used so far, because of time constraint, but could be used in the future for a more complete meta-analysis. Appendix 3, Table 8 presents the case studies included in this report.

A special attention should be paid to the spatial distribution of our case studies. A number of studies are concentrated near particular sites: National Parks, dams, projects sites. Also, historically, research has been concentrated near Luang Prabang because field work was facilitated by plane connection. Furthermore, accessibility plays an important role because of evident logistic constraints related to field work and the popular theme of focal zones (Appendix 4, Table 10). This heterogeneity somehow affects the representativeness of our sample of case studies. This bias should be carefully taken into account in the interpretation of the results.

2. Data organization and management in an Access database

All data extracted from the case studies and other sources of information were organized in an Access database, which structure reflected the methodological framework introduced in the previous section (Figure 3). Information about the reviewed documents is systematically stored and can be queried for different purposes, i.e. statistical analysis and/or diffusion of the database to the public. The case study location is also identified with geographic coordinates allowing spatial analysis (Figure 1).

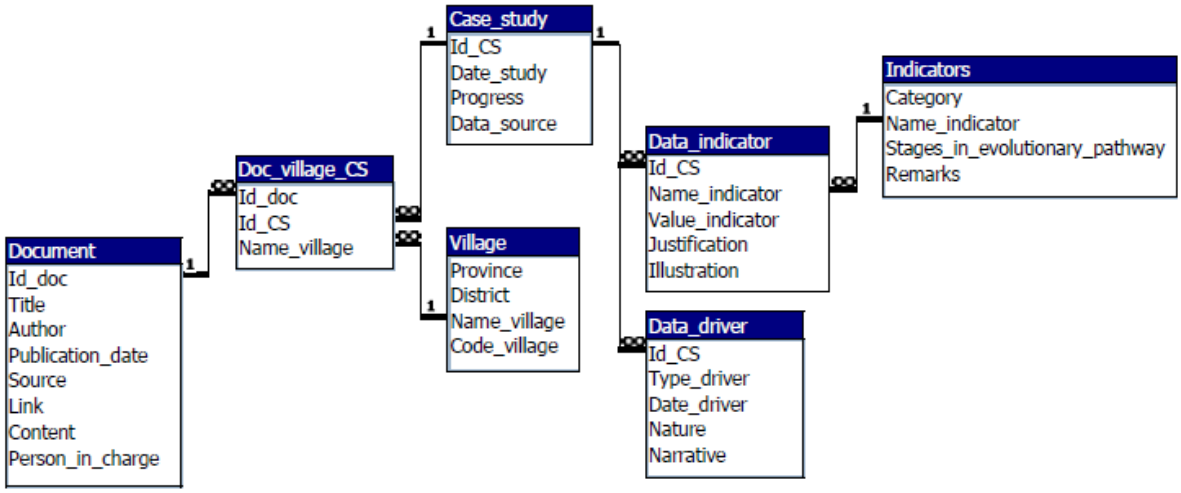

Figure 3: Database relational structure

Papers and writings used for the analysis are classified in the table **[Document]**. The PDF files are attached. The column *"Content"* provides metadata about the study, for instance duration of the field work, methods used for the research, or data available in the paper. The table **[Village]** lists all the villages included in the case study. When possible, the column *"Code_village*" is filled in in order to link the village to the 2005 Census data, gathered in the table **[Census_data]**. After reading a document, the researcher decides how many case studies can be documented. The case studies are listed in the table **[Case_study]**. Appendix 2, Table 7 presents the encoding process.

Each document is associated with a number of villages and case studies. In the table **[Doc_village_CS]**, one line links a document with a village and a case study. As presented above, one case study can gather several villages and be documented by several papers. One village can also be studied at different dates, and is then documented in several case studies. At last, one document can focus on several villages included the same case study or in different case studies if

this is justified by their differences in relation with important criteria (e.g. accessibility, physical context). The easiest way to create these links is to stay in the table **[Document]** and to fill the sub-table **[Doc_village_CS]**, by filling in the villages described in the paper and the corresponding case studies.

The case studies are then ready for the analysis, i.e. reading through the corresponding documents and assigning a value to each indicator in the table **[Case_study],** sub-table **[Data_indicator]**. If comparisons with other case studies are needed, the sub-table can be filled in from the table **[Indicators]**, which lists all the indicators.

The table **[Data_driver]** is also filled in with the main events that happened in the case study sites and were brought about by external forces such as resettlement, land use policy, investment from companies or governmental authorities, development project by NGOs.

The query [Doc_village_CS] displays the link between documents, villages and case studies. The query [Analysis_progress] calculates the number of indicators that have been filled for each case study. The query [Indicator_completeness] calculates the number of case studies for whom an indicator has been filled in. If the number of case studies with a value provided for this indicator is too low, the indicator may not be used for the statistical analysis.

3. Statistical analyses

The proposed framework covers many aspects of land use changes, their driving forces and impacts on livelihoods and forest resources. Many indicators can be both driving forced and impacts because of the feedbacks and complex causality links between the resources, the users and the external context. In order to understand these relations, we quantified the indicators with ordinary variables (see section 2, Table 5), using stages in empirical evolutionary pathways.

The aim is to build a typology of case studies based on a series of indicators and to highlight the interdependence and causal links between the indicators. We chose statistical tools according to the nature of the data to be processed, i.e. the ordinal variables corresponding to stages in our evolutionary pathways and the metric variables from 2005 National census.

A correlation test and a Principal Component Analysis (PCA) were conducted on selected data from the national census in order to highlight possible statistical relations between variables like accessibility, poverty, ethnicity and migration. Ordinal variables derived from the review of case studies were then used for exploratory data analysis (Ruiz-Pérez 1999). In this regard, Multiple Coordinates Analyses (MCA) were conducted in order to build a typology of case studies based on livelihood and land use information.

Further statistical tests will be conducted when more case studies will be integrated in our framework. A constraint to the number of case studies is the difficulty to deal with missing data, because only few field reports mention the whole range of indicators.

IV. The trajectories and drivers of land use changes in Northern Lao PDR

1. Overwhelming influence of accessibility

Independently of the sources and methods of analysis, all the information collected converge to indicate an overwhelming influence of accessibility on local trajectories of livelihood and land use change. Statistical analysis of data derived from the National Census and the MODIS VCF collection

highlights that, in the 96 villages covered by the meta-analysis, accessibility (ACC) [1] is key to understanding local variations in poverty (POV_RAT), dependency ratios (DEP_RAT), literacy (LIT_RAT), access to services and infrastructure (S&I), school attendance (SCHOL_ATD), off-farm employment (OFF_FARM) and forest cover (FC2005) – see correlations in Table 6 and Figure 4.

Variables	DEP_RAT	SIMP_ETH	GEN_RAT_SCHOL	SCHOL_ATD	LI_RAT	POV_RAT	OFF_FARM	INF_MORT	CHIL_MORT	OUT_MIG	IN_MIG	S&I	ACC	FC2005	DEF_RAT
DEP_RAT	**1**	-0,020	0,190	**-0,425**	**-0,717**	**0,683**	**-0,344**	-0,048	0,009	-0,216	-0,113	**-0,546**	**0,404**	**0,380**	-0,116
SIMP_ETH	-0,020	**1**	-0,091	0,147	0,169	-0,049	0,235	0,190	0,133	-0,036	**0,300**	0,115	-0,206	-0,223	0,144
GEN_RAT_SCHOL	0,190	-0,091	**1**	0,129	-0,228	0,200	-0,136	-0,020	0,186	-0,090	0,084	-0,234	0,192	0,177	**-0,287**
SCHOL_ATD	**-0,425**	0,147	0,129	**1**	**0,737**	**-0,564**	**0,307**	0,149	0,064	0,226	0,245	**0,459**	**-0,561**	**-0,465**	0,032
LI_RAT	**-0,717**	0,169	-0,228	**0,737**	**1**	**-0,805**	**0,387**	0,114	-0,054	**0,268**	0,198	**0,676**	**-0,688**	**-0,580**	0,200
POV_RAT	**0,683**	-0,049	0,200	**-0,564**	**-0,805**	**1**	**-0,383**	0,007	0,208	**-0,273**	**-0,276**	**-0,665**	**0,637**	**0,482**	-0,158
OFF_FARM	**-0,344**	0,235	-0,136	**0,307**	**0,387**	**-0,383**	**1**	0,132	0,123	0,113	0,185	**0,567**	**-0,353**	**-0,395**	0,215
INF_MORT	-0,048	0,190	-0,020	0,149	0,114	0,007	0,132	**1**	**0,425**	-0,056	0,086	0,025	-0,032	-0,023	-0,052
CHIL_MORT	0,009	0,133	0,186	0,064	-0,054	0,208	0,123	**0,425**	**1**	-0,061	0,131	-0,131	0,176	0,012	-0,030
OUT_MIG	-0,216	-0,036	-0,090	0,226	**0,268**	**-0,273**	0,113	-0,056	-0,061	**1**	0,153	**0,275**	-0,138	-0,119	-0,068
IN_MIG	-0,113	**0,300**	0,084	0,245	0,198	**-0,276**	0,185	0,086	0,131	0,153	**1**	**0,319**	**-0,299**	-0,254	0,116
S&I	**-0,546**	0,115	-0,234	**0,459**	**0,676**	**-0,665**	**0,567**	0,025	-0,131	**0,275**	**0,319**	**1**	**-0,642**	**-0,606**	**0,362**
ACC	**0,404**	-0,206	0,192	**-0,561**	**-0,688**	**0,637**	**-0,353**	-0,032	0,176	-0,138	**-0,299**	**-0,642**	**1**	**0,659**	-0,255
FC2005	**0,380**	-0,223	0,177	**-0,465**	**-0,580**	**0,482**	**-0,395**	-0,023	0,012	-0,119	-0,254	**-0,606**	**0,659**	**1**	**-0,326**
DEF_RAT	-0,116	0,144	**-0,287**	0,032	0,200	-0,158	0,215	-0,052	-0,030	-0,068	0,116	**0,362**	-0,255	**-0,326**	**1**

Note: Underlined values represent statistically significant correlations at the 0.01 level

Table 6: Correlation matrix (Pearson): Data from the 2005 National Census and MODIS VCF (n = 96)

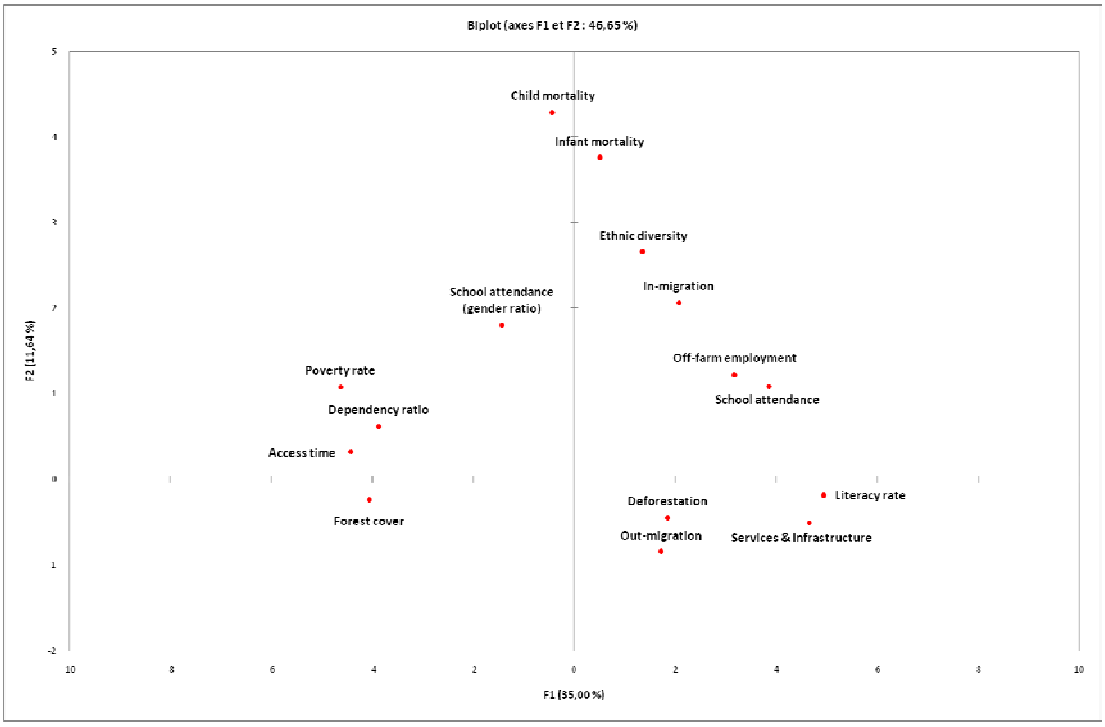

Figure 4: Principal Component Analysis (PCA): Data from the 2005 National Census and MODIS VCF (n = 96)

A Multiple Correspondence Analysis (MCA) of the data derived from the 45 case studies reviewed gives similar results. As illustrated by Figure 5, variations in poverty (POV), health (HEA), education (EDU), dependency ratios (DEP), capitalization levels (SAV), access to services and infrastructure (S&I) and forest cover (FC) appear structured along a gradient of accessibility – from villages that are only accessible by foot (ACC-1) to villages that are located near a permanent paved road (ACC-4).

[1] Accessibility (ACC) refers here to the average travel time in hours from one location to the nearest district centre.

Figure 5: Multiple Correspondence Analysis: Case study data (n = 45)

2. Typology of case studies and trajectories of change

Integrating the whole set of indicators into the statistical analysis provides further information on livelihood and land use variability and associated differentiation factors. In the following analyses, indicators were grouped into three categories:

- Structural variables (e.g. accessibility, tenure rules, population density, ethnicity…)
- Variables characterizing livelihood status (e.g. education, poverty, conflicts, migrations…)
- Variables characterizing land use status (e.g. forest cover, land quality, land rent…)

MCAs were carried out with the structural variables and the two other groups of indicators – livelihood and land use variables – were projected as supplementary inactive variables on the factorial axes. As illustrated by Figure 6 and Figure 7 (axis F1), alongside increasing accessibility (ACC), most of the variations between case studies follow a composite gradient of increasing population density (POP), decreasing dependency ratios (DEP), growing ethnic diversity (ETH), increasing state control and rule enforcement (RUL), land privatization (TEN), increasing access to services and infrastructure (S&I) and privatization of credit services (CRE). Significant variations also emerge on axis F2 mainly in relation with differing access to lowlands (%LO), different levels of rule enforcement (RUL) and ethnic diversity levels (ETH).

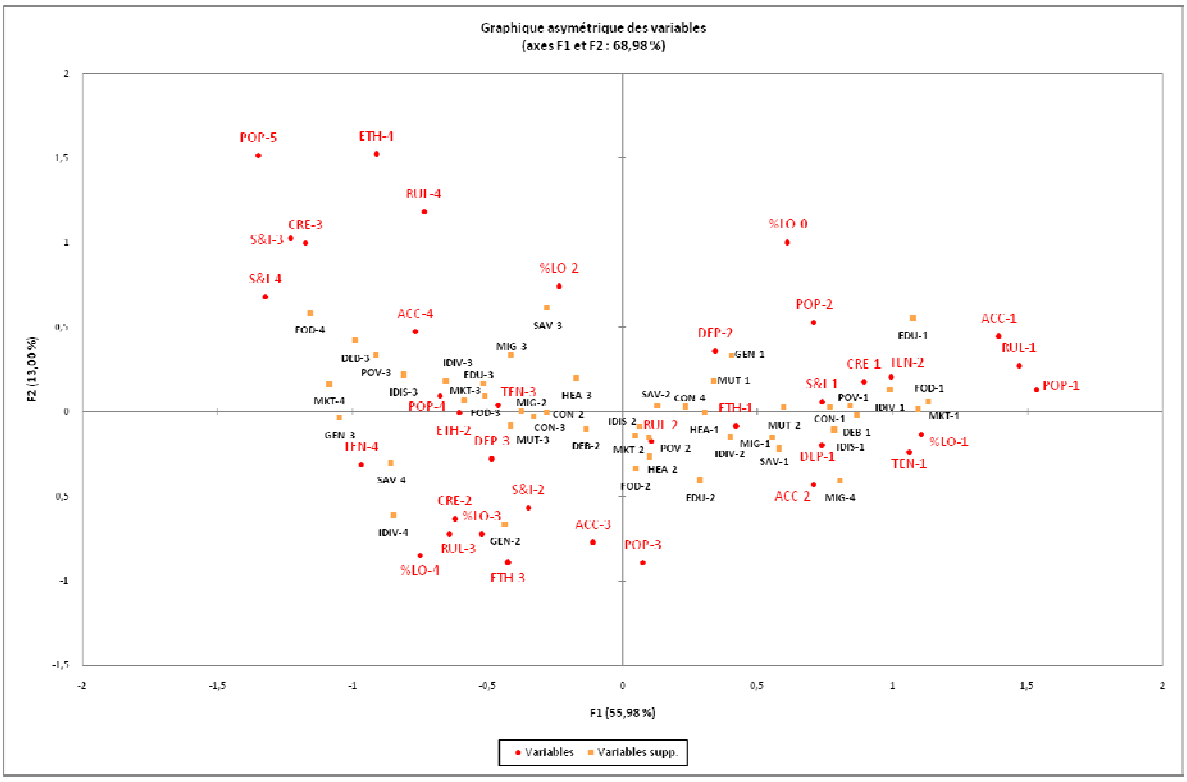

Figure 6: Multiple Correspondence Analysis: Livelihood indicators (n = 45)

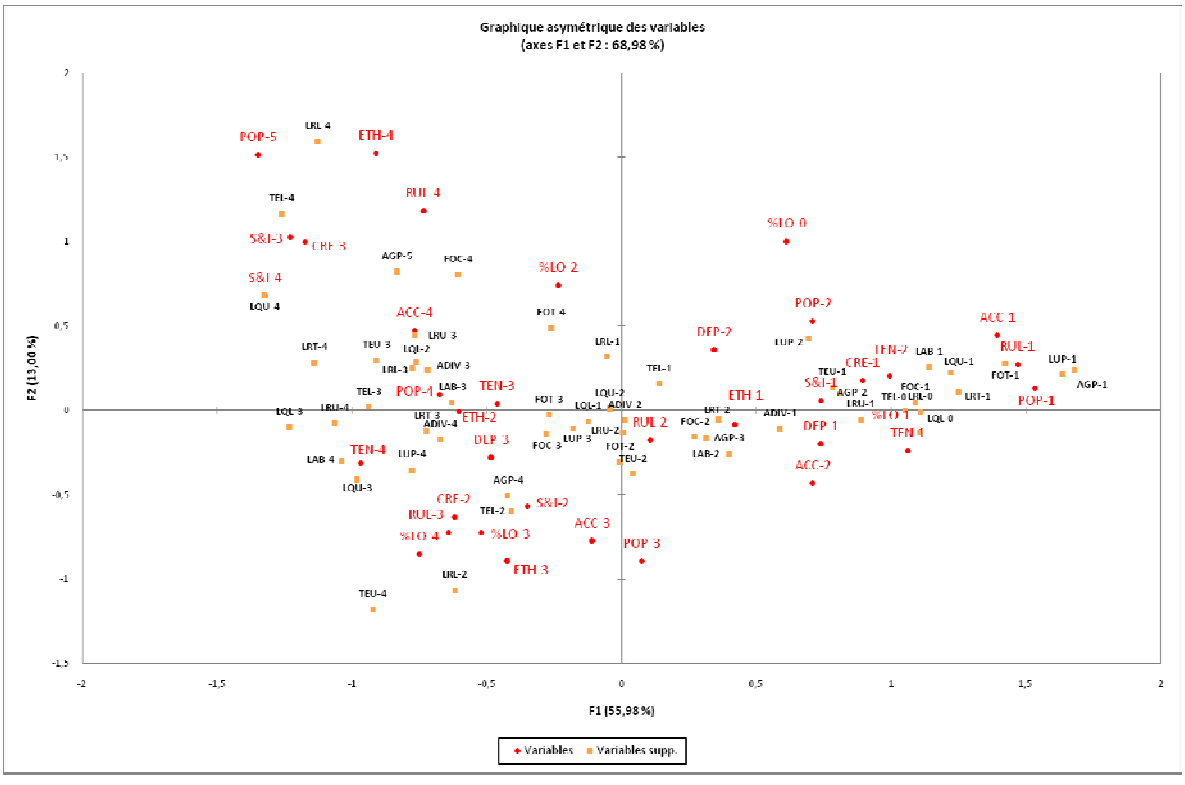

Figure 7: Multiple Correspondence Analysis: Land use indicators (n = 45)

On this basis, four main types of situations can be identified and described according to their livelihood and land use characteristics (Figure 8):

Type 1 corresponds to poorly accessible locations, with important autonomy of local governments, very low population densities, no access to water, electricity and phone networks and unregulated or

customarily regulated access to land. The economy is focused on subsistence (low diversity of agricultural production and incomes, low capitalization and high dependence on forest products), poverty rates are high and education levels very low. Landscapes are largely natural with an important forest cover that declines very slowly. Land rent and return to labour are very low with an agricultural sector characterized by extensive cropping systems and low value productions.

Type 2 corresponds to the 'mainstream' evolution pathway of Type 1villages as they gradually become more accessible, as population density increases, access to market, state services and infrastructures is enhanced, tenure rules change from open access to private property and state rule enforcement becomes stronger. Poverty rates decrease while the economy becomes more diversified and less dependent upon forest resources. Capitalization and education levels increase as do household debt and income disparities. Although Type 2 encompasses a diversity of land use trajectories (see below), the general trend is one of agricultural diversification, increased technological levels and land rent and decreased land quality (in both upland and lowland), increased agricultural pressure and return to labour, and segregation (after fragmentation) of the agricultural and natural landscapes. Depending on local land use strategies, two sub-types can be identified.

Type 2a reflects significant investments made on lowland agricultural production. With very important population densities and agricultural pressure and important upland degradation issues, lowland surfaces (not necessarily important) are used for growing high value crops through intensive cropping systems (e.g. mechanisation, irrigation, chemical inputs). While this trajectory does not appear to have specific impacts on livelihoods, it tends to favour a reforestation trend in heavily deforested upland areas. In contrast, **Type 2b** corresponds to an intensification of agriculture in the uplands. In a context of important agricultural pressure and notwithstanding important access to the lowlands, farm investment is mainly directed towards high value, intensive crops in the uplands. As a result, land rent and technological levels are particularly important in the uplands while the lowlands are used for traditional, subsistence productions.

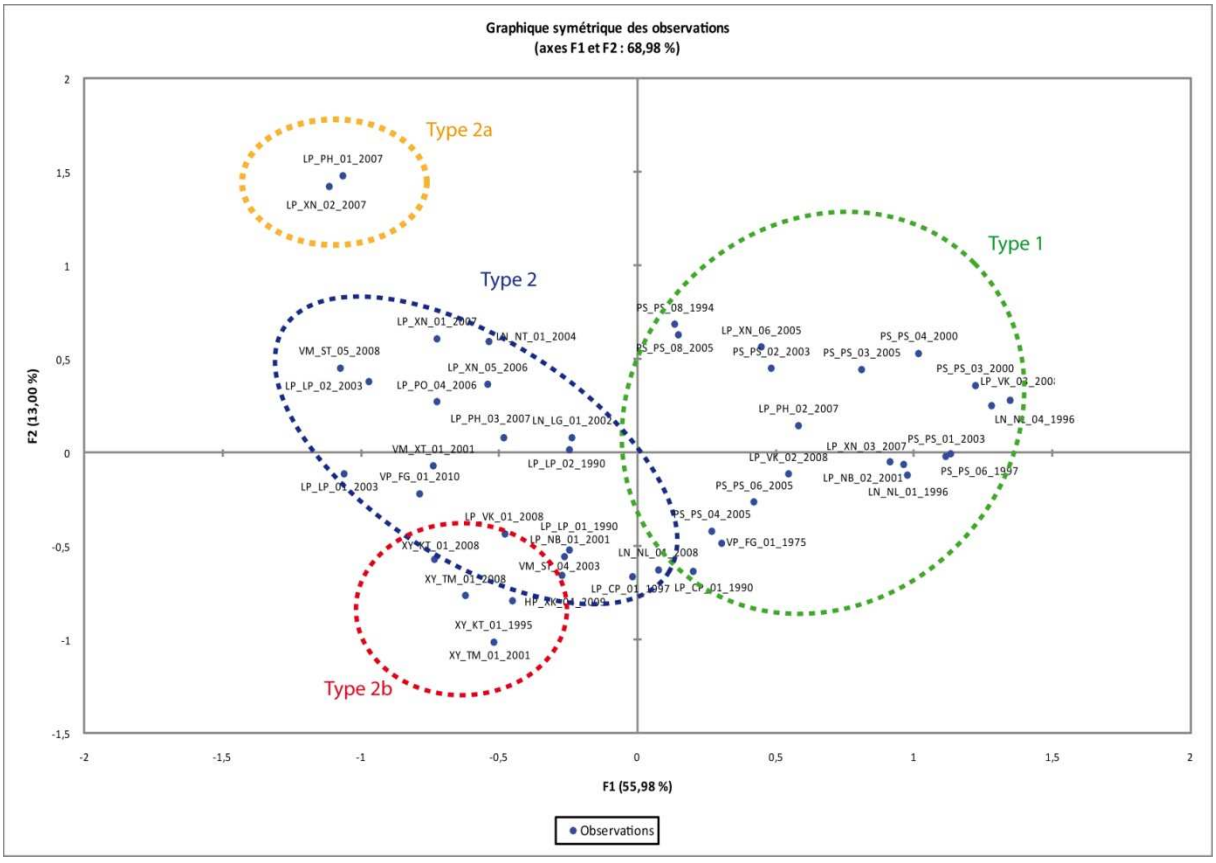

Figure 8: Multiple Correspondence Analysis: Case studies (n = 45)

In order to go beyond the influence of accessibility, we conducted separate statistical tests on the Type 1 and Type 2 populations. However, only Type 1 case studies present clear subdivisions (Figure 9):

Type 1a encompasses villages that have been relocated near a road or a river, where they enjoy better access to markets and successful economic diversification. Population density is very high but villagers have developed alternative activities like paddy cultivation, livestock farming, tea production or off-farm activities. **Type 1b** corresponds also to villages relocated in more accessible areas. However, with resettlement, access to agricultural land has become very limited while access to markets has remained relatively low. This type of village tends to experience massive out-migration (i.e. young villagers or entire households searching for off-farm opportunities and/or better access to agricultural land). Finally, **Type 1c** corresponds to highly remote locations where livelihood activities and the economy remain essentially focused on subsistence.

The arrow represents the evolution of a study site between 1994 and 2005. This village in Phongsaly district has been relocated closer to a road, which improved its access to markets.

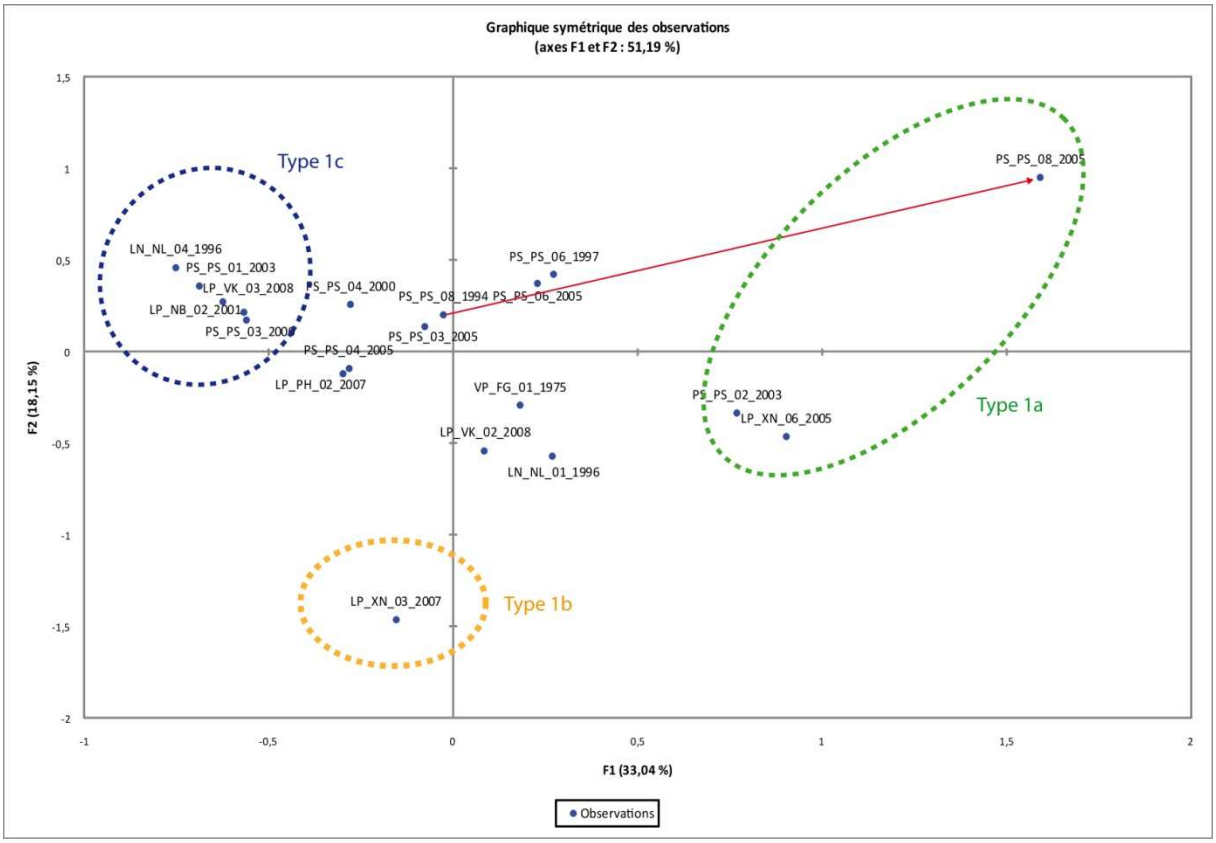

Figure 9: Multiple Correspondence Analysis: Sub-types 1 (n = 20)

Conclusion

Limits of our study

The study deals with fewer case studies than was initially expected, mainly due to time constraints and the lack of relevant information in research documents. Statistical tools allowing to handle missing data may help including more case studies. A greater number of cases would allow refining the evolutionary pathways and improving the statistical analyses. Therefore, more studies will be incorporated in the next stages. Appendix 1 provides a list of case study documents that could be included in the meta-analysis. The spatial distribution of the trends described in the result section above is not presented here. The combination of case studies and land use data at the national level will provide further insights in the drivers of changes and their impact on landscapes and livelihoods in places that have not been studied in detail but are covered by regional maps and census data.

Methodological achievements

The development of a database that could be made available online is a major outcome of our research. The database contains empirically grounded evidences on land use changes in Northern Lao PDR which could provide guidance for future development projects. More than a mere compilation of case studies, the database represents also a tool for further thematic studies, thanks to the diversity of indicators that were included in our research framework. Potentially, the database could be complemented by the research community in Lao PDR. Given the original coding method of our indicators on land use and livelihood changes, additional data and case studies could be integrated into the framework. The approach is particularly useful for making use of student research with long field work on a restricted study area which is often poorly disseminated. Generally speaking, our work provides a platform for improved researchers' collaboration on land use changes in Northern Lao PDR.

Policy implications

Many lessons can be drawn from this meta-analysis in term of land use policy, but we only provide here an example about how the framework could be used to support policy formulation. More detailed analysis based on the complete set of case study will be provided at a later stage. Our preliminary results show a major transformation of agricultural systems away from swidden, with a rapid diversification of agricultural productions and segregation of the agricultural and natural forested landscapes. Although many qualitative analyses have drawn similar conclusions, the meta-analysis outlines the intensity of these trends, their spatial distribution and their driving forces. Reduction in shifting cultivation can be related to many factors, such as improved access to market, increased population density and degraded land quality. It therefore appears inevitable. Since accessibility is the overarching driver of on-going changes, projects could invest in transportation infrastructures development in order to accelerate the transition to diversified and market-oriented activities as a way out swidden cultivation.

However, increased accessibility is also associated with to forest loss and land degradation. Therefore, rather than promoting further eradication of shifting cultivation, development projects should focus on buffering the potentially negative impacts of the rapid and inevitable agrarian transition. These impacts, such as degraded land quality, could be further studied and sustainable alternatives promoted. Improved education system in remote rural area could also represent a key buffer to prevent the next generations to enter into a spiral of poverty while reducing their dependence from forests and natural resources. Further monitoring of the status of the agrarian transition by continuing adding recent case studies to the framework presented here will help providing adapted policy responses (i.e. timely and locality specific) to emerging changes in the future.

References

Azadi H., Ho P., Hasfiati L., 2010. Agricultural land conversion drivers: a comparison between less developed, developing and developed countries. Land degradation and environment.

Belcher B., Ruiz-Pérez M., 2001. An International Comparison of Cases of Forest Product Development: Overview, Description and Data Requirements. CIFOR Working paper 23.

Byron N., Arnold M., 1999. What Futures for the People of the Tropical Forests?. World Development.

Cramb R., Pierce Colfer C., Dressler W., Laungnaramsri P., Trang Le Q., Mulyoutami E., Peluso N., Wadley R., 2009. Swidden Transformations and Rural Livelihoods in Southeast Asia. Human Ecology 37, 323-346.

Douangsavanh, 2004. Enhancing sustainable development of diverse agriculture in Lao PDR. CAPSA Working Paper No. 89.

Erout A., Castella J.C., 2004. Riz d'en bas, riz d'en haut : éléments structurants des systèmes de production agricole d'une province de montagne du nord du Vietnam. Cahiers Agricultures 13, 413-420.

Geist H., Lambin E., 2002. Proximate causes and underlying driving forces of tropical deforestation. Bioscience 52, 143-150.

Geist H., Lambin E., 2004. Dynamic causal patterns of desertification. Bioscience 54, 817-829.

Hansen, M., R. DeFries, J.R. Townshend, M. Carroll, C. Dimiceli, and R. Sohlberg (2006), Vegetation Continuous Fields MOD44B, 2001 Percent Tree Cover, Collection 4, University of Maryland, College Park, Maryland, 2001.

Lambin E., Geist H., Lepers E., 2003. Dynamics of land use and land cover change in Tropical regions. Environmental Resources 28, 205-241.

Messerli P, Heinimann A, Epprecht M, Phonesaly S, Thiraka C, Minot N, editors, 2008. Socio-Economic Atlas of the Lao PDR – an Analysis based on the 2005 Population and Housing Census. Swiss National Center of Competence in Research (NCCR) North-South, University of Bern, Bern and Vientiane: Geographica Bernensia.

Missehorn A., 2005. What drives food insecurity in southern Africa? a meta-analysis of household economy studies. Global Environmental Change 15, 33–43.

Mo L., 2005. Évolution de la composition du revenu des personnes âgées au Canada entre 1980 et 2002. Cahiers québécois de démographie, vol. 34, n° 1: 117-147.

NSC. 2004. The households of Lao PDR: Social and economic indicators - Lao Expenditure and Consumption Survey No. 3. Vientiane: State Planning Comittee, National Statistical Center.

Oldekop J., Bebbington A., Brockington D., Preziosi R., 2010. Understanding the Lessons and Limitations of Conservation and Development. Conservation Biology 24, 461-469.

Ostrom E., 2007. A diagnostic approach for going beyond panaceas. PNAS 39, 15181–15187.

Pagdee A., Kim Y.S., Daugherty P.J., 2006. What Makes Community Forest Management Successful: A Meta-Study From Community Forests Throughout the World. Society and Natural Resources 19, 33-52.

Rigg J., 2005. Living with transition in Laos. Routledge.

Rudel T., 2008. Meta-analyses of case studies: A method for studying regional and global environmental change. Global Environmental Change 18, 18-25.

Ruiz-Pérez M., Byron N., 1999. A Methodology to Analyze Divergent Case Studies of Non-Timber Forest Products and Their Development Potential. Forest Sciences 45, 1-14.

Schmidt-Vogt D., Leisz S., Mertz O., Heinimann A., Thiha T., Messerli P., Epprecht M., Van Cu P., Kim Chi V., Hardiono M., Dao T., 2009. An Assessment of Trends in the Extent of Swidden in Southeast Asia. Human Ecology 37, 269-280.

Sommer L., 2010. Auswirkungen von politischen Einflüssen auf die Landnutzung im nördlichen Laos.. Geographisches Institut, Universität Bern.

Sonderegger G., 2010. Understanding the impact of market forces on land use changes in Laos, A meta-analysis of case studies. Geographisches Institut, Universität Bern.

Tallis H., Goldman R., Uhl M., Brosi B., 2009. Integrating conservation and development in the field: implementing ecosystem service projects. Frontiers in Ecology and the Environment 7(1), 12–20.

Umemiya C., Rametsteiner E., Kraxner F., 2010. Quantifying the impacts of the quality of governance on deforestation. Environmental Science & Policy, doi:10.1016/j.envsci.2010.07.002.
Valbuena D., Verburg P., Bregt A., 2008. A method to define a typology for agent-based analysis in regional land-use research. Agriculture, Ecosystems and Environment 128, 27-36.
Vedeld P., Angelsen A., Sjaastad E., Kobugabe Berg G., 2004. Counting on the Environment Forest Incomes and the Rural Poor. The World Bank Environment Department.

Table of figures

Appendix 1: list of documents

Development of the comparative framework

Cherief M., 2010. Impact des dynamiques paysagères sur la biodiversité et les usages locaux sous l'effet des réformes agraires dans le bassin versant de la Nam Khan (Laos). Université d'Angers.

Ducourtieux O., 2006. Du riz et des arbres. PhD thesis, Institut National Agronomique Paris-Grignon.

Fitriana Y., 2008. Landscape and farming system in transition. Master thesis, IRD-Institut des Régions Chaudes, SupAgro Montpellier.

Gabeloux M., 2007. Dynamiques d'exploitation des ressources naturelles dans le bassin versant de la Nam Khan. Master thesis, Université Montpellier 2 Sciences et Techniques du Languedoc.

Guemas M., 2007. Un environnement sous contrainte. Master thesis, IRD-Université UCPP Poitiers.

Lestrelin G., 2009. Changing lives, changing nature(s). PhD thesis, Durham University.

Sany J.P., 2008. Etude des dynamiques d'utilisation des terres dans le bassin versant de la Nam Khan au Nord du Laos. Master thesis, IRD-SupAgro Montpellier.

Viau J., Keophosay A., Castella J.C., 2009. Impact of maize expansion on traditional rice production systems in Northern Lao PDR. A case study in Xiengkhor district, Huaphan province. Catch-Up Programme, NAFRI, Vientiane, Laos.

Included in the meta-analysis

Alberny E., 2009. Dynamics of rubber plantation in Lao PDR. Master Thesis MSc SUTROFOR, Montpellier.

Alexander K., 2007. Agricultural change in Lao PDR: Pragmatism in the face of adversity. PhD thesis, Charles Sturt University.

Alexandre J.L., Eberhardt N., 1998. Des systèmes agraires de la rive gauche de la Nam Ou. CCL.

Alton C., Bluhm D., Sananikone S., 2005. Para rubber study. Lao - German Program Rural Development in Mountainous Areas of Northern Lao PDR.

Alton C., Rattanavong H., 2004. Service Delivery and Resettlement: Options for Development Planning. UNDP/ECHO, Vientiane.

Baudran E., 2000. Derrière la savane, la forêt. CCL.

Chanthavong N, Xayleuxong K., Chitpanya S., Badenoch N., Keonakhone T., 2009. Rubber institutions in Ban Hat Nyao: Managing trees, markets and producers. NAFRI.

Chatenet M., 2005. Le potentiel écotouristique de la vallée de la Nam Khan. Programme UNL/IRD – UR 168.

Daviau S., 2004. Developpement, modernité et relocalisation: Etude de cas de la zone focale de la Namma, district de Long, Luang Namtha. Master thesis, Université de Montréal.

Daviau S., 2005. Etude de l'impact du PDDP sur la pratique des cultures de défriche-brûlis et sur l'évolution du couvert forestier dans le district de Phongsaly. PDDP.

Evrard O., 2006. Chronique des cendres. Anthropologie des sociétés khmou et dynamiques interethniques du Nord-Laos.. IRD Editions.

Funke I. E., 2001. Analysis of Land Allocation and implications on land management: A case study of two villages in Sang Thong district, Vientiane municipality, Lao PDR. Master thesis, Dresden University of Technology.

Kashio M., Johnson D., 2001. Monograph on Benzoin. Food and Agriculture Organization of the United Nations, Regional Office for Asia and the Pacific, Bangkok, Thailand.

Kousonsavath T.P., Lemaitre E., 1999. Bassin versant de la Nam Chan. CCL.

Gurung H., H.Bhandari, M. L. Velasco, T. Keonakhone, S. Pandey, O. Velarde, and B. Samson. Poverty, water, and livelihoods: A case of two upper-catchment villages in the northern Lao PDR. IRRI, NAFREC, Luang Prabang.

Laffort J.R., 1998. Des tracteurs dans les vallées. CCL.

Laffort J.R., Jouanneau R., 1997. Deux systèmes agraires de la province de Phonsaly. CCL.

Louzé A.-F., 2006. L'éradication de la culture du pavot en RDP Lao : Etude de ses répercussions socioéconomiques au niveau du village de Choka May (Province de Phongsaly). Master thesis, IRD-Université Paris 1.

Manivong V., R. A. Cramb, 2008. Economics of smallholder rubber expansion in Northern Laos. Agroforest Systems 74: 113-125.

Manivong V., R. A. Cramb, 2008. The Adoption of Smallholder Rubber Production by Shifting Cultivators in Northern Laos: A Village Case Study. in Snelder D.J. and Lasco R.D. Smallholder Tree Growing for Rural Development and Environmental Services, chap 5, Springer.

Meknapapong P., 2008. Condition and Value of Secondary Forest in Lao PDR. Master thesis.

Monnot M., Ortega R., 2010. Diagnostic agraire du bassin de la Nam Lik, District de Fuang, Province de Vientiane, République Démocratique Populaire Lao. CCL.

Pasquet J., 2002. Les rizières au-delà des montagnes. CCL.

Sacklokham S. Degoul D., 2001. Une agriculture à la limite de sa capacité?. CCL.

Slaats J., Lestrelin G., 2010. Improving cropping systems by introducing conservation agriculture. PASS, PRONAE.

Thapa G. B., 1998. Issues in the conservation and management of forests in Laos: the case of Sangthong district. Asian Institute of Technology, Bangkok, Thailand.

Document to be included in further work

Bouahom B., Douangsavanh L., Rigg J., 2004. Building sustainable livelihoods in Laos: untangling farm from non-farm, progress from distress, Geoforum 35 (2004) 607–619.

Boupha L., Phimmavong S., 2006. Laos Resource Mapping and Farmer Input Market - Bamboo study.

Darr D., 2003. Farm forestry in semi-subsistence and monetary economies and its interdependency with the land tenure system - Case studies from central Laos, .

Daviau S., 2003. Land tenure, Livelihood and Natural Resource Management in Rmeet and Khmu Rok Communities , Concern Worldwide.

Dirou S., 2006. Can participation affect "community forestry" project performance?. Master thesis, IRD-Engref.

Douangsavanh L., Bouahom B., 2006. Pathways out of Poverty through Maize and Job's Tear in Lao People's Democratic Republic. CAPSA Working Paper No. 92.

Douangsavanh L., Phouyyavong K., 2009. Food Security and Biodiversity in the upland Lao PDR: A Review on Recent situation of Causes and Effect. .

Fujita Y., Phanvilay K., 2004. Land and Forest Allocation and Its Implication on Forest Management and Household Livelihoods: Comparison of Case Studies from CBNRM Research in Central Laos. Tenth Biennial Conference of the International Association for the Study of Common Property, Oaxaca, Mexico.

Haberecht S., 2009. From Rice to Rubber. Development, Transformation, and Foreign Investment in Northern Laos – an Actor-Oriented Approach. Diploma thesis, University of Bielefeld.

Jobard E., 2008. Assessing the socioeconomic impacts of conservation agriculture adoption in Xieng Khouang Province, Lao PDR.. MSc Dissertation, IRD-AgroParisTech, Vientiane.

Joseph A., 2007. Changements agricoles dans le nord du Laos : Perceptions villageoises, impacts sociaux et environnementaux. Master thesis, IRD-Ecole Nationale d'Agronomie de Rennes.

Moser P., 2008. Livelihood transitions in upland Lao PDR in the light of changing policies. Can traditional rural institutions be maintained?. Diploma thesis, Universität Wien.

Thongmanivong S., Fujita Y., 2006. Recent Land Use and Livelihood Transitions in Northern Laos. Mountain Research and Development Vol 26 No 3: 237–244.

Thongmanivong S., Fujita Y., Fox J., 2005. Resources use dynamics and Land Use Change in Ang Nhai Village and Phou Phanang National Reserve Forest, Lao PDR. Environmental Management Vol. 36, No. 3, 382-393.