



Integrating ecosystem services into agricultural land use analysis and planning in Mondulhiri Province, Cambodia

Asikin Yoeu

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THÈSE

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Docteur

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Présentée par Asikin YOEU

**INTEGRATING ECOSYSTEM SERVICES
INTO AGRICULTURAL LAND USE
ANALYSIS AND PLANNING IN
MONDULKIRI PROVINCE, CAMBODIA**

Soutenue le 06 Decembre 2016 devant le jury composé de

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MONTPELLIER SUPAGRO

Ecole Doctorale Economie et Gestion de Montpellier

**INTEGRATING ECOSYSTEM SERVICES
INTO AGRICULTURAL LAND USE
ANALYSIS AND PLANNING
IN MONDULKIRI PROVINCE, CAMBODIA**

Dissertation presented and publicly defended by

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for the degree of a PhD in Economics

Montpellier, 06 December 2016

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ces opinions doivent être considérées comme propres à leur auteur.

ABSTRACT

The concept of ecosystem services (ES) is helpful to assess the benefits of policies that influence both the production of goods and services as well as the environmental conditions in which human societies are situated. In the rural sector, while addressing the trade-offs between agricultural production and the other services is now becoming common for a given stage of the land use at a precise date and for a specific region, this theoretical framework is more rarely used to measure their transformations over time and space. This dissertation generally looks at the provision of different ES in the province of Mondulakiri in Cambodia as the result of changes in the land uses, ultimately aiming at identifying feasible solutions for the possible challenges rose by the trade-offs between the different services. The combined impact of these changes on the agricultural production taken globally is appraised by using the land policies and the rubber market prices as the main variables. The results show the powerful drive of the rubber market to explain the changes in land use, the land policies demonstrating a lower impact, or more visible when the prices of the rubber are high when they decrease as it is the case nowadays. Farming systems that are the most efficient economically for the producers and ecologically in terms of ES provision, are systems in which farmers combined shifting cultivation in the mountain with cassava production in the plain. Finally, the possible strategies to mitigate trade-offs in provision of ES are evaluated and compared. The benefits and costs of the land use and ES management are measured along several designed scenarios. The findings of this study indicate that the policy favoring large-scale concessions may result in several positive effects, while only when the rubber prices are high. The analysis of the land use foresight based on various tested scenarios and their impact suggests that in some cases, the value-added of crops may be high enough to generate a positive income, but the compensation for environmental losses and opportunity costs are still uncertain. This seems to be particularly the case of rubber compared to other alternative land uses including forest or shifting cultivation. In all these cases, the scenarios may serve as a transparent framework to ensure that decisions are based on assessments that consider ecosystem trade-offs in the future.

Keyword: Ecosystem service, land use policy, planning, trade-off, farming systems, Mondulakiri, Cambodia

RÉSUMÉ

Le concept de service écosystémique est souvent utilisé pour évaluer des politiques publiques qui ont un impact à la fois sur la production agricole et sur les conditions environnementales dans lesquelles sont situées les sociétés qui les portent. En milieu rural, si traiter de l'utilisation des terres en termes de compromis entre besoin de production agricole et nécessité de préserver les autres services écosystémiques devient une approche courante pour une région et à une date précisément définis, il est plus rare que ce cadre théorique se trouve mobilisé pour évaluer des transformations dans le temps et des dynamiques spatiales. Cette recherche s'intéresse à l'offre de différents services écosystémiques dans la province de Mondulakiri au Cambodge, ceux-ci étant considérés comme le résultat de transformations passées dans l'utilisation de l'espace, dans le but ultime de cerner les solutions possibles aux défis soulevés par les compromis entre ces services. L'impact combiné de ces changements sur la production agricole, considérée globalement, est apprécié en utilisant les politiques foncières et le marché du caoutchouc comme variables principales. Les résultats de la prospective qui en est tirée confirment le caractère surdéterminant des prix du caoutchouc pour expliquer les transformations de l'utilisation de l'espace. Les politiques foncières ne présentant qu'un impact plus limité, davantage visible lorsque les prix sont hauts que dans les creux de cycle, comme c'est le cas actuellement. Les systèmes de production agricole qui s'avèrent les plus efficaces économiquement pour les agriculteurs de la région apparaissent ceux combinant agriculture de défriche-brûlis sur les piémonts avec la production de manioc dans les plaines. En définitive, les stratégies envisageables pour réduire ce compromis entre services sont évaluées et comparées. Les bénéfices et les coûts liés à l'utilisation de l'espace et à la gestion des écosystèmes sont évalués et comparés en fonction de plusieurs scénarios. Les résultats de cette prospective montrent qu'une politique qui favoriserait les grandes plantations présenterait des impacts économiques positifs, mais seulement lorsque les prix du caoutchouc sont élevés. L'analyse des prévisions d'utilisation des sols selon les différents scénarios et l'anticipation de leur impact suggère que, dans certains cas, la valeur ajoutée des cultures peut être suffisamment élevée pour conduire à un revenu positif, mais les compensations pour les dégradations environnementales et les coûts d'opportunité demeurent incertains. En particulier, tel est le cas de la plantation d'hévéa en comparaison d'autres alternatives d'utilisation de l'espace, en particulier le maintien de la forêt ou les cultures de défriche-brûlis. Dans tous ces cas, la construction des scénarios offre un cadre transparent pour permettre que les décisions publiques puissent être basées sur des évaluations qui prennent en compte les projections de compromis environnementaux.

Mots clés: Services écosystémiques, politiques foncières, planification, compromis, systèmes de production agricoles, Mondulakiri, Cambodge

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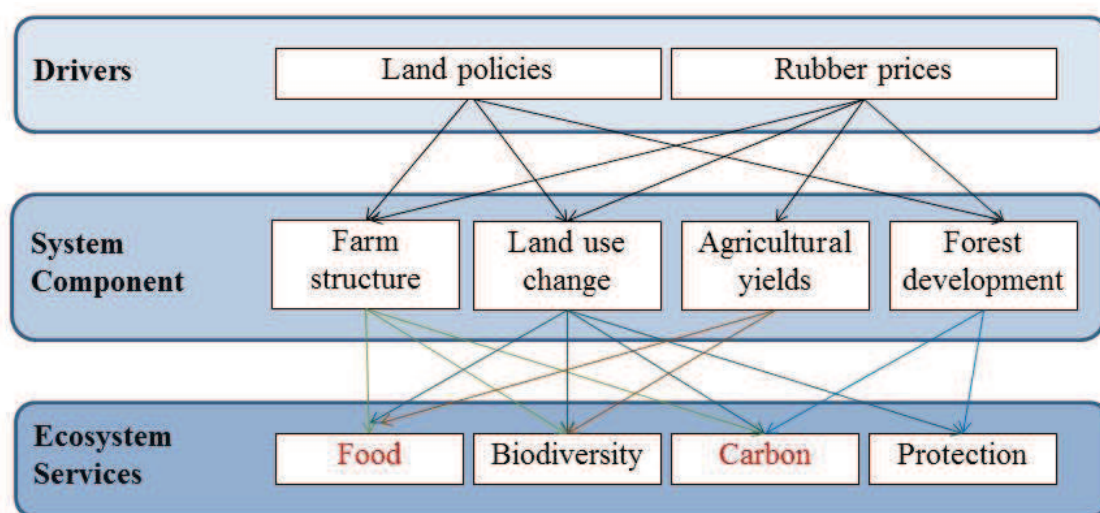


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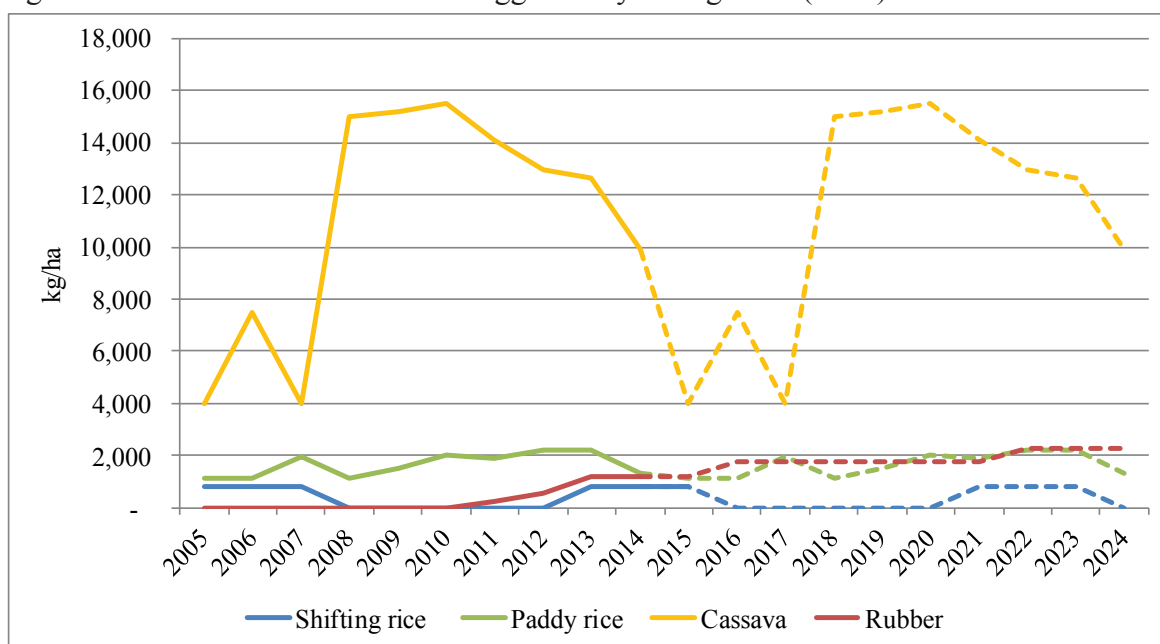


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LIST OF ABBREVIATIONS

ADB	Asian Development Bank
AIPP	Asia Indigenous People Pact
ASB	Alternative to Slash-Burn
ASDPs	Agricultural Sectoral Strategic Development Plans
ASEAN	Association of Southeast Asian Nations
C	Carbon
C	Cassava
CA	Cellular Automata
CBA	Cost-Benefit Analysis
CAP	Common Agricultural Policy
CDRI	Cambodia Development Research Institute
CF	Community Forest
CLUE	Conversion of Land Use and its Effects
CO ₂	Carbon Dioxide
CIAT	International Center for Tropical Agriculture
CTOs	Certified Tradable Offsets
DC	Depreciation Cost
EBA	European Banking Authority
EC	European Commission
EDS	Ecosystem Dis-services
ELCs	Economic Land Concessions
ES	Ecosystem Services
EU	European Unions
FA	Forest Administration
FAO	Food and Agriculture Organization
FCPF	Forest Carbon Partnership Facility
FGDs	Focus Group Discussions
FI	Farm Income
FPP	Forest Peoples Program
FONAFIFO	Fondo Nacional de Financiamiento Forestal
GDP	Gross Domestic Product
GHG	Green House Gas
GO	Gross Output
GVA	Gross Value-Added
Ha	Hectare
IAD	Institutional Analysis and Development
IC	Intermediate Cost
IPs	Indigenous Peoples
IPCC	Intergovernmental Panel on Climate Change
ISFR	Independent Forest Sector Review
KOICA	Korea International Cooperation Agency
LbP-F	Labor Productivity at Farm scale
LbP-P	Labor Productivity at Plot scale
LdP-F	Land Productivity at Farm scale
LdP-P	Land Productivity at Plot scale
LTER	Long-Term Ecology Research
LUCC	Land-Use and Cover Change
LULC	Land Use and Land Cover
M	Khmer Immigration
MA	Millennium Ecosystem Assessment

MAFF	Ministry of Agriculture, Forestry and Fisheries
MLMUPC	Ministry of Land Management, Urban, Planning and Construction
MoE	Ministry of Environment
MoT	Ministry of Tourism
MRD	Ministry of Rural Development
NGO	Non-Governmental Organization
NIS	National Institute of Statistic
NPV	Net Present Value
NRC	National Research Council
NTFPs	Non-Timber Forest Products
ODC	Open Development Cambodia
OECD	Organization for Economic Cooperation and Development
P	Paddy rice
PDR	People Democratic Republic
PES	Payment for Ecosystem Services
PESP	Payment for Environmental Services Program
PRK	People's Republic of Kampuchea
RGC	Royal Government of Cambodia
REDD	Reduction Emission from Deforestation and forest Degradation
REDD+	Reduced Emissions from Deforestation and forest Degradation, conservation, sustainable forest management and enhancement of forest carbon stocks
S	Shifting
SINAC	Costa Rica's National System of Conservation Areas (Sistema Nacional de Áreas de Conservación)
SREAS	Special Report on Emission Scenarios
SOC	Social of Cambodia
SONEXIM	Cambodia's National Import-Export Society
SRI	System of Rice Intensification
TEC	Total Ecosystem Carbon
TEV	Total Economic Value
UN	United Nations
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNESCAP	United Nations Economic and Social Commission for Asia and Pacific
UNICEF	United Nations Children Funds
USAID	United States Agency for International Development
USD	United States Dollar
USDA	United States Department of Agriculture
WCS	World Conservation Society
WTO	World Trade Organization

CHAPTER 1: GENERAL INTRODUCTION

CHAPITRE 1: INTRODUCTION GÉNÉRALE

CHAPTER 1: GENERAL INTRODUCTION

1.1 BACKGROUND OF STUDY

The development of large-scale land concessions, mostly driven by foreign direct investment, has been quite massive in the Mekong region countries, more specifically in Cambodia, Lao PDR, and Myanmar (Castellanet and Diepart, 2015). Rudel and Roper (1996) described a process of frontier colonization with sequences of poverty (refers to the ecological marginalization of farmers who have lost their resource entitlements) and capital driven deforestation (refers to public or private investments to develop the frontier for political, economic, or social reason).

The causal variables of land use change are proximate factors (Turner, Lambin and Reenberg, 2007), for instance immigration, subsistence farmers' impacts, deforestation, or local common property resource management strategies (Lambin and Geist, 2006) and more distant factors, such as national policies, that tend to be difficult to connect empirically to land use change outcomes.

National government policies to liberalize trade and market access to or from the villages have been the most active triggers initiating land use change in upland areas (Fox, Vogler and Poffenberger, 2009; Mellac, 2014). For instance, land governance is a significant scaled issue, involving broad level influences at the global, regional, national and local scales (Hirsch and Scurrah, 2015). Number of land grabbing and conflicts have increasingly gained attention over the last years (Bues, 2011). Various factors have for sure increased the problems, such as poorly defined access rights to land for different stakeholders, or overlapping responsibilities of the public institutions to issue concessions (Un and So, 2011; Sperfeldt, Tek and Billy, 2012). These conflicts and tensions have raised the image of this far-east as either a battlefield for land or as a desert of institutions in which a handful of capitalist entrepreneurs were competing for logging the forest, and, occasionally, for planting rubber in the deforested lands.

Geist and Lambin (2002a) show that deforestation is best explained by multiple factors and drivers acting synergistically rather than by any single factor, with more than one-third of the cases they look at being driven by full interplay of economic institutional, technological, cultural and demographic variables. Institutional factors are involved in 78 percent of the deforestation cases. These mainly include formal pro-deforestation measures such as policies on land use and economic development as related to colonization, transportation, or subsidy for

land-based activities. As a general cause of deforestation (e.g. Deacon, 1994; Mendelsohn and Michael, 1995), property rights issues tend to have ambiguous effects upon forest cover: insecure ownership, quasi-open access conditions, maladjusted customary rights, as well as the legalization of land titles, are all reported to encourage deforestation.

In such a regional context, Cambodia has often been described as a demographically saturated “inner country”, on the alluvial plains of the Mekong and the Tonle Sap Lake, with less than one hectare of land available per rural family, surrounded by an upland “empty Cambodia” where the population density was, before 2002, ten times lower. As a consequence, the forest cover in Cambodia has long been mainly located in the north, the east and in the south-west of the country where the population densities were lower.

The development of large-scale land concessions, largely driven by foreign direct investment, has been quite massive in the Mekong region countries, more specifically Cambodia, Laos, and Myanmar (Castellanet and Diepart, 2015). In Cambodia, the land conversion is mainly for industrial investments, plantation or industrial farming-involving high specialization, high input of capital, mass production and application of modern techniques- a completely different system compared to small-scale farming. The so-called ‘Economic Land Concessions’ (ELCs) were created by the Land Law (2001) and Sub-Decree No. 146 (2005) for this kind of investment. The government has claimed that agricultural development was a priority, citing the aims of ensuring food security, providing raw materials for industry, increasing exports and creating employment (Sokheng, 2009).

Rubber plantations in countries such as Cambodia pose a serious threat to the region’s wildlife and wider ecosystems, especially concessions have been given to rubber producers in supposedly protected areas. For instance, according to World Resource Institution, global rubber prices were surging around 2010, the year Cambodia lost the greatest forest cover, and peaked in 2011 before falling again (Harfenist, 2015), whereas the ELCs have been given and issued to investors and smallholders. Despite the promising trends in the country’s rubber industry, a number of challenges could weaken the competitiveness and marketability of Cambodian rubber. One such issue is the growing surplus of rubber worldwide, which is steadily decreasing the demand for Cambodian rubber (Natividad, 2015). As overall observation, rubber prices are now so low that many industrial players as well as small stakeholders-are starting to convert their rubber fields to crops that are currently experiencing high prices such as pepper or cassava (Khum, 2016). They are very concerned with what will happen if the price does not pick up over the next few years?

Meanwhile, in an attempt to control illegal logging, the government also introduced a concession system in the forest areas. Whereas investors have demonstrated ability to promote their own interests, they have rarely been in line with the production of common goods. The consequences of the extension of the concessions included widespread damage to these forests (World Bank, 2000) and cost to the indigenous groups, since it accelerated legal and illegal logging, and it threatened the access of indigenous people (IP) to their traditional land, with consequences on their traditional culture and livelihoods. During the first half of 2010, more than 3,500 families were affected by land grabbing (Human Rights Watch, 2011).

The northeast margins of Cambodia represent such a situation. For historical reasons particularly, the population density is ten times lower in Monduliri province than in the overpopulated central plain. Rural immigration has been active for 30 years and dynamics of deforestation by the indigenous population, immigrants and private investors, results in fast changes in the agricultural production and in the environment. Crucially, little is known about trade-off between ecosystem services within various types of land use in Monduliri province, especially about the consequences of the replacement of forest and long-fallow shifting agricultural systems by permanent agriculture, to provide convincing evidence as to which land cover/land use offers the more valuable services.

The concept of ecosystem services is helpful to assess the benefits of policies which impact both the production of goods and services and the environmental conditions in which human societies are situated (MA, 2003a). In the rural sector, while addressing the trade-off between agricultural production and the other services is now becoming common for a given stage of the land use at a precise date and for a precise region, this theoretical framework is more rarely used to assess their transformations over time and space.

However, ecosystem services' values are not yet effectively incorporated in actual planning and design processes, although awareness of administrations on these important resources is rising and indicator inventories measuring the performance of ecosystems are emerging (Hayek, Neuenschwander and Grêt-Regamey, 2012). Particularly in the regions where rapid land use changes generate increasingly complex and unsustainable environments, multiple trade-offs have to be made between socio-economic and ecological variables. There is therefore a need for new tools supporting better integration of the ecosystems' services into planning and enabling effective trade-off decision-making for balancing social, ecological and economic aspects of landscape (De Groot *et al.*, 2010).

1.2 OBJECTIVE OF STUDY

Historically, land use situations of upland Cambodia clearly undertook as a rapid change due to land use reform policies of the government from the 2000s. The conversion of land use for from food crops production to other uses, the ongoing expansion of the cultivated area, and the situation of unused or under-used cropland has not achieved sustainable increases in productivity and to provided sufficient quantities of quality foods. Little attention has been paid to effective governance and supportive services, land use planning and land management. Population growth, together with increasing migration of land users has increased tension in respect of access to farming land and land ownership. Significant changes in land use, especially on fragile, erosion-prone soils in upland areas, along with watersheds, are other issues of concern (Seng, 2014).

The dissertation is mainly to looking at the provision of different ES in Mondulkiri province as the result of changes in the land uses, ultimately aiming at identifying feasible solutions for the possible challenges rose by the trade-offs between the different services. For this assignment and exercise, it was mainly to understand the historical change in policies or instructions as well as institutions of the country; to determine the driver of changes; and design the different scenarios for future planning of land use by integrating ES provision. The model was complemented by farm scale, local community, provincial level that allow for the assessment of different land policies options and farm strategies that may overcome trade-offs in provision of different ES. Specifically, this dissertation is seeking to answer the following research questions:

1. What are the determining factors for change in land use and the provision of ES?
2. What are trade-offs in the provision of different ES and are there trade-offs affected by the change in policies?
3. On farm level, what are the possible strategies that contribute to mitigate trade-offs in the provision of ES?

Hypothesis and Objective 1

Cambodia experienced a first round of modest redistributive land reforms in the early 1980s. These reforms, however, remained incomplete with serious issues remaining with respect to land titling and Land Laws pertaining to land transactions. Furthermore, over the last three decades, landlessness has re-emerged in Cambodia due to population pressures and land alienation amongst the peasantry. The 2001 Land Law and 2005 Sub-Decree set out the

procedures, mechanisms, and institutional arrangements for offering economic land concessions (ELCs), with the objective of improving crop diversity, productivity, and employment, among other benefits. In addition, the 2001 Land Law, the 2002 Forestry Law recognized indigenous communities' rights to collective ownership on their traditional land. Herewith, the general question is preliminarily to assess whether policy on ELCs may have had positive impacts on economic outputs rather than on environment while policy on collective titles produced high ES. Internal threats like the increasing the pressure on land resources, due to uncertain land ownership and unsecured tenure as well as external shocks caused by global recession or climate change issues such as increased floods and droughts in recent years also pose major challenges to Cambodia's thriving agricultural development (Mund, 2011).

We assumed that the land use changes depend on the public policies, especially the land and the forest, which have been developed in the 1990s and the 2000s. The allocation of concessions should have strong influence on the land use and ES, while the access to the right of indigenous communities is also essential to explain the current land use and the perspective scenarios. The study seeks to answer the questions: why and how the current situation has been historically generated; what were the consequences of the successive policies on the land rights of the stakeholders, hence on the migrations and the population growth, and finally how one can use this knowledge to assess the potential political choices by looking forward to their possible impacts. Thus, the objective firstly is to analyze the role of the demographic factors as well as the changes of the institutional framework that occurred in the period, particularly with regard to the access to land. We assess then the combined impact of these changes on the agricultural production taken globally, using the land policies and the rubber market prices as the main variables.

Hypothesis and Objective 2

At the heart of the problem, transformation is needed from a primarily subsistence-oriented agriculture, characterized by low use of inputs and low returns to land, to a more intensive agriculture, probably more commercially oriented. Given that the agricultural sector is dependent mainly on family based rice production, converting smallholder households into an emerging class of commercial farmers is of strategic importance. For such a transformation remains large, yet the capacity to modernize and benefit from the opportunities of an evolving market economy seem limited. As a result, there are major obstacles, ranging from the poor

physical infrastructure resulting in high transport costs and poor market integration, to low levels of education, training in new techniques and imperfect or virtually non-existent rural credit and insurance market (Van Acker and Sint-Ignatius, 1999). In addition, the specific topography of Cambodia may put a number of natural resource obstacles in the way of a sustained intensification. Overcoming these bottlenecks will be the main key for achieving sustained rapid economic growth based on expansion of increasingly productive employment opportunities. Attempts to increase production to meet demand could generate more environmental damages. Understanding the relation among population, technology, and resources embedded in the interpretation of such agricultural intensification remains a fundamental problem confronting the human sciences (Dobermann *et al.*, 2013).

These relationships are critical to the question of agricultural change in Monduliri province of Cambodia. The study has generated a “hypothesis” on farm level, the strategies of farmers are very diverse according to the social groups (Khmer and IP) and the means of production (land, capital, labour...). Each strategy can be essential to explain its contribution to the land use and ES. The global change can be better understood by looking at the strategy of various groups. What are the factors of the changes? What are the natures of change? Are those changes the same for everyone? What are the impacts and will the changes be sustainable? We explore and assess the diversity of the ethnic, social and economic situation of different households. At the level of the production units, the strategies of stakeholders and their consequences are also considered.

Hypothesis and Objective 3

Since Cambodia further embraces a green economic growth pathway, ES valuation may still play an important role in ensuring that the flow of goods and services which natural providers will be protected, restored and managed to enhance livelihoods, especially for those who are most vulnerable and lacking in resources. Changes in forest areas in the Northern plains of Cambodia from 2002 to 2010 (Rainey, Heng and Evans, 2010) via population growth, logging and deforestation for agricultural purposes have resulted in changes in ES, especially carbon sequestration. Despite the adoption of a new Land Law in 2001, deforestation has increased following the attribution of economic land concessions (ELCs) to private companies for agro-forestry plantations. Therefore, land issues are major typical threats to this region like uncertain land ownership and insecure tenure, or expansion of uncontrolled deforestation of concession

areas, followed by environmental degradation and increased erosion of fertile topsoil (Mund, 2011).

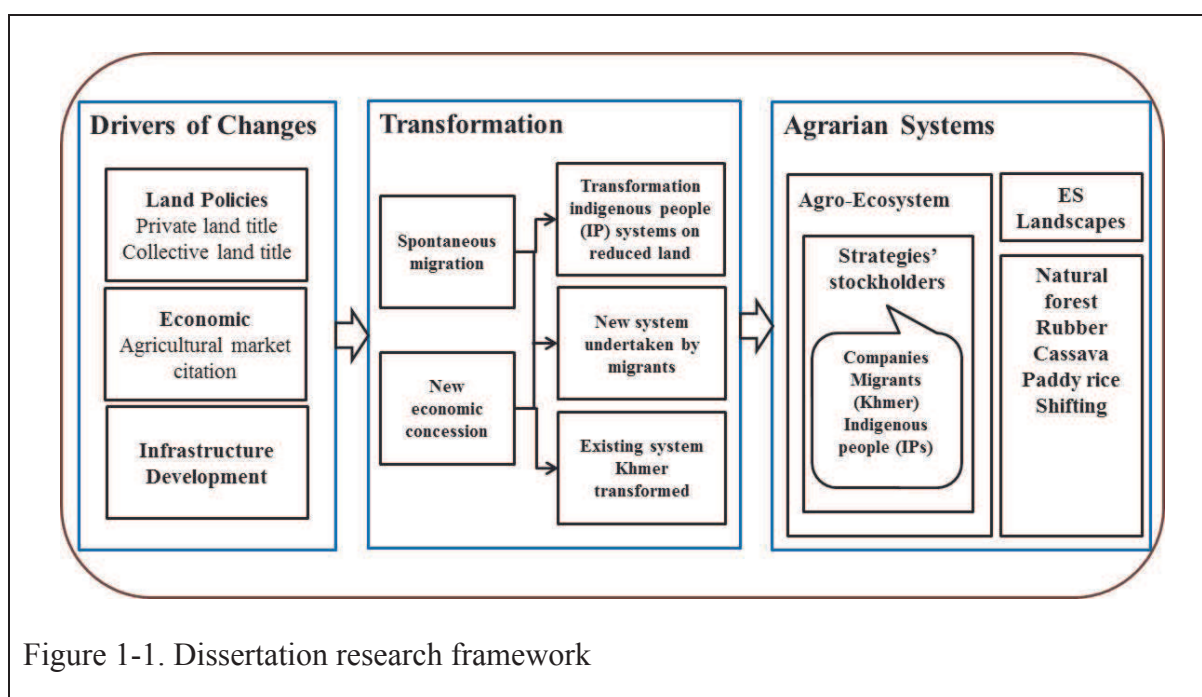
The values of ES, particularly the indirect use values, are not well reflected and factored in both individual and governmental policy decision making, due to its environmental externalities. Most of forest and agricultural ES (e.g. water, clean air, pollination etc.) are very difficult to quantify or put a value in money terms. Although direct value such as timber or crop yields, non-timber forest products (NTFPs) are tradable in the markets, the price mechanism often fails to reflect the real value of those services since their market price is based on the cost of extraction and raw materials only; this does not take into consideration the ES value such as watershed protection, soil fertility, carbon sequestration, biodiversity protection. Therefore, market failure often occur in ecosystem management as markets and economic development rarely reflect the full social costs or benefits of environmental goods or services, and valuation of ES is essential in correcting the market failures and in economic planning to support decision making.

Remarkably, little is known about trade-offs between ES within various types of land use in Mondulkiri province, especially about the consequences of the replacement of forest and long-fallow shifting agricultural systems by permanent agriculture, to provide convincing evidence as to which land cover or land use offers the more valuable services.

Given the rapid global trends, land use decisions often affect multiple and competing objectives. We assumed that the main trade-offs between forest and agricultural land that lead to loss the carbon above soil and soil loses. Considering uncertainties about carbon stocks and fluxes under potential alternative land uses, it remains unclear how trade-offs among services can be addressed, what contexts or policies may help to reduce some of the most undesirable impacts; and how possible rational decisions on land use can be made. The challenge on future land use and planning is still a question with regard to change in land use policies (land ownerships) together with the important weight of rubber prices that produce various total ecosystem values of alternative land use types but unclear defined and estimated. There is also a need for land use projection under proposed scenarios that will be applied for the analysis. This paper aims at evaluating and comparing the possible strategies to manage trade-offs in provision of ecosystem services. The benefits and costs of the land use and of the management of ecosystem services along several designed scenarios.

1.3 DISSERTATION RESEARCH FRAMEWORK

Generally, dissertation research framework comprises three different components (Figure 1-1). The first step of dissertation starts with understanding the driver of the changes in the study area. The transformation of households in regard to land use changes then have detailly been determined with gathering needed information and data, and understanding of agricultural techniques allow to identify ecosystem services (ES) and dis-services (EDS) flow to agriculture. Last step is highly focused on calculation related to the economic efficiency of production systems. The approach of agrarian system analysis and diagnosis is employed that allow the study combining with ES and EDS framework and linkage between agro-ecosystem and agricultural practices, and then calculating the opportunity cost of conversion to assure ES provision. The land use projections are estimated for two specific durations (Article 1- 10 years and Article 2- 20 years).



1.4 STRUCTURE OF DISSERTATION

This dissertation compiles six chapters including three main written manuscripts. The first manuscript aims to define and understand the land policies for upland Cambodia; we detail discussion on historical perspective and impacts on land use. We begin to collect and review

all the relevant policies, instructions and orders that generate change in land use. This manuscript is also to analyze the major changes in the land use as a result of the successive public policies in upland Cambodia. Considering the diverse strategies of local stakeholders previously studied, the chapter also elaborates on four scenarios of further transformations foreseen in the next ten years.

Second manuscript aims at analysing the transformations of the land use in the forest margins of upland Cambodia, with a special interest to the economic outputs of the various cropping and farming systems resulting from the strong dynamic of immigration coming from the central part of the country. This paper significantly contributes to identifying different farm strategies in relation to main historic milestones, interactions within households, family projects, strengths and constraints. In particular, we estimated economically farms production as well as household farm incomes.

Lastly, the third manuscript mainly analyze the trade-offs between ES across landscapes, Mondulkiri province, Cambodia. The challenge on future land use and planning is still a question with regard to change in land use policies (land ownerships) together with the importance of rubber prices that result in contrasting total ecosystem values of alternative land use types. There is also a need for land use projection under the proposed scenarios that will be used for the analysis.

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CHAPITRE 1: INTRODUCTION GÉNÉRALE

1.1 CONTEXTE DE L'ÉTUDE

Le développement des concessions de terres à grande échelle, principalement tirée par l'investissement étranger direct, a été assez massif dans les pays de la région du Mékong, plus particulièrement le Cambodge, le Laos et le Myanmar (Castellanet et Diepart, 2015). Rudel et Roper (1996) décrivent un processus de frontière de colonisation avec des séquences de pauvreté (c'est-à-dire une marginalisation écologique des agriculteurs qui ont perdu leurs droits sur les ressources) et une déforestation entraînée par le capital (c'est-à-dire des investissements publics ou privés pour développer la frontière pour des raisons politiques, économiques, ou sociales).

Les variables responsables des changements dans l'utilisation des sols se répartissent entre des causes directes (Turner, Lambin et Reenberg, 2007), notamment l'immigration, l'impact de l'agriculture de subsistance, la déforestation, ou les stratégies de gestion des ressources locales en propriété commune (Lambin et Geist, 2006), et des causes indirectes, comme les politiques nationales qui tendent à être difficiles à connecter empiriquement aux changements d'usage des sols observés.

Les politiques gouvernementales locales de libéralisation du commerce et l'accès au marché des ou dans les villages ont été les déclencheurs les plus actifs qui ont initié les changements d'utilisation des terres dans les zones de montagne (Fox, Vogler et Poffenberger, 2009; Mellac, 2014). En particulier, la gouvernance foncière est une question importante à différentes échelles, impliquant de larges influences de niveau à l'échelle mondiale, régionale, nationale et locale (Hirsch et Scurrah, 2015). Nombre d'accaparement des terres et de conflits ont de plus en plus attiré l'attention au cours des dernières années (Bues, 2011). On sait que différents facteurs ont aggravé les problèmes, comme les droits d'accès à la terre mal défini pour les différentes parties prenantes, ou le chevauchement des responsabilités des institutions publiques dans l'émission des concessions (Un et So, 2011; Sperfeldt, Tek et Billy, 2012). Ces conflits et ces tensions ont contribué à l'image de ce far-east soit comme un champ de bataille pour la terre, soit un désert d'institutions dans lequel une poignée d'entrepreneurs capitalistes étaient en concurrence pour l'exploitation forestière de la forêt, et, parfois, pour la plantation de caoutchouc dans les terres déboisées.

Geist et Lambin (2002a) montrent que les meilleurs modèles d'explication de cette déforestation reposent sur de multiples causes et facteurs agissant de façon synergique, plutôt que par n'importe quel facteur simple, dans plus du tiers des cas qu'ils ont analysés la déforestation résulte d'interactions entre des variables institutionnelles, technologiques, culturelles et démographiques. Les facteurs institutionnels sont impliqués dans 78% des cas. Ils incluent des mesures explicitement pro-déforestation, telles que les politiques sur la mise en valeur des terres et le développement économique liées à la colonisation, aux transports, ou à des subventions aux activités qui artificialisent les terres. En tant que cause fondamentale de la déforestation (e.g. Deacon, 1994; Mendelsohn et Michael, 1995), les droits de propriété tendent à avoir des effets ambigus sur la dynamique de la couverture forestière : insécurité foncière, condition d'accès quasi-libre, droits coutumiers inadaptés, ainsi que la légalisation des droits sur les terres sont tous identifiés comme facteur favorisant la déforestation.

Dans un tel contexte régional, le Cambodge a souvent été décrit, pour sa partie centrale, comme démographiquement saturé, dans la plaine alluviale du Mékong et la périphérie du lac de Tonle Sap, le « pays intérieur, avec moins d'un hectare par famille rurale, entourée par une zone de plateau, le « Cambodge vide », où la densité de population était, avant 2002, dix fois plus faible. En conséquence, la couverture forestière au Cambodge a longtemps restée surtout située dans le Nord, l'Est et le Sud-ouest du pays, là où les densités de population étaient basses.

Le développement des concessions de terres à grande échelle, largement tirée par les investissements étrangers directs, a été assez massif dans les pays de la région du Mékong, plus particulièrement le Cambodge, le Laos et le Myanmar (Castellanet et Diepart, 2015). Au Cambodge, la conversion des terres est principalement liée à des investissements industriels, à la plantation ou l'agriculture impliquant industrielle forte spécialisation, des niveaux élevés de capital, la production de masse et l'application de techniques moderne- un système complètement différent de l'agriculture familiale ou à petite échelle. Les «concessions foncières économiques» (ELC) ont été créées par la loi foncière (2001) et le sous-décret n°146 (2005) pour ce type d'investissement. Le gouvernement a affirmé que le développement agricole est une priorité, en mentionnant des objectifs de sécurité alimentaire, la fourniture de matières premières pour l'industrie, l'augmentation des exportations et la création d'emplois (Sokheng, 2009).

Les plantations d'hévéas dans les pays tels que le Cambodge représentent une menace grave pour la faune de la région et plus large écosystème, en particulier des concessions ont été données aux producteurs de caoutchouc dans les zones théoriquement protégées. Par exemple,

selon le World Resource Institution, les prix mondiaux du caoutchouc ont été chaotiques autour de 2010, l'année où le Cambodge a perdu le plus grand couvert forestier, et a atteint un sommet en 2011 avant de retomber (Harfenist, 2015), alors que les ELC ont été données aux investisseurs et aux petits exploitants. Malgré des tendances prometteuses dans l'industrie du caoutchouc du pays, un certain nombre de défis pourrait affaiblir la compétitivité et l'accès au marché du caoutchouc cambodgien. Un des problèmes est l'excédent croissant de caoutchouc à travers le monde, qui entraîne en baisse régulière de la demande de caoutchouc cambodgien (Natividad, 2015). Comme observation générale, les prix du caoutchouc sont maintenant si bas que beaucoup d'acteurs industriels ainsi que les petits producteurs commencent à convertir leurs champs en caoutchouc vers les cultures qui connaissent actuellement des prix élevés comme le poivre ou le manioc (Khum, 2016). Celles-ci sont très concernées par ce qui se passera si les prix ne remontent pas au cours des prochaines années?

Pendant ce temps, dans une tentative de contrôler l'exploitation forestière illégale, le gouvernement a également introduit un système de concession dans les zones forestières. Alors que les investisseurs ont démontré leur capacité à promouvoir leurs propres intérêts, ils ont rarement été en accord avec la production de biens communs. Les conséquences de l'extension des concessions comprenaient des dommages étendus à ces forêts (Banque mondiale, 2000) et le coût des groupes autochtones, car il a accéléré l'exploitation forestière légale et illégale, et il a menacé l'accès des populations autochtones (IP) à leurs terres traditionnelles, avec des conséquences sur leur culture et les moyens de subsistance traditionnels. Au cours de la première moitié de 2010, plus de 3500 familles ont été affectées par l'accaparement des terres (Human Rights Watch, 2011).

Les marges du Cambodge du nord représentent une telle situation. Pour des raisons historiques notamment, la densité de la population est dix fois plus faible dans la province de Mondulhiri que dans la plaine centrale surpeuplée. L'immigration rurale est active depuis 30 ans et la dynamique de la déforestation par la population indigène, les immigrants et les investisseurs privés, entraîne des changements rapides dans la production agricole et dans l'environnement. Fondamentalement, on sait peu de chose sur les compromis entre les services écosystémiques dans les différents types d'utilisation des terres dans la province de Mondulhiri, en particulier sur les conséquences du remplacement de la forêt et longue jachère décalant les systèmes agricoles par l'agriculture permanente, afin de fournir des preuves convaincantes quant aux terres sous protection / terre offre les services les plus précieux.

Le concept de services écosystémiques est utile pour évaluer les avantages des politiques qui ont un impact à la fois la production de biens et de services et les conditions environnementales dans lesquelles les sociétés humaines sont situées (MA, 2003a). Dans le secteur rural, tout en abordant le compromis entre la production agricole et les autres services est soit désormais commun pour un stade donné de l'utilisation des terres à une date précise et pour une région précise, ce cadre théorique est plus rarement utilisé pour évaluer leur transformations au fil du temps et de l'espace.

En outre, les valeurs de services écosystémiques ne sont pas encore clairement intégrées dans les processus de planification et de conception réels, bien que la sensibilisation des administrations sur ces importantes ressources augmente et des indicateurs de stock mesurant la performance des écosystèmes soient en train d'émerger (Hayek, Neuenschwander et Grêt-Regamey, 2012). En particulier dans les régions où les changements rapides d'utilisation des terres génèrent des environnements de plus en plus complexes et non durables, plusieurs arbitrages doivent être faits entre les variables socio-économiques et écologiques. Il existe donc un besoin de nouveaux outils de soutien une meilleure intégration des services des écosystèmes dans la planification et de permettre la prise de décision de compromis efficace pour équilibrer les aspects sociaux, écologiques et économiques du paysage (De Groot *et al.*, 2010).

1.2 OBJECTIFS DE CE TRAVAIL

Historiquement, les situations d'utilisation des terres de hautes terres du Cambodge sont clairement dans un processus de changement rapide en raison des politiques de réforme de l'utilisation des terres du gouvernement des années 2000. La conversion de l'utilisation des terres pour la production de cultures vivrières vers d'autres usages, l'expansion continue de la superficie cultivée, et la situation des terres agricoles inutilisés ou sous-utilisés n'a pas atteint une augmentation durable de la productivité et à fourni des quantités suffisantes d'aliments de qualité. Peu d'attention a été accordée à une gouvernance efficace et aux services de soutien, à la planification de l'utilisation des terres et à la gestion des terres. La croissance de la population, ainsi que la migration croissante des utilisateurs des terres a augmenté la pression à l'égard de l'accès aux terres agricoles et la propriété foncière. Des changements importants dans l'utilisation des terres, en particulier sur les sols sensibles à l'érosion fragiles dans les zones de montagne, ainsi que des bassins versants, sont d'autres sujets de préoccupation (Seng, 2014).

La thèse vise principalement à identifier les conditions de la production ou au maintien de différents ES dans la province de Mondulhiri à la suite de changements dans les utilisations des

terres, visant en fin de compte à identifier des solutions réalisables pour relever les défis possibles ont augmenté de compromis entre les différents services. Pour cette mission et l'exercice, il a été principalement pour comprendre le changement historique dans les politiques ou les instructions ainsi que les institutions du pays; pour déterminer le pilote des changements; et concevoir les différents scénarios pour la planification future de l'utilisation des terres en intégrant la fourniture ES. Le modèle a été complété par échelle de l'exploitation, la communauté locale, au niveau provincial qui permettent l'évaluation des différentes politiques foncières options et stratégies agricoles qui peuvent améliorer les compromis dans la fourniture de différents ES. Plus précisément, cette thèse cherche à répondre aux questions de recherche suivantes:

1. Quels sont les facteurs déterminants pour le changement dans l'utilisation des terres et la fourniture d'ES?
2. Quels sont les compromis dans la fourniture de différents ES et ces compromis sont-ils affectés par les changements dans les politiques?
3. Au niveau des exploitations agricoles, quelles sont les stratégies possibles qui contribuent à atténuer les compromis dans la fourniture de ES?

Hypothèses et Objectif 1

Le Cambodge a connu un premier tour de modestes réformes agraires redistributives au début des années 1980. Ces réformes sont cependant restées incomplètes avec des problèmes graves restant par rapport au cadastre et des lois foncières relatives aux transactions foncières. En outre, au cours des trois dernières décennies, le manque de terres agricoles est réapparue au Cambodge en raison de la pression démographique et l'aliénation des terres parmi la paysannerie. La loi de 2001 Terre et 2005 sous-décret définissent les procédures et mécanismes et arrangements institutionnels pour offrir des concessions foncières économiques (ELC), avec l'objectif d'améliorer la diversité des cultures, la productivité et l'emploi, entre autres avantages. En outre, la loi foncière de 2001, la loi forestière 2002 a reconnu les droits des communautés autochtones à la propriété collective sur leurs terres traditionnelles. Ici, la première question est de déterminer au préalable si la politique sur ELC peut avoir eu des effets positifs sur les résultats économiques plutôt que sur l'environnement alors que la politique sur les titres collectifs produit élevé ES. Les menaces internes comme l'augmentation de la pression sur les ressources terrestres, en raison de la propriété foncière incertaine et le régime non garanti, ainsi que des chocs extérieurs causés par les problèmes mondiaux de récession ou le changement climatique, tels que l'augmentation des inondations et des sécheresses ces dernières années

posent également des défis majeurs au développement agricole prospère du Cambodge (Mund, 2011).

L'étude vise à répondre aux questions: pourquoi et comment la situation actuelle a été générée historiquement; quelles ont été les conséquences des politiques successives sur les droits fonciers des parties prenantes et, par conséquent, sur les migrations et la croissance de la population, et enfin comment on peut utiliser ces connaissances pour évaluer les choix politiques possibles à partir de leurs impacts potentiels. Ainsi, l'objectif est d'abord d'analyser le rôle des facteurs démographiques, ainsi que les changements du cadre institutionnel qui ont eu lieu dans la période, notamment en ce qui concerne l'accès à la terre. Nous évaluons ensuite l'impact combiné de ces changements sur la production agricole prises à l'échelle mondiale, en utilisant les politiques foncières et les prix du marché du caoutchouc comme les principales variables.

Hypothèses et Objectif 2

Au cœur du problème, la transformation est rendue nécessaire à partir d'une agriculture de subsistance principalement orientée, caractérisée par une faible utilisation d'intrants et de faibles rendements de la terre, vers une agriculture plus intensive, sans doute plus orienté vers le commerce. Étant donné que le secteur agricole dépend principalement basée sur la production de riz de la famille, la conversion des ménages de petits exploitants dans une nouvelle classe de fermiers commerciaux est d'une importance stratégique. Une telle transformation apparaît très lourde, mais la capacité de moderniser et de bénéficier des opportunités d'une économie de marché en évolution semble limitée. En conséquence, il y a des obstacles majeurs, allant de l'infrastructure physique médiocre entraînant des coûts de transport élevés et une intégration limitée aux marchés, jusqu'au faible niveau d'éducation, à la formation aux nouvelles techniques et au marché du crédit et de l'assurance rurale imparfaite ou pratiquement inexistante (Van Acker et Sint-Ignatius, 1999). En outre, la topographie spécifique du Cambodge peut mettre un certain nombre d'obstacles naturels à la forme d'une intensification durable. Surmonter ces goulots d'étranglement sera la clé principale pour parvenir à une croissance économique rapide et soutenue sur la base de l'expansion des possibilités d'emplois de plus en plus productifs. Les tentatives visant à augmenter la production pour répondre à la demande pourrait en outre générer des dommages environnementaux. Comprendre la relation entre la population, la technologie et des ressources incorporées dans l'interprétation d'une telle

intensification de l'agriculture demeure un problème fondamental auquel les sciences sociales sont confrontées (Dobermann *et al.*, 2013).

Ces relations sont essentielles pour la question du changement agricole dans la province de Mondulakiri du Cambodge. Quels sont les facteurs des changements? Quelle est la nature de des changements? Ces changements sont-ils les mêmes pour tout le monde? Quels sont les impacts et les changements seront être durables? Nous explorerons et évaluerons la diversité des situations ethniques, sociales et économiques des différents ménages. Au niveau des unités de production, les stratégies des acteurs et de leurs conséquences seront également considérées.

Hypothèses et Objectif 3

Dès lors que le Cambodge souhaite désormais suivre une voie de croissance économique verte, l'évaluation des ES peut jouer un rôle important en veillant à ce que la circulation des biens et des services dont les fournisseurs naturels seront protégés, restaurés et gérés afin d'améliorer les moyens de subsistance, en particulier pour ceux qui sont les plus vulnérables et manquent de ressources. Les changements dans les zones forestières dans les plaines du nord du Cambodge de 2002 à 2010 (Rainey, Heng et Evans, 2010) à travers la croissance démographique, l'exploitation forestière et la déforestation à des fins agricoles ont entraîné des changements dans les ES, en particulier la séquestration du carbone. Malgré l'adoption d'une nouvelle loi foncière en 2001, la déforestation a augmenté suite à l'attribution de concessions foncières économiques (ELC) à des entreprises privées pour les plantations agro-forestières. Par conséquent, les questions foncières sont les principales menaces spécifiques à cette région, en particulier la question de l'insécurité foncière, ou l'expansion de la déforestation incontrôlée des zones de concession, suivie par la dégradation de l'environnement et de l'érosion accrue de la couche arable fertile (Mund, 2011).

Les valeurs des ES, en particulier les valeurs d'usage indirect, ne sont pas bien reflétées ni prises en compte dans les choix de politique à la fois individuelle et gouvernementale, en raison de ses effets sur l'environnement. La plupart des ES liés aux forêts et écosystèmes agricoles (par exemple, de l'eau, l'air pur, la pollinisation, etc.) sont très difficiles à quantifier ou à recevoir une valeur en termes monétaires. Bien que la valeur directe tels que le bois ou le rendement des cultures, les produits forestiers non ligneux (PFNL) soient négociables sur les marchés, le mécanisme des prix omet souvent de refléter la valeur réelle de ces services car leur évaluation marchande est basée seulement sur le coût de l'extraction et des matières premières;

cela ne prend pas en considération la valeur des ES pour la la protection des bassins versants, la fertilité des sols, la séquestration du carbone, la protection de la biodiversité. Par conséquent, les marchés n'intègrent les informations nécessaires pour une meilleure gestion des écosystèmes, de même que les marchés et le développement économique reflètent rarement les coûts ou les avantages de biens ou de services environnementaux sociaux complets, et l'évaluation des ES est alors essentielle pour corriger les défaillances du marché et pour la planification économique visant à guider les prises de décision.

Fait remarquable, on sait peu sur les compromis entre ES au sein de différents types d'utilisation des terres dans la province de Mondulkiri, en particulier sur les conséquences du remplacement de la forêt et des systèmes d'agriculture itinérante avec jachères longues par de l'agriculture permanente, afin de produire des arguments convaincantes sur quelle couverture terrestre ou l'utilisation des terres offre les services les plus avantageux.

Compte tenu des tendances mondiales, les décisions relatives à l'utilisation des terres affectent souvent des objectifs multiples et concurrents. Compte tenu des incertitudes sur les stocks et flux de carbone dans le cadre des utilisations possibles des terres alternatives, on ne sait pas comment les compromis entre les services peuvent être abordés, quels contextes ou politiques peuvent aider à réduire certains des effets les plus indésirables; et comment les décisions rationnelles possibles sur l'utilisation des terres peuvent être faites. Le défi sur l'utilisation future des terres et la planification est encore une question liée aux politiques de changement d'utilisation des terres (propriétés foncières) avec l'importance des prix du caoutchouc qui produisent différentes valeurs totales de l'écosystème selon les types alternatifs d'utilisation des terres, mais pas clairement définies et estimées. Il y a aussi un besoin de projection sur l'utilisation des terres dans les scénarios proposés qui seront utilisés pour l'analyse. Ce document vise à évaluer et à comparer les stratégies possibles pour gérer les compromis dans la fourniture de services écosystémiques. Les avantages et les coûts de l'utilisation des terres et de la gestion des services écosystémiques suivant plusieurs scénarios.

1.3 CADRE GENERAL DE LA RECHERCHE

Le cadre général de la recherche de cette thèse comprend trois éléments différents (Figure 1-1). La première étape de la dissertation vise à comprendre les causes des changements dans la zone d'étude. La transformation des ménages en ce qui concerne les changements d'utilisation

des terres, puis ont été déterminées précisément par la collecte des besoins d'informations et de données, et la compréhension des techniques agricoles permettent d'identifier les services écosystémiques (ES) et des dis-services (EDS) liés à l'agriculture. La dernière étape est fortement axée sur l'évaluation économique des systèmes de production. L'approche s'appuie sur l'analyse et le diagnostic du système agraire qui permettent une étude combinant avec le cadre ES et EDS et les liens entre l'agro-écosystème et les pratiques agricoles, puis le calcul du coût d'opportunité de la conversion pour assurer la fourniture ES. Les projections d'utilisation des terres sont estimées pour deux durées spécifiques (Article 1- 10 ans et Article 2-20 ans).

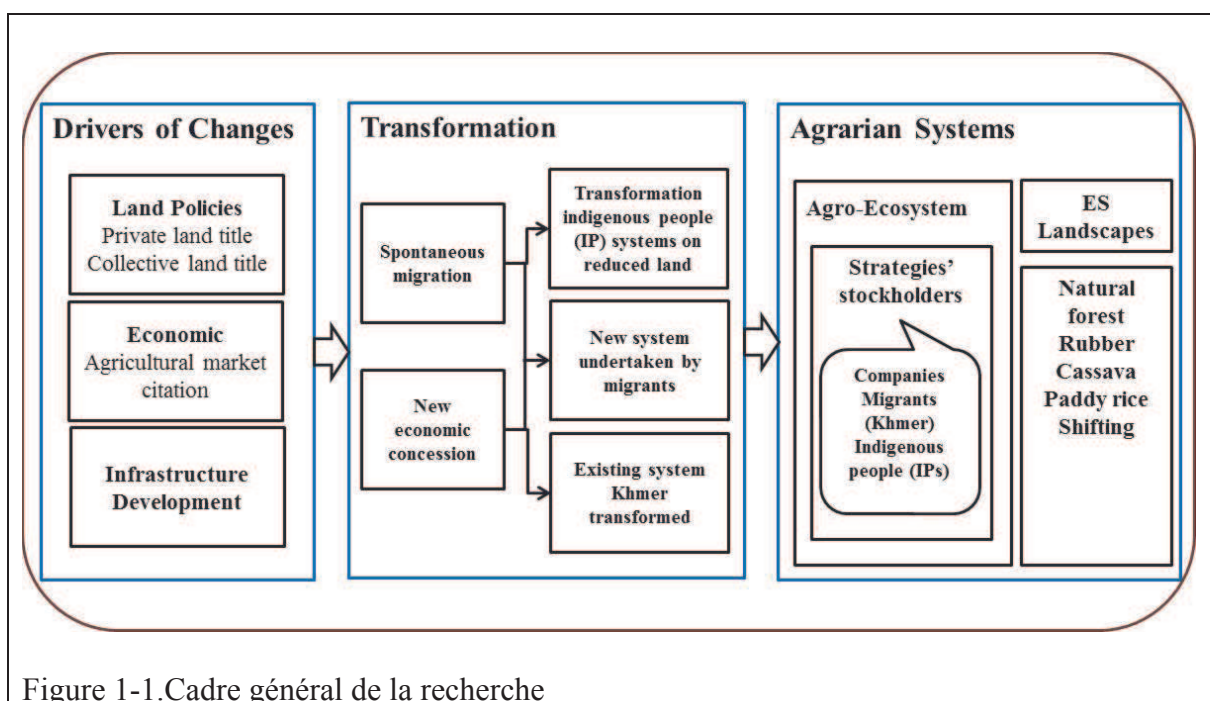


Figure 1-1.Cadre général de la recherche

1.4 STRUCTURE DE LA THÈSE

Cette thèse se compose de six chapitres dont les trois principaux sont présentés. Le première vise à caractériser et à comprendre les politiques foncières upland Cambodge; nous développons une discussion détaillée sur la perspective historiques et les impacts sur l'utilisation des terres. Nous commençons à organiser l'information et à examiner toutes les politiques, les instructions et les décrets qui génèrent des changements dans l'utilisation des terres concernées. Ce chapitre vise également à analyser les changements majeurs dans l'utilisation des terres à la suite des politiques publiques successives dans les hautes terres du Cambodge. Compte tenu des diverses stratégies des acteurs locaux précédemment étudiées, le chapitre développe également quatre scénarios de nouvelles transformations prévues dans les dix prochaines années.

Le deuxième manuscrit vise à analyser les transformations de l'utilisation des terres des plateaux du Cambodge dans les marges forestières, avec un intérêt particulier pour les résultats économiques des différents systèmes de culture et d'élevage résultant de la forte dynamique de l'immigration en provenance de la partie centrale du pays. Ce travail contribue beaucoup à l'identification des différentes stratégies agricoles par rapport aux principales étapes historiques, les interactions au sein des ménages, des projets de la famille, les forces et les contraintes. En particulier, nous avons estimé économiquement la production agricole, ainsi que les revenus des ménages agricoles.

Enfin, le troisième manuscrit analyse principalement les compromis entre les ES à l'échelle des paysages, dans la province de Mondulhiri, Cambodge. Le défi de l'utilisation future des terres et de sa planification est encore une question en lien avec les changements dans les politiques d'utilisation des terres (propriétés foncières) avec l'importance des prix du caoutchouc qui conduisent à différentes valeurs totales de l'écosystème selon des types alternatifs d'utilisation des terres. Il y a aussi un besoin pour une projection de l'utilisation des terres dans les scénarios proposés qui seront utilisés pour l'analyse.

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CHAPTER 2: LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

2.1 ECOSYSTEM SERVICES

Ecosystem services (ES) are the contributions that ecosystems make to human well-being both goods (e.g. food and freshwater) and services (e.g. flood reduction and carbon sequestration) (e.g. MA, 2003). Daily (1997) provided the following definition: “ES are the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life. They maintain biodiversity and the production of ecosystem goods such as seafood, forage, timber, biomass fuel, natural fiber, and many pharmaceuticals, industrial products and their precursors.” Costanza *et al.*, (1997) defined that “ecosystem goods (e.g. food) and services (e.g. waste assimilation) represent the benefits human populations derived directly or indirectly from ecosystem functions”. Due to ecosystems contribute to the production of these goods and services in much the same way that human, financial, and manufactured capital produce other goods and services, the literature on ES sometimes refers to ecosystems as “natural capital.” The terms “ecosystem services” and “natural capital” both refer to the fact that nature itself provides valuable goods and services to society, and that human well-being thus depends on the protection of nature, and the terms are often used interchangeably (MA, 2003b; Thompson Jr., 2012).

2.1.1 Historical Concept of Ecosystem Services

Historically, the concept of ecosystem services (ES) has generated increased attention as a way to communicate societal dependence on ecological life support system (Daly, 1997; De Groot, Wilson and Boumans, 2002). The historical mainstream of ES is presented in Figure 2-1.

Gómez-Baggethun *et al.*, (2010) have extensively reviewed the concept of ecosystem services: “in the late 1970s, the origins of modern history of ES were explored. Initially, it begins with the utilitarian framing of beneficial ecosystem functions as services to increase public interest in biodiversity conservation (Westman, 1977; Ehrlich and Ehrlich, 1981; De Groot, 1987). In 1990s, it was demonstrated with the mainstreaming of ES in the literature (Costanza and Daly, 1992; Perrings *et al.*, 1996; Daily, 1997) and with increased attention on methods to estimate their economic value (Costanza *et al.*, 1997). The Millennium Ecosystem Assessment (MA, 2003a) contributed much to putting ES firmly on policy agenda, and since its release the literature on ES has grown exponentially (Fisher, Turner and Morling, 2009). Nowadays ES are increasingly arriving economic decision-making through the widespread promotion of market based instruments for conservation

such markets for ES (Bayon, 2004) and so-called Payment for ES schemes (Landell-Mills and Porras, 2002; Pagiola and Platais, 2005; Wunder, 2005; Engel, Pagiola and Wunder, 2008).”

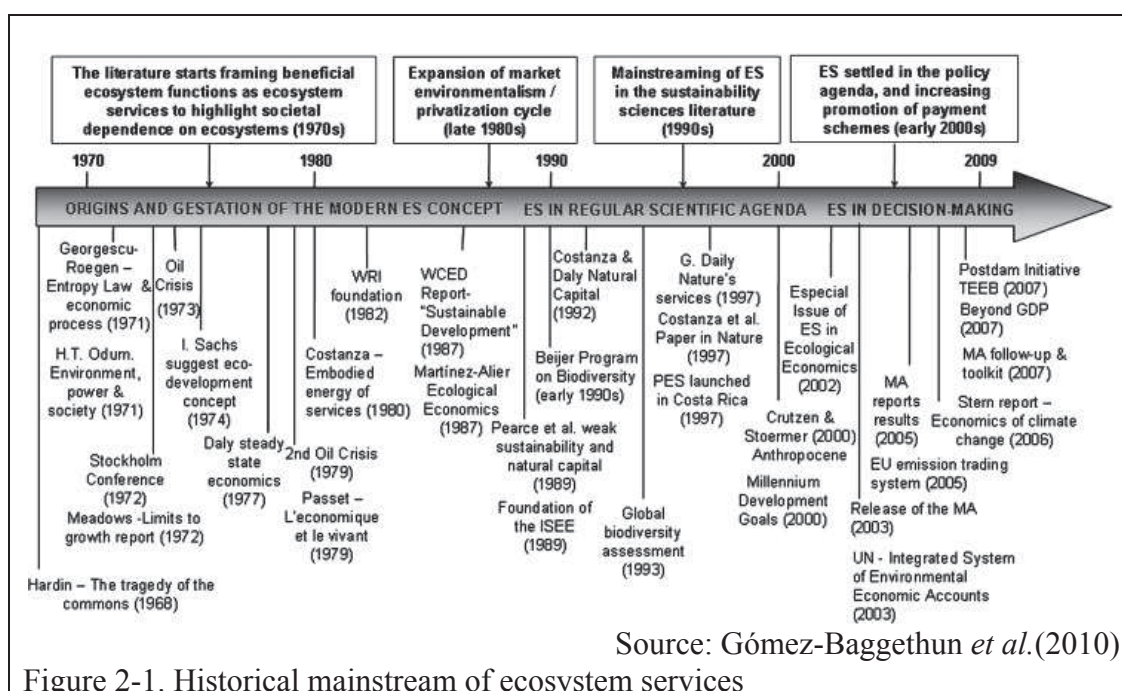


Figure 2-1. Historical mainstream of ecosystem services

Gómez-Baggethun *et al.*, (2010) have characterized ecosystem functions as services, valued in monetary terms and to a lesser extent, incorporated into markets and payment mechanisms. Gómez-Baggethun *et al.*, (2010) cited that “as a part of this process, the use of the ES concept has transcended the academic arena to reach governmental policy as well as non-private and financial sectors (Bayon, 2004; EC, 2008). On the other hands, mainstreaming of ES has also resulted in application of the concept in directions that diverge significantly from the original purpose for which the concept was introduced. For instance, in relation to PES, Redford and Adams (2009) noted that such payment schemes are being adopted with great speed, and often without much critical discussion across the spectrum of conservation policy debate, developing a life of its own independent of its promulgators. These remarks add to a growing body of literature that has brought up questions on how utilitarian farming or ecological concerns and markets strategies can modify the way to be counter-productive for conservation purposes (Rees, 1998; Martínez-Alier, 2003; Robertson, 2004; McCauley, 2006; Soma, 2006; Spash, 2008a, 2008b).”

However, Gómez-Baggethun *et al.*, (2010) also illustrated that “the recent surge in studies and scholarship surrounding ES has dramatically increased attention to the concept in policy circles. As a result, an increasing number of governments have explicitly incorporated ES into their laws and policies (Thompson Jr., 2012). Currently, the scientific

scholarship on ES has also changed the way in which policy makers and others now focus on the concept. Rather than looking at ES on an individual basis, recent research has emphasized that ES can provide a large range of different services. The scholarship also has focused to value the services, and to develop new, simply replicable methods of valuing them for public and private purposes (Kareiva *et al.*, 2011). This force has helped highlight the tremendous value that ES provide to humans, including values that is directly translatable into economic terms (Thompson Jr., 2012). Thompson Jr. (2012) concluded that the concept of ES holds out the promise of increasing and improving conservation in at least three different ways. First, ES may provide a new and resonant argument for conservation by demonstrating the enormous value of conservation to society. Second, ES might provide a framework for better specifying the purposes of environmental management and for expanding its purposes. Lastly, ES might provide the basis for new markets that could increase the funds flowing into conservation. Of these opportunities, the second currently appears to be the strongest. Therefore, recognizing and embracing all the potential benefits depends on being able to better measure and value ES.”

2.1.2 Different Ecosystem Services

The Millennium Ecosystem Assessment (MA, 2005) suggested to divide ecosystem services (ES) into four categories including provisioning, regulating, and cultural services that directly affect people and supporting services which need to maintain other services (Figure 1-2).

- 1) **Provisioning services**, these are the products obtained from ES. They include products such as food and fiber, fuel, genetic resources, biochemicals, ornamental resources and fresh water.
- 2) **Regulating services**, there are the benefits obtained from regulating of ecosystem processes. These services include air quality maintenance, climate regulation, water regulation, erosion control, water purification and waste treatment, regulation of human diseases, biological control and pollination.
- 3) **Cultural services** are the non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, recreation, aesthetic experience and reflection. For example, they included cultural diversity, spiritual and religious values, knowledge systems, social relations, recreation, ecotourism and inspiration.

- 4) **Supporting services** are necessary for the production of all other ES including in supporting services are soil formation, photosynthesis, nutrient and water cycling (MA, 2003b).

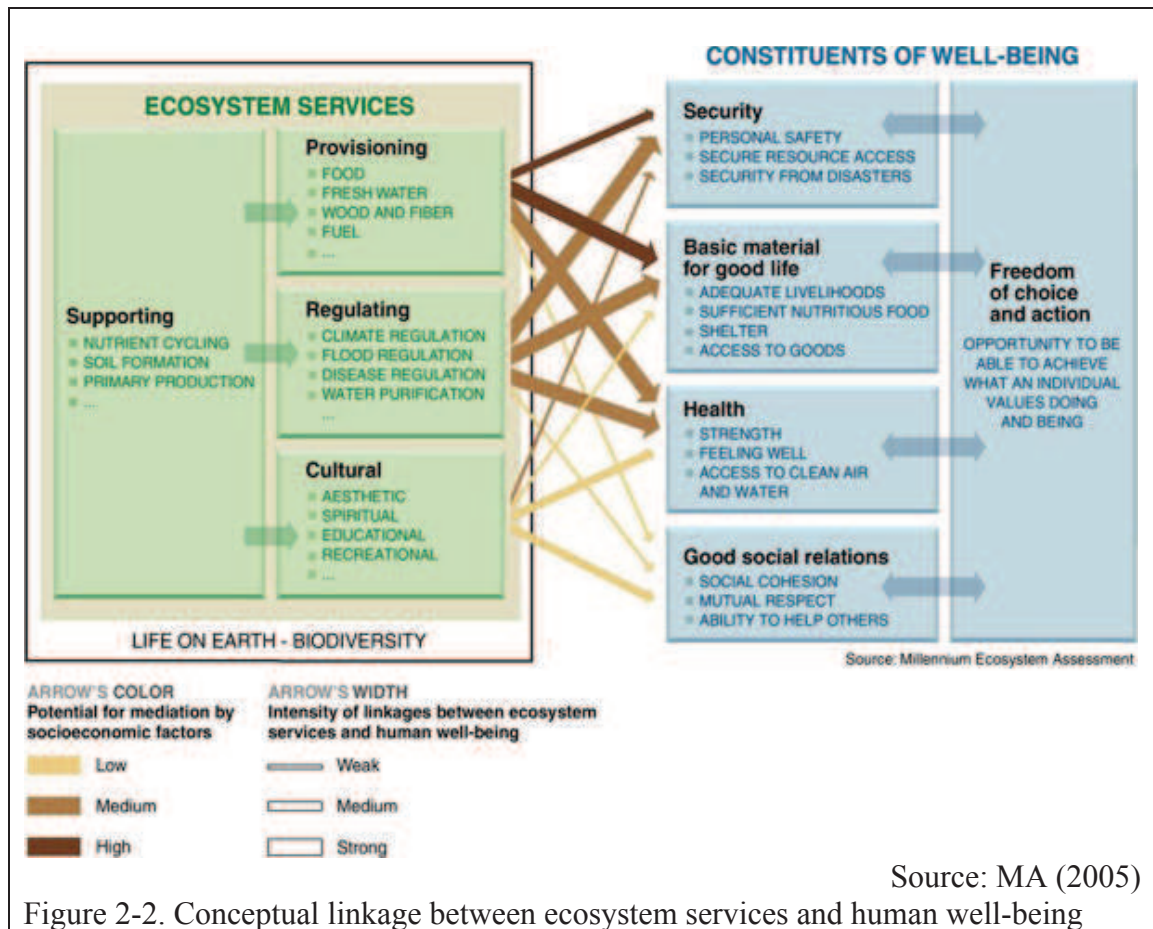


Figure 2-2. Conceptual linkage between ecosystem services and human well-being

The linkages between ES and human well-being are illustrated in Figure 2-2. The equitable and sustainable well-being relies on these links with ES. The biodiversity is the basis for many ES and has a buffering and stabilizing function. Biodiversity provides sources of ES and when the times are bad, it is a fallback option e.g. for food supply. As already mentioned the supporting services provide the base for all other services, thus the connection between the supporting service and human well-being is indirect. In contrast, it is not only the ES influencing the human well-being but also economic, social, technological and cultural factors have an influence on human well-being (MA, 2003b, 2005).

Functioning ecosystems produce multiple services and these interact in complex ways, different services being interlinked together and therefore are affected negatively or positively as one service or goods increases. Some ecosystem positively co-vary (more of

one means more of another) e.g. maintain soil quality may promote nutrient cycling and primary production, enhance carbon storage and hence climate regulation, help regulate water flows and water quality and improve most provisioning services, notably food, fiber and other chemicals. On the other hands, other services negatively co-vary such as when increasing provisioning services may reduce many regulating services e.g. increased provision of agricultural crops may reduce soil quality, climate regulation and water regulation (Elmqvist *et al.*, 2013).

Any region of the earth produces a set of services that in turn influences human well-being. It also receives flows of energy, water, organisms, pollutants, and other materials from adjacent regions and releases similar materials into those regions. Different strategies and interventions directly or indirectly influence the quantity and quality of the services provided.

2.1.3 Ecosystem Services and Agriculture

Power(2010)identified: “agricultural ecosystems provide humans with food, forage, bio-energy and pharmaceuticals and are essential to human well-being. These systems rely on ecosystem services (ES) provided by natural ecosystems, including pollination, biological pest control, maintenance of soil structure and fertility, nutrient cycling and hydrological services (MA, 2005; NRC, 2005). Preliminary assessments indicate that the value of these ES to agriculture is enormous and often underappreciated.” Agricultural production depends on a wide variety of supporting and regulating services. Pollination and soil fertility, for example, determine the underlying biophysical capacity of agricultural systems (Zhang *et al.*, 2007). Agriculture also receives ecosystem disservice that reduce production or increase production costs (e.g. herbivory and competition for water and nutrients by undesired species).

FAO (2009) stated that agriculture is a dominant form of land management globally, and agricultural ecosystems cover nearly 40 percent of the terrestrial surface of the earth. Agro-ecosystems are both providers and consumers of ES (Figure 2-3). According to Power(2010), “humans value these systems chiefly for their provisioning services. In turn, agro-ecosystems depend strongly on a suite of ES provided by natural, unmanaged ecosystems. Supporting services include genetic biodiversity for use in breeding crops and livestock, soil formation and structure, soil fertility, nutrient cycling and the provision of water. Regulating services may be provided to agriculture by pollinators and natural

enemies that move into agro-ecosystems from natural vegetation. Natural ecosystems may also purify water and regulate its flow into agricultural systems, providing sufficient quantities at the appropriate time for plant growth.”

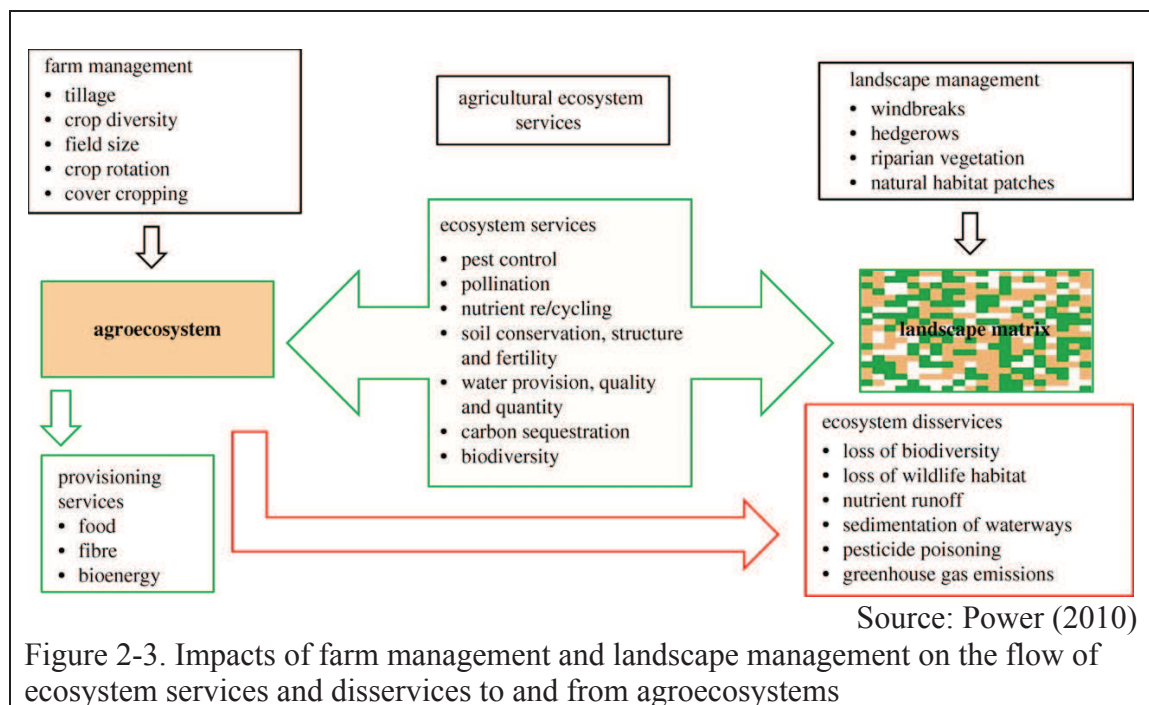


Figure 2-3. Impacts of farm management and landscape management on the flow of ecosystem services and disservices to and from agroecosystems

ES flow to agriculture by the production of agricultural goods is highly dependent on the services provided by neighboring natural ecosystems, but only recently have been attempts to estimate the value of many of those services to agricultural enterprises. Some services are more easily quantified than others, to the extent that they are essential to crop production or they substitute directly for purchased inputs (Power, 2010).

Beside thatPevere(2016)cited “on-farm management practices can significantly enhance the ES provided by agriculture. Farmers routinely manage for greater provisioning services by using inputs and practices to increase yields, but management practices can also enhance other ES, such as pollination, biological pest control, soil fertility and structure, water regulation, and support for biodiversity.” Habitat management within the agro-ecosystem can provide the resources necessary for pollinators or natural enemies (Tscharncke *et al.*, 2005). Many studies have identified the important role of perennial vegetation in supporting biodiversity in general and beneficial organisms in particular (Perfecto and Vandermeer, 2008). Evidence suggests that management systems which emphasize crop diversity through the use of poly-cultures, cover crops, crop rotations and agro-forestry can often reduce the abundance of insect pests that specialize on a particular

crop, while providing refuge and alternative prey for natural enemies (Andow, 1991). Similar practices may benefit wild pollinators, including minimal use of pesticides, no-till systems and crop rotations with mass-flowering crops.

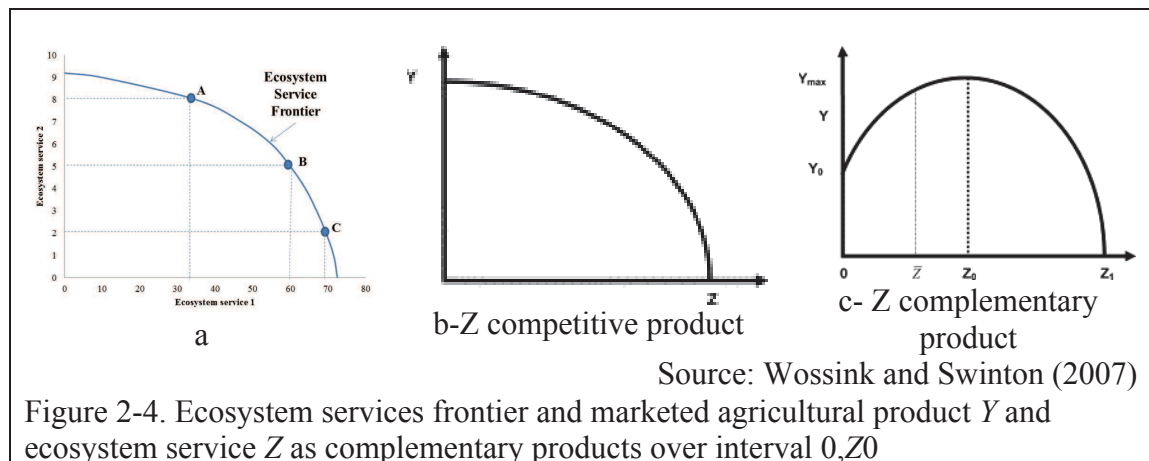
Therefore, the delivery of ES to agriculture is highly dependent on the structure of the landscape in which the agro-ecosystem is embedded (Figure 2-3). Power (2010) kept showing: “agricultural landscapes span a continuum from structurally simple landscapes dominated by one or two cropping systems to complex mosaics of diverse cropping systems embedded in a natural habitat matrix. Water delivery to agro-ecosystems depends on flow patterns across the landscape and it can be influenced by a variety of biophysical factors. Stream flow is influenced by withdrawals for irrigation, as well as landscape simplification. Water provisioning is also affected by diversion to other uses in the landscape or watershed, such as domestic, industrial or energy consumption.”

2.1.4 Ecosystem Services Frontiers and Trade-offs

Rodríguez *et al.* (2006) have drawn attention to trade-offs in ecosystem services (ES) and some progress has been made in documenting them through ES assessments (Cheung and Sumaila, 2008; Nelson *et al.*, 2009; Raudsepp-Hearne *et al.*, 2010; Raudsepp-Hearne, Peterson and Bennett, 2010). By contrast, many cutting edge attempts to model and quantify ES which do not disaggregate the beneficiaries of those ES, thus ignoring distribution of benefits between groups and individuals in society. Other disaggregates between very broad groups of beneficiaries such as private interests and net social benefits (Polasky *et al.*, 2010) or broadly between stakeholders at different scales (Hein *et al.*, 2006).

The economizing problem involves the allocation of resources among competing wants. The objective is to determine the economic efficiency in terms of allocative efficiency (Pareto superiority or optimality). Wossink and Swinton (2007) supposed that ecosystem produces two main services: ES 1 and 2. Therefore, the production possibilities curve of ES is a simple model that can be shown as the various amounts of two services that an economy can produce using the available resources (Figure 2-4a). The graph illustrates the supply of these ES by showing the combinations produced with this economy's resources. For instance, point A 34 units of ES 1 and 8 units of ES 2, point B 60 units of ES 1 and 5 units of ES 2, or point 70 units of ES 1 and 2 units of ES 2. Many other combinations of service 1 and service 2 could also be produced. The production possibility frontier shows all of them. Combinations of service 1 and service 2 outside the

frontier cannot be produced because not enough resources are available. The production frontier reminds us of the basic economic fact that resources are scarce; there are not enough resources available to produce all we might want of every good. Particularly, management options that maximize two services combined possibly lie on the frontier; A, B and C is said to be efficient and indicates that an ecosystem's scarce resources are being fully utilized. This is also called Pareto efficiency. Therefore, choosing among optimal solutions depends on societal values or preferences.



Furthermore, we need to understand the trade-offs between marketed products and non-marketed ES to determine the need for agricultural policy intervention (Weersink, Jeffrey and Pannell, 2002). When the output of agricultural commodities and an ES can be jointly increased from the same resource bases (complementary products; Figure 2-4b), producers have private incentive to produce the non-marketed ES. However, when there are 'win-lose' trade-off between agricultural production and a non-marketed ES (competitive products; Figure 2-4c), profit maximizing farmers have no private incentive to produce the ES (Swinton *et al.* 2007). For external incentive are necessarily required to stimulate adoption of alternative farm practices (Weersink, Jeffrey and Pannell, 2002).

Many cases illustrated such trade-offs, for instance, the establishment of a Marine Protected Area in coastal Kenya reduced the overall number of fishers in the area who benefited from fisheries (McClanahan and Kaunda-Arara, 1996), while likely improving opportunities to benefit from tourism which increased their benefits from ecosystem. Apart from these studies, there are analysis explicitly focused on the analysis of possible trade-offs between the supply of various ES from agricultural systems. In general, ES are not independent from each other and the relationships between them are likely to be highly

nonlinear. In fact for agriculture, the problem is typically posed such as the trade-off between provisioning services e.g. production of agricultural goods such as food, fiber or bio-energy—andregulating services such as water purification, soil conservation or carbon sequestration (MA, 2005). Cultural services and biodiversity conservation are also often viewed as trade-offs with production.

Rodríguez *et al.*(2006) suggested that trade-offs among ES should be considered in term of spatial scale, temporal scale and reversibility. Power(2010) raised questions: “are the effects of the trade-offs felt locally, for example on-farm, or at a more distant location? How quickly does the trade-offs occur? Are the effects reversible and if so, how quickly can they be reversed?” Management decisions often focus on the immediate provision of a commodity or service, at the expense of this same or another ES at a distant location or in the future. As either the temporal or spatial scale increases, trade-offs become more uncertain and difficult to manage.

Analysis of trade-offs is ranged of flexible option. Alternative to Slash-and-Burn (ASB), researchers summarize the indicators of local, regional and global benefits of a range of land use options in matrix format, and then analyze the trade-offs and synergies for a range of management intensities among the major systems (Tomich *et al.*, 1998). Some of the land, specifically complex agro-forestry systems, can maintain almost half of the carbon stocks and perhaps more than half of the biodiversity while providing products and economic profitability. Asexample, complex agroforestry system provides foods, including nutritionally diverse fruits; products sold for cash, including timber and fruits; and international commodity crops such as rubber, cocoa and coffee. However, these systems also rich 25 to 50 percent of the carbon of the natural forest; often contain levels of biodiversity similar to that of forest; maintain hydrological functions; and sustain many soil supporting functions. Not all agroforestry or tree-based systems maintain carbon and biodiversity (Tomich *et al.*, 2005).

For example, a case from Cameroon, most of the tree-based systems maintains similar amounts of carbon but have drastically different levels of biodiversity (Tomich *et al.*, 2005). On the other hands, intensification of food crop production systems, under current conditions of inadequate inputs to maintain, lead to loss of many ecosystem functions especially those that pertain to sustained production, nutrition cycling pest and disease control, and also result in continued degradation of carbon sequestration and biodiversity. Therefore, the trade-offs are concerned with plot-level analyzes and assume that the ES

come from the same plots at the same time. The assumption does not always hold, some of the provisioning services such as food crops can come from the same plots but different times in the cycle of the land use system, and there may be temporary trade-offs (increased food production decreased biodiversity or vice versus) that are switched through the rotation time of the land use systems. Figure 2-5, additionally if this is expanded to the landscape level, certain provisioning services are produced in parts of the landscape at the expense of carbon and biodiversity while carbon and biodiversity probably maintained in other land use systems on the landscape (Tomich *et al.*, 2005).

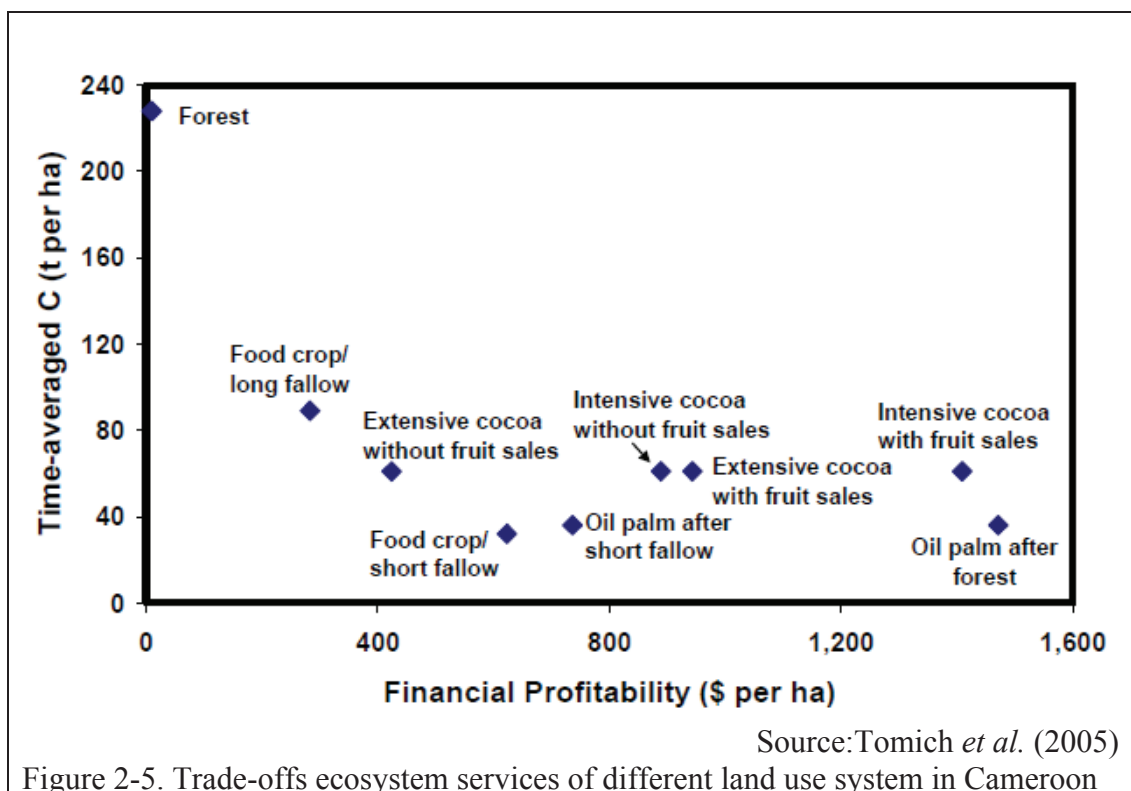


Figure 2-5. Trade-offs ecosystem services of different land use system in Cameroon

So far, studies proposed that trade-offs between agricultural production and various ES are not inevitable and that ‘win-win’ scenarios are possible (Power, 2010). Badgley *et al.* (2007) showed that an analysis of yields from agro-ecosystems around the world indicated, on average, agricultural systems that conserve ES by using practices like conservation tillage, crop diversification, legume intensification and biological control practices as well as intensive, high-input systems. The introduction of these types of practices into resource-poor agro-ecosystems in 57 developing countries resulted in a mean relative yield increase of 79 percent (Pretty *et al.*, 2006). In these illustrations, there was no evidence that the provisioning services provided by agriculture were jeopardized by modifying the system to improve its ability to provide other ecological services. Therefore,

these analyzes suggested that it may be possible to manage agro-ecosystems to support many ES while still maintaining or enhancing the provisioning services that agro-ecosystems were designed to produce. Sustainable intensification will depend on management of ecosystem processes rather than fossil fuel inputs (Baulcombe *et al.*, 2009).

2.2 HOW THE CONCEPT CAN BE USEFUL FOR DEFINING OR IMPLEMENTING PUBLIC POLICIES, ESPECIALLY IN AGRICULTURE

Ecosystem services (ES) are increasing attention as a promising concept to more actively consider and plan for varied benefits of the urban environment. In this section, we seek to understand how ES have been taken up in planning and implementing in policies especially in agriculture based on the examples of common agricultural policy (CAP), Costa Rica PES, and other case studies in Southeast Asia countries.

2.2.1 Ecosystem Services Integrating into the Common Agricultural Policy (CAP)

The Common Agricultural Policy (CAP) aims at viable food production throughout Europe, to guarantee long-term food security, sustainable management of natural resources and a balanced territorial development. The European Commission (EC, 2010) stated that agriculture plays a key role in the production of public goods, such as landscapes, farmland biodiversity and climate stability. The reformed common agricultural policy has come into force after 2013. Why a CAP reform? First reason is there is a need to respond to the economic, environmental and territorial challenges faced by agricultural and rural areas today and in the future, and in doing so to better align the CAP to the Europe 2020 strategy for smart, sustainable and inclusive growth. Second, there is a need to make the policy more efficient and effective, as well as to further simplify it while maintaining sound financial management and controllability. Third, CAP support could be made more equitable and balanced between Member States and farmers, and better targeted at active farmers.

Therefore, ES approach is to be integrated into a reformed CAP considering to sustainable development and modern-day ecosystem management in rural areas of Europe and establishing the CAP as an archetype of a progressive agricultural support system in the world. In the following, eight guidelines for the integrating ES into the CAP are briefly listed by Plieninger *et al.*, (2012).

1. **ES and human well-being:** CAP payments should only be granted if their effects can be linked to verifiable benefits to society and human well-being (ES). The focus should lie on the maintenance of ES that are short in supply due to ecosystem degradation.
2. **Non-market based ES:** Some ES, such as water purification functions or the scenic beauty of a pristine landscape, are not traded on existing markets and have subsequently been neglected in economic transactions. Non-market based valuation methods should therefore be used to identify the value of these services and incorporate them in CAP payment schemes.
3. **Bundles and trade-offs of ES:** ES are often highly interrelated and can either develop synergies or be in conflict with each other. These bundles and trade-offs of ES should be taken into account in payment schemes in order to avoid fostering single services at the expense of various others.
4. **Regional organization of payments for ecosystem services (PES):** ES are generally very site-specific, as they depend for example on the local climate or culturally stratified perceptions and valuations. Hence, agreements on payments from the CAP for ES should be made on a regional level in order to suffice for this variability and complexity.
5. **ES as part of the broader landscape:** Many ES, such as flood mitigation and aesthetic values, are provided by an area larger than the stretch of land managed by a single farmer. In this case, agreements should be made with a group of farmers. This approach encourages a collective ES management, uses the local ecological knowledge and can reduce transaction costs.
6. **Time horizon of ES provision:** The delivery of ES can be a long-term engagement, in particular if they are related to time-consuming ecological processes such as carbon sequestration. In this manner, it is important that a high funding continuity for the provision of these services is ensured. Funding continuity would be enhanced if measures to provide ES were to be financed fully by the EU or if the degree of co-financing could be decreased and linked to the economic capacity of a member state.
7. **Evaluation of PES schemes:** Market-based instruments for the provision of ES develop over a long period of time and are based on changing societal recognition of ES. In addition, the immature legal framework of PES undergoes continuous reformation. These circumstances require that agreements of PES are periodically

evaluated based on the most recent environmental, societal and legal settings and conditions.

8. **Coherence of PES with other public policies:** Within the EU, agricultural landscapes and their connected ecosystems are subject to a variety of local, national and international policies. The aims of the reformed CAP with integrated PES should therefore complement and build on other related national policies.

Thus, the main expected outcomes would be obtained such as (Plieninger *et al.*, 2012):

1. The traditional CAP has not considered multidimensional ES and has therefore contributed to environmental degradation in European agricultural landscapes.
2. The structural reforms proposed by the European commission provide a window of opportunity to implement PES in the CAP framework while considering the most recent research in the field.
3. Payments from the second CAP “pillar” (rural development policies) should reflect the non-market based social and cultural values, site-specify, time horizon, bundles and potential trade-offs of ES.
4. Agreements should be conducted with a collective and holistic management approach. Payments schemes should be constantly assessed and they should not interfere but collaborate with other related public policies.

2.2.2 The Costa Rican Payments for Ecosystem Services Program (PESP)

The payments for ecosystem services (PES) program in Costa Rica was created in 1987, and the legal basis was provided by Forest Law 7575 adopted in 1996. Due to Costa Rica experienced one of the highest rates of deforestation worldwide during the 1970s and 1980s. In 1950, forests covered more than one-half of Costa Rica; by 1995, forest cover had declined to 25 percent of the national territory. Approximately 60 percent of forest cover, totaling 1.2 million hectares, is on privately owned lands outside of national parks and biological reserves. World Bank estimates indicated that 80 percent of deforested areas, nearly all on privately owned lands, were converted to pasture and agriculture. Deforestation was principally driven by policies including cheap credit for cattle, land-titling laws that rewarded deforestation, and rapid expansion of the road system. These policy incentives have since been removed and Costa Rica has become one of the world’s leading proponents of environmentally sustainable development. Due to the forest

conservation policy and economic factors affecting agricultural production, deforestation rates have slowed considerably (Malavasi and Kellenberg, 2002).

The Payments for Environmental Services Program (PESP) aims at protecting primary forest, allowing secondary forest to flourish, and promoting forest plantations to meet industrial demands for timber and paper products. In the PES system, the landowners receive direct payments for the ecological services that their lands produce when they adopt land uses and forest management techniques which do not have negative returns on the environment and that maintain people's life quality. Costa Rica's Forest Law reorganizes four environmental services provided by forest ecosystems: (i) mitigation of greenhouse gas (GHG) emissions; (ii) hydrological services, including provision of water for human consumption, irrigation, and energy production; (iii) biodiversity conservation; and (iv) provision of scenic beauty for recreation and eco-tourism (Malavasi and Kellenberg, 2002).

In fact, the implementing regulation of the Forest Law provides that the government enter into multiyear contracts with landowners for reforestation, sustainable forest management, and forest protection. Landowners cede their GHG emissions reductions rights to FONAFIFO (Fondo Nacional de Financiamiento Forestal), to be sold on international market. As a result, FONAFIFO exempts indigenous territories from complying with land ownership regulation. So far, there are three different types of PES contracts and Malavasi and Kellenberg (2002) indicated as below:

1. Forest conservation contracts: USD 210/ha (equivalent to USD 42/ha/year), disbursed evenly over a five-year period, for forest conservation easements. About 85 percent of contracts in the PES program to date support forest conservation easements, which target the conservation of vegetative cover in primary and secondary forest areas. Contracts are for five years, however they can be renewed depending upon funds availability.
2. Sustainable forest management contracts: USD 327/ha, disbursed over a five-year period, and about 90 percent of contracts in PES program support for sustainable forest management easements. Landowners must make a commitment to maintain forest areas for a period of 15 years.
3. Reforestation contracts: USD 537/ha, disbursed over a five-year period, for reforestation easements. Landowners must make a commitment to maintain reforestation areas for a period of 15 to 20 years, depending upon tree species. Only

six percent of contracts in program support reforestation of degraded and abandoned agricultural lands.

As a result, from a conservation perspective, the PESP provides market-based incentives to conserve natural forest ecosystems. These economic incentives are supposed to contribute to maintain habitats that are critical to a rich, globally essential biodiversity, and have the potential for helping to maintain biological corridors linking national parks and biological reserves. Through the PESP program for approaching forest conservation is akin to the system of conservation easements that are widely used in the United States and European countries. Since 1997 to 2001, FONAFIFO had paid to private landowners approximately USD 57 million for total land area of 283,384 ha.

Principal sources of funding for the program significantly include a tax on fuel sales, payments to FONAFIFO from private sector firms (renewable energy producers and water blotters) for the conservation of critical watersheds, and through the sale of Certified Tradable Offsets (CTOs) derived from forest ecosystems. The Global Environmental Facility has also donated USD eight million to FONAFIFO; USD five million would be invested in direct payments for forest conservation contracts with landowners located in the Mesoamerican Biological Corridors in Costa Rica (MBC/CR), and USD three million will be funded in increasing institutional efficiency of FONAFIFO, SINAC (Costa Rica's National System of Conservation Areas or Sistema Nacional de Áreas de Conservación), and non-governmental organization (NGO) promoting conservation, and sustainable management of forest ecosystems through the PESP (Malavasi and Kellenberg, 2002)

Costa Rica's PES program illustrates that patience and perseverance are critical to the implementation of PES strategies. The program has evolved over several decades, experiencing many challenges along the way. Furthermore, the program alone is not the key solution to protecting Costa Rica's ES. Zoning and other regulations complement the program (Sanchez-Azofeifa *et al.*, 2007).

2.2.3 Payments for Ecosystem Services (PES) in Southeast Asian Countries

As demand for PES program increases in the Asian and Pacific region, national level policy frameworks have become more important than ever. PES projects have provided vital foundation for formulating such policies and operationalizing PES (Sanchez-Azofeifa *et al.*, 2007).

- **Vietnam** is the first Southeast Asian country to operate a national pilot policy on Payment for Forest Environmental Services (PFES) (USAID, 2009). Lam Dong province, located in the upstream of Dong Nai River Basin and with more than 60 percent forest covered area, was selected as one of the pilot project areas in 2007. During the implementation of this pilot policy, more than 300,000 ha of forestland were contracted to about 14,000 local households for sustainable management. This project has ensured a high level of participation using communication media like radio and television and local institutions. Through funding from USAID, the Asia Regional Biodiversity Conservation Program supported the effort of policy development providing training spreading awareness. Major buyers of the ES are hydropower, tourism and water bottling industry. For instance, the hydropower plants and water utilities that use water from Dong Nai River are expected to invest about USD three million per year to maintain the long-term productivity of the hydropower plant, water supply and water quality.
- In **Indonesia**, a regulation on “Implementation of Demonstration Activities for REDD-Reducing Emissions from Deforestation and Degradation” was launched in 2008, and followed by regulation on “Procedure of REDD” in 2009. A draft for a Presidential Decree on PES regulation covering watershed, eco-tourism and REDD has been prepared. Indonesia has become the first nation in the world to release the rules governing the revenue sharing of forestry projects based on REDD (Yvonne, 2009). These rules stipulate that between 20 to 70 percent of revenues would go to local forest communities and the central, provincial and local government would share the rest.
- **Cambodia** presents an excellent example with its Seima Biodiversity Conservation Area project. The project was launched in 2002 and paid local people for conserving bird-nests to address increasing threats to endangered species. As the coordinating agency, Wildlife Conservation Society (WCS) contracts local people and pays them for their labor as well as outcomes in terms of the number of nest protected. The project initially started with four villages in 2002, and six years later it had expanded to 21 villages and could protect more than 1,500 nests (Tom, 2009).

Another program operates in Angkor that WCS and the Sam Veasna Centre, a local NGO, have started an innovative eco-tourism project in coordination with local communities and the eco-tourism industry. Under this community-based eco-tourism project, villages sign contracts under which hunting would be banned and land use

planning with NGO and government supported. As a result, payments of up to USD 4,000 per village were established, and served as the most important source of rural income in the area (Rankine, Watkins and Kasemsawasdi, 2009).

In addition, the Agri-environment project started by WCS in coordination with government and local NGOs in northern Cambodia provides an example of promoting sustainability through the supply chain. The buyers for the environmental services are city-based hotels and sellers are farmers in villages. Farmers receive payment and guarantee the purchase of their farm products from hotel industry if they agree to limit further expansion of their farmland. The products are sold at markets with a “Wildlife-Friendly” label and thus ultimately the end users are paying a premium for conserving the forests and biodiversity.

2.2.4 REDD and PES

Payment for ecosystem services (PES) is also gaining attention due to its linkage to the growing mitigation efforts associated with climate change. Markets for carbon sequestration have organized payments for Reducing Emissions from Deforestation and Degradation (REDD) on voluntary basis, and are growing. These markets are anticipated to generate a USD 30 billion annual revenue stream for developing countries, stimulating an exponential increase in demand for carbon sequestration services from Southeast Asian forests in particular (Rankine, Watkins and Kasemsawasdi, 2009). The market expansions for carbon sequestering ES could have very significant local impacts.

In addition, World Bank launched the Forest Carbon Partnership Facility (FCPF) in order to help building capacity for REDD in developing countries. The FCPF also supports the implementation of small-scale REDD pilot projects. Cambodia, Indonesia, the Lao People’s Democratic Republic (Lao PDR), Thailand and Vietnam are among 37 which have partnered with FCPF in the development of national REDD Readiness Plans. For example, World Bank has estimated that Indonesia alone could earn up to USD two billion a year in such a forest carbon market.

PES/REDD schemes in Southeast Asia need to account for poverty considerations and shortcomings associated with poverty (budget and capacity constraints). About two third of the world’s poor reside in Asia, and poverty is an important underlying cause of deforestation and forest degradation in many areas, including Vietnam and Lao PDR. Experience with pro-poor PES is growing rapidly and preliminary evidence suggests that

the poor generally benefit from PES if their transaction costs are reduced and inappropriate access barriers are removed (Grieg-Gran, Porras and Wunder, 2005; Grieg-Gran, 2008; Wunder and Albán, 2008). Therefore, there is scope for the Asian PES/REDD model to benefit from these experiences and focus on ‘pro-poor REDD’ as one element of the regional REDD strategy (Wertz-Kanounnikoff and Kongphan-Apirak, 2008).

Lawlor and Huberman (2009) indicated that relying on the access and exclusion framework, it can be seen that REDD has increased tenure security over local agricultural lands and future agricultural lands. In the meantime, it also supported a State-led process that has actually weakened local control over most forest areas, as the communal land tenure system in place is linked with the State’s move to take control of other forested lands as “state land,” a fundamentally disempowering designation for local people. Thus, in this case REDD has the potential to provide increased access to some, through helping exclude others from taking their land. Communal land titling could help provide comprehensive secure long-term land and forest tenure, but only if forests designated as “state lands” can be considered as community land, as is the case in Laos. REDD does not exist in a vacuum, and lessons about the importance of secure long-term tenure and access to resources are as relevant when it comes to REDD as with other types of land-use management programs.

Recently, the Royal Government of Cambodia, through a long-running partnership with Wildlife Conservation Society (WCS), has sold to Disney the first carbon credits from a climate change mitigation project in Keo Seima Wildlife Sanctuary, which encompasses a total area of 292,690 ha. Reducing deforestation is crucial to cutting the greenhouse gas (GHG) emissions that cause climate change. The Keo Seima Project, under the international approach called REDD+ (Reduced Emissions from avoided Deforestation and Degradation), projects to avoid the emissions of more than 14 million metric tons of CO₂-equivalents over the first 10-year period between 2010 and 2019.

2.3 SHIFTING AGRICULTURE AND ECOSYSTEM SERVICES QUESTIONS RAISED

Shifting is a longstanding, widespread, and diverse category of land use (Fox *et al.*, 2009). It is considerably either the main source of livelihoods or a vital source of supplementary income for millions of people world-wide (Cramb *et al.*, 2009; Mertz *et al.*, 2009). Numerous studies, including Conklin (1957, 1963), illustrated that in many situations it is

in fact a rational economic and environmental choice for farmers in the humid tropical uplands (Fox, 2000; Mertz, 2002; Ickowitz, 2006). While FAO did not succeed in its proposed research-driven attack on shifting cultivation change in areas formerly dominated by shifting cultivation are now occurring at a rapid pace and, in much of Southeast Asia (and elsewhere) (Ziegler *et al.*, 2012). Change from shifting cultivation to other land uses may indeed be desirable for some farmers, but in other cases, such factors as prohibitive legislation, land reform, logging, large-scale land development, exclusionary conservation zoning, and resettlement are driving change towards new land use systems with consequences that are still poorly understood. Mertz *et al.* (2009) questioned “Do they, in all cases, represent an improvement, or is there a continuing rationale for shifting cultivation in the twenty-first century?”

However, recent research has also provided evidence to the contrary the debate on shifting cultivation affected on the current climate change. According to FAO, UNDP and UNEP, the main causes of deforestation and thus carbon emission in Asia have been intensification of agriculture and large-scale direct conversion of forest for small-scale and large industrial plantations, and not shifting cultivation (FAO, UNDP and UNEP, 2008). Shifting system also contribute to biodiversity enhancement and food security due to this cultivation is a complex land use system that typically relies on a large number of crops planted both simultaneously and successively during the cropping cycle. In the Karen community of Huay Hin Lad (Thailand), for example, more than 100 varieties of domesticated plants are grown, 90 of them in shifting cultivation field (AIPP, IWGIA and NDF, 2011). The Intergovernmental Panel on Climate Change (IPCC, 2006) has also acknowledged the contribution of fallow to sequestering carbon. The amount of CO₂ released through burning and decomposition during the preparation of the field and cropping period is sequestered again through natural restoration of the forest during the fallow period. Furthermore, the carbon sequestration capacity of shifting cultivation is higher than that of other forms of land use (Bruun *et al.*, 2009; AIPP, IWGIA and NDF, 2011).

Frequently, one assumed that replacing shifting leads to improvements in environmental services since agriculture becomes intensified and concentrated in limited areas while larger areas are left to forest growth. For example, there are some evidences that this is occurring in Vietnam, but this change has resulted in negative consequences for local livelihoods (Jakobsen *et al.*, 2007). Beside that in other areas, forests are converted to plantation or tree crops, not natural forest (Angelsen, 1995; Hansen and Mertz, 2006).

In addition, many studies on the effects of shifting systems on biodiversity, and soil and water resources pointed to a sustainable system if a minimum fallow period is retained (Kleinman, Pimentel and Bryant, 1995; Szott, Palm and Buresh, 1999), however an overview of how biodiversity in Southeast Asia is affected by shifting cultivation in carbon storage is still poorly understood, partly because the carbon cycle of the soil-vegetation system is not well researched (Leisz *et al.*, 2007). Particularly, the role of shifting in conserving soil carbon is still not clear, although some studies pointed to a positive impact of shifting, as compared to alternative land use systems, including forests (Sommer, Denich and Vlek, 2000; Lawrence, Suma and Moge, 2005).

On the other hand, based on the updated version of report by the UK-based Forest Peoples Program (FPP) “many initial REDD concepts fail to acknowledge forest governance problems, do not propose forest tenure reform and too often unjustly identify ‘shifting cultivators’ as a primary driver of deforestation-without scientific or legal justification” (Griffiths and Martone, 2009). With this regard, there have been critical questions and need further investigation and assessment for relations of shifting cultivation with forest degradation and conservation in a more holistic manner, taking into account the livelihoods, resource management system, culture and identity of indigenous people (IP), and ES trade-offs.

2.4 AGRICULTURE AND ENVIRONMENTAL SERVICES IN CAMBODIA

Cambodia borders three emerging economies-the Lao People’s Democratic Republic (Lao PDR), Thailand, and Vietnam- and has an important link to the sea through its coast on the Gulf of Thailand. Plains in the Tonle Sap Basin and the Mekong Lowlands comprise about three quarters of the country topography. Upland areas are suitable for plantations, mainly for rainfed rice and agro-forestry. The Mekong River enters Cambodia from the North before making its way to the sea through Vietnam in the Southeast. The flat, well-watered terrain is conducive to food production. The country covers a land area of 181,035 km² and 15 million people. It ranks eighth in land area and seventh in population among the 10 member countries of the Association of Southeast Asian Nations (ASEAN).

2.4.1 Agriculture in Cambodia

2.4.1.1 General Presentation of Agriculture in Cambodia, the Inner and the Outer Cambodia

Agriculture (including fisheries) is mainstay of the economy, employing over 70 percent of the workforce and contributing 37 percent of national value-added. Large parts of the country are forested, although forestry is not a significant industry. Oil and natural gas deposits lie offshore and are being explored, but have yet to be explored (ADB, 2014).

In agriculture, expanded cultivation of fertile land, supported by ample water and a large rural labor force, led to major increases in rice production. Modernizing and increasing productivity in this sector is also a key to promoting broad-based economic growth in the National Strategic Development Plan Updated 2009-2013. With generally flat terrain and vast water resources, agriculture continues to hold considerable potential for development. The sector essentially contributes to enhance domestic food security, increase export earning, and share inclusive growth by raising household income and reducing rural poverty. Particularly, this employment poverty nexus is relevant in the context of female agriculture workers. In 1998, agriculture accounted for 78 percent of the country's total employment, compared with an average of 44 percent in the selected ASEAN countries. A decade later, agricultural employment slightly declined to 72 percent of the total, while the Asian average dropped to 37 percent (ADB, 2014).

Pillot *et al.*(2000) identifiedseven types of farming systems in the rural sector of Cambodia. First group comprises at least four major rice-based faming system (for more detail, see Pillot, 2007):

- (i) the first are those found in non-irrigated terrace zones, distinguished by seasonal rice cropping that is often uncertain and poorly productive, and by frequent association with the exploitation of sugar palm;
- (ii) the second groupis made of those systems in flood recession zones where the control of water permits for intensive rice cropping;
- (iii) next come those in large flooded fields-floating rice-in which the extensive nature of farming practices does not prevent good levels of work productivity but in which the hydraulic risks are higher; and
- (iv)last come the upland rice-based systems, cultivated with slash-and-burn land preparation, in the sparsely populated areas of the northeastern provinces.

The second group is made up of widely diversified farming systems in which rice cropping is most often found but in which, unlike the previously family, there is a great deal more “dry” cropping-often called *chamkar* cropping in Cambodia. These were two specific systems have been distinguished in the second group:

- (i) river bank farming systems in areas along the riverbanks that are dominated by diversified cropping systems and follow the annual rhythm of flooding; and
- (ii) red and black soil upland farming systems where rubber farming is concentrated and near which the cultivation of many other crops is also increasing.

The last group covers “modern” capital-intensive systems that are found mostly near cities, whether in riverbank zones (such as around Phnom Penh) or in combination small riverbank or terrace zone (e.g. Battambang, Siem Reap): intensive market garden cropping, industrial, chicken farming for eggs or meat, orchards, etc.

2.4.1.2 Agrarian History of Cambodia

The Angkorian-Khmer Empire (9th to 15th century)

The dawn of the Angkorean Empire established an area, as the capital to be called Angkor. Just north of the largest lake in the region, the Tonle Sap, the area provided a central location for the expansion of the empire and helped ensure the foundation for an agricultural sector that would supply the surrounding area for centuries to come (Chandler, 1992). As at least one million inhabitants were living within the ancient city’s boundaries, the cultivation of the land surrounding land for agriculture use was undoubtedly a large task (Taylor, 2006). Leading Cambodia scholar David Chandler has written of period spanning 1794-1848.

Nearly all the people of [Cambodia] were ethnic Khmer, who occupied themselves with rice farming and with the monastic and official life. Commercial and industrial tasks were handled by minority groups. Marketing, garden farming, and foreign trade for example implemented by Chinese or by people of Chinese descent. Cattle trading, weaving, and commercial fisheries were controlled by a Muslim minority composed partly of immigrants from Malay archipelago... The Kui people in the northern part of the country smelted Cambodia’s small deposits of iron ore (Chandler, 1992).

Originally, Cambodia’s ethnic majority has always been overwhelmingly Khmer, but among its neighbors, Cambodia seems like an American melting pot of shorts (Ear, 1995). Becoming the alternative vassal of its neighbors Siam (Thailand) and Hue (Vietnam), Cambodia was on the verge of national extinction in the early 19th century.

The French Colonial Period (1863/1883-1953)

The contemporary history of Cambodia's economy begins with the colonization in 1863, yet little happened for quite sometimes because France's development focus was on Sothorn Vietnam, where most tax revenues from Cambodia were sent (Country Profile, 1993). From Alain Forest's doctoral dissertation, *Le Cambodge et la colonization Française* (1980), mentioned that Cambodia had begun efforts to modernize and develop under the French guidance (Forest, 1897). He cited the evolution of property rights and the taxation of rice paddies, tobacco, cotton, sesame, sugar cane, indigo, and other foodstuffs. During this same period, Forest boldly noted the end of patronage and the birth of representative institutions in its place. However, Ear (1995) judged that may be Forest is mistaken in that respect, because patron-clientelism has not subsided to this day.

By the 1930s, little progress on developing Cambodia's economy had been made. According to Etcheson (1984) France's need to import labor from Vietnam, was due to the low productivity of Khmer workers. Ear (1995) pointed that it is a problem tackled in the dual sector classical economy model with ominous wage repression. Due to labor was instead imported from Vietnam, inter-sectoral labor flows (from agriculture into industry) from Cambodians were hampered.

The Sihanoukist Period (1953-1970)

In the postwar years, Cambodia's economy remained strictly non-industrial: fishing, agronomy, spice cultivation, and (rubber) plantations (Delvert, 1983). The economy continued to export rice and rubber to France, while the latter sent high value added goods (i.e., luxury imports) to the upper echelons of Cambodian society (Khieu, 1979). In 1954 Geneva Conference and French defeated at Dien Bien Phu, Vietnam, marked the end of French presence in Indochina, but was not the final conflict for that region. A year earlier, however, Cambodia had been granted independence peacefully. In the following years, Sihanouk made a number of critical choices, which would become the backbone of economic development for Cambodia during 1950s and 1960s.

Sihanouk, as it will become evident, made some good choices for Cambodia's economy, when he did make them. However, for the most part, it seems, he failed to govern with forethought. For instance, as became fashionable during the 1950s and 1960s, Cambodia issued numerous economic plans. The first two-year plan, promulgated in 1956 and renewed in 1958, emphasized the development of infrastructure and agricultural

development. Prud'Homme's description of planning approach to development is insightful (Prud'Homme, 1969). The creation of a port at Kampong Som named "Sihanoukville" for maritime traffic eased the burden placed on the Mekong River (which had, until then, been the only pipeline for transport to and from Vietnam to Cambodia) (Dauphin-Meunier, 1961). For the next decade, five-year plans were promulgated under Sihanouk's Planning Ministry for 1960-1964, 1964-1968, and 1968-1972.

During that time, rice had still always been at the center of Cambodian life. As in most Asian societies, one can be asked "how are you?" with "have you eaten rice today?" Rice gave Cambodians their daily diets, of course, and for many an occupation. According to statistics available on rice production and exports, Cambodia was self-sufficient in rice production from 1956 to 1966 (Dauphin-Meunier, 1961; Country Profile, 1993). In 1960s, Cambodian national self-sufficiency in rice production was achieved as a result of the steady expansion of acreage worked by smallholders who sold surpluses alongside the state-supported development of a modernized, commercial subsector centered in Battambang province (Prud'Homme, 1969). Since Cambodia exported rice, fertilizer use, which is a good indicator of improvements in agriculture, increased from 1961 to 1964, decreased by one-half in 1965, then went up again in 1966 and 1967.

Furthermore, Prud'Homme's observation that "Mechanization has on begun: there are hardly more than 600 tractors in 1963, of which nearly 400 are in Battambang (Country Profile, 1993)." Growth in the agricultural sector slowed down beginning 1964, a result of upstream industries tied to the sale of rice (transportation, alcohol, etc.) (Prud'Homme, 1969). This was correlated with a general downturn in construction, textiles, and other industries in 1965, 1966, and 1967 (Ear, 1995).

It was not until the early 1970s a time of extreme turmoil for Southeast Asia that Cambodia suddenly found itself in the unusual position of importing rice via American food aid. Etcheson's data on rice production refer only aggregate output, not per capita production (Etcheson, 1984). To explain this, Prud'Homme concluded that Cambodia soil was relatively poor and unsuited for agriculture (Prud'Homme, 1969). Thus, as population increased from 1931 to 1965, the area of cultivated land increased from 2,508 square miles to 6,398 (Etcheson, 1984).

The Khmer Republic (1970-1974)

On March 18, 1970, a day that lives in infamy for Norodom Sihanouk, the chief of the army and prime-minister, Marshall Lon Nol, performed a coup d'état (while Sihanouk was in Moscow). This came as a deep shock to both Sihanouk and high elements of the American government because neither had anticipated the move (contrary to popular misconceptions) (Vickery, 1986). Lon Nol's pro-American regime renamed the Kingdom of Cambodia, the "Khmer Republic." The monarchy was officially dissolved; stripping Sihanouk of his kingly status and position as chief of state. A new constitution abolishing the monarchy was passed and Cambodia became a Republic.

Rice production declined substantially from 3.8 million tons in 1970 to 2.7 and 2.1 million tons in 1971 and 1972, respectively. There were also decreased in rubber, corn and palm sugar output, due to the war with the North Vietnamese who had made several incursions into Cambodia (Ear, 1995). As whole agricultural sector, the Khmer Republic saw a dramatic declined. From self-sufficient net exporter of rice, SONEXIM (Cambodia's National Import-Export Society) reported imports of rice (309,214 tons), cotton fiber (5,633 tons), cotton linen (1,614 tons), tobacco leaves (2,043 tons), wheat (30,740 tons), and flour (20,720 tons) using American economic aid by 1974. Burstein (1976) explained that, the small export sector absorbed resources largely irrelevant to home production and, as the writ of the Lon Nol government became more and more confined to Phnom Penh, exportation became less and less significant.

Democratic Kampuchea (1975-1978)

On April 17, 1975, the Khmer Rouge (Democratic Kampuchea) guerrillas, who had for the last five years and amassed virtually all Cambodia provinces, entered the capital. The Khmer Rouge has issued a four-year plan for 1977 to 1980; the purpose was to evacuate of all cities as revolution. The fact that the cities were all emptied within several days of the fall, with the people knowingly directed to spots in the countryside where they camped at least temporarily, does not give the impression of a sudden, knee jerk action. This had all been organized beforehand (Twining, 1975).

Agriculture and in particular the production of rice, rebounded to prewar levels by 1976, but what human cost? According to Ear (1995), surely few others but the Khmer Rouge leadership and those having full rights ate well. The role of rice was significant to the Khmer Rouge. Rice was at core of their plan to develop an industry that would serve agriculture. Rice was highly considered as the basic crop of our people as well as the basis

of Cambodia's new economy. If we have plenty of rice, we have plenty of everything (Official Khmer Rouge Announcement in FBIS IV, April 28, 1977:H3) (Jackson, 1978).

It was ambitious in its goals, and detailed too in the four-year plan. For instance, the Khmer Rouge goal for rice production called for the doubling of productivity per hectare. "Sensibly enough," Chandler (1992) writes, the document argued that exports of agriculture, rather than minerals or manufactured goods, could best provide the income needed by Democratic Kampuchea for autarchic economic growth. No other resources existed in the country.

The People's Republic of Kampuchea (1979-1989) and the State of Cambodia (1989-1992)

After invading Cambodia in December 1978 and taking control of Phnom Penh in January 1979, Vietnam overthrew the Khmer Rouge regime and installed a communist regime known as the 'People's Republic of Kampuchea (PRK)'. In 1989, the regime changed its name into 'State of Cambodia (SOC)'. Out of the devastation inherited from Khmer Rouge, the Vietnamese faction development a dictatorial but, nevertheless, effective authority over more than 80 percent of the territory. The PRK was considered the de facto government of Cambodia between 1979 and 1993, albeit with limited international recognition(Keller, 2005).

What was left of Cambodia's economy was further ravaged by war in this, the Third Indochina Conflict. The People's Army of Vietnam refused to withdraw from Cambodia for a decade, which meant that for these ten years the U.S Embargo on Vietnam now applied to Cambodia as well. As a devoutly Socialist state, the People's Republic of Kampuchea's (PRK) trade with non-Marxist states was discouraged. The most thorough study of that economy was Grant Curtis' Cambodia, a Country Profile(1993). Cambodia's major trading partners and patrons were Vietnam and the Soviet Union with some help from relief agencies such as UNICEF and the Red Cross (Vickery, 1986).

While the "ultra-collectivization" of the Democratic Kampuchea period had been left behind, attempts to forge ahead with agricultural collectivization failed because, "the system did not bring much to the peasants and due to the lack of efforts from the government in implementing it (Country Profile, 1993)." In 1979, land utilization for the production of rice was less than 30 percent that of the pre-war level (Wright and MacGregor, 1989); the data quoted is 700,000 ha compared to 2.4 million in 1960s. For

the new government, development of a collective economy was the goal; family (i.e. individual private) economy should be encouraged and expanded in order to aid the collective economy (Vickery, 1986). The lack of draft animals such as water buffaloes and cattle combined with what Viviane Frings calls “individualistic peasant culture” made agriculture collectivization a failure.

Average yields for rice as measured by tons per hectare showed that from 1987 to 1992, Cambodia remained at about 1.28 ton/ha without any sign improvement. Nevertheless, agriculture sector still has a long way to go before returning to 1960s production levels. Total recovery is not assured anyhow since the devastation of two decades of war, revolution, and starvation has left much of the land unsafe because of landmines (Country Profile, 1993).

Agricultural production outside of rice since 1967 has not recovered with respect to corn and vegetables. In contrast, root and oleaginous crops (which includes sweet potatoes and soybeans) have rebounded. Most of the 1980s saw this type of recovery, at times remarkable. For example, 369,000 tons of root crops were produced in 1980, more than ten times the level of 1967 and more than three times, 1984, 1988, and 1992 levels, respectively (Country Profile, 1993).

Kingdom of Cambodia (1993-present)

Since the 1993 election, overseen by the United Nations (UN), Cambodia has been in transition to a full market economy, following decades of war and isolation from international markets by socialist regime. It is since then that an expansion of industry has been observed. The first phase (1993-1998) saw an increase in the share of manufacturing to gross domestic products (GDP) from 12 to 16 percent. The second phase (1999-2003), when the growth in the manufacturing sector escalated after Cambodia achieved full peace throughout in 1998 and successfully integrated into ASEAN in 1999. The third phase of manufacturing development began in 2004 when Cambodia became a member of the World Trade Organization (WTO). During the fourth and most recent phase the fast growth rate of the manufacturing sector has subsided in the aftermath of global financial crisis (Chhair and Ung, 2013).

Based on the World Bank (2009), forestry and fisheries sectors accounted for 19 percent of GDP growth in 1993-1998 but only two percent in 2003-2008. Forest production accounted for 43 percent for exports in 1994 and less than one percent in 2006. Out of

concern for the rapid degradation of forest resources and fish stocks, the government banned logging in 2000 and reformed large commercial fishing lots in 2002. The concept of community approach to forestry and fishing has been promoted since then. These two sectors which thrived in the 1990s became sunset industries in the 2000s.

According to Korea International Cooperation Agency (KOICA, 2013), to respond to the two National Strategic Development Plans respectively, Agricultural Sectoral Strategic Development Plans (ASDPs) (2006-2010 and 2009-2013) were prepared to achieved the long term vision to ensure the availability of enough and safe food for all people, and that poverty will be reduced by sustainable natural resource management and conservation. The ASDPs have laid down the following objectives: (i) to enhance national food security and agricultural productivity; (ii) to commercialize agriculture by increasing the ratio of sales production through expansion of market access for agricultural products; (iii) to strengthen industrial system and legislations framework, and human resource development which are obstacles in achieving agricultural sector goals; (iv) to boost productivity through structural reform in fisheries; and (v) to raise productivity through structural reform in forestry.

The Strategy for Agriculture and Water (2010-2013) was jointly developed by the Ministry of Water Resources and Meteorology in 2010 with the goals to contribute to poverty reduction, enhancing food security and economic growth by (i) enhancing agricultural productivity and diversification and (ii) improving water resources development and management (Chhair and Ung, 2013).

The European Union's EBA (European Banking Authority) initiative, which took full effect in 2009, permitted Cambodia as a least developing country to export rice to EU tariff free. The government took this opportunity to set up its local rice processing industry which has great potential due to the large surplus of paddy rice leading the government to set targets for large production and export volumes to be achieved by 2015.

2.4.2 Ecosystem Services in Cambodia

In Cambodia, as in all other countries in Southeast Asia, there are a variety of policy settings that can be concerned by ecosystem services (ES) valuation. Protection and conservation of ecosystems is prioritized by the Cambodian Government as stated in the constitution: "The State shall protect the environment and balance of abundant natural resources and establish a precise plan of management of land, water, air, wind geology,

ecologic systems, mines, energy, petrol and gas, gems, forest and forest products, wild life, fish and aquatic resources” (Article 59 of the Constitution) (CDRI, 2010). The government has made some efforts to address the issue of deforestation in recent years. Under Cambodia’s Millennium Development Goal 7, the country aims to attain forest cover of at least 60 percent of the country by 2015 (Kingdom of Cambodia, 2003).

Several policy venues in Cambodia have been highlighted where ES can play a role. First, one of the most obvious policy venues for ES is in the context of decisions to protect lands and waters by designating them as off limits to most forms intensive use. In Cambodia, major protected areas include national parks, habitat conservation areas, and areas protected with sustainable use of natural resources. A total of 42,592 km² is officially protected according to the most recent estimates (ASEAN, 2009). Second, ES place in agriculture and aquatic through the trade-offs between benefits of ecosystems in their natural state and the benefits of converting to more intensive uses. In fact, there has been a rapid increase in large economic land concession (ELCs) to export agriculture and industrial tree plantations. Conflicts arise with the ELCs due to ES including direct provision of food and fiber as well as cultural and spiritual uses are overlooked in the decision making process according to human rights advocates (UN, 2007). Third, within the context of development projects and programs, there is increasing interest in exploring “green infrastructure” solutions such as green alleys, green rooftops, urban forestry, and open spaces including parks and wetlands to better cope with floods and coastal storm surges than conventional or “grave” infrastructure technologies. ES can play a vital role in these contexts by helping to establish whether or not are more cost effective than grave infrastructure, particularly in light of ES they provide (Talberth *et al.*, 2013). Last, as in other Lower Mekong Basin countries, hydropower development is an area where ecosystem service valuation can provide important role in the decision making process.

Recently, the notion of ES has been highly increased both in public policies and in operational projects for forest conservation. The notion of ES has first been explicitly employed from the early 2000s in a number of ecosystem valuation studies (Chervier, Neang and Depres, 2010). From 2009, the concept of ES then has emerged in subsidiary public policies and government strategies, but not yet in overarching laws. A case for the Green Growth Roadmap, initiated by UNESCAP (United Nations Economic and Social Commission for Asia and Pacific) and defined with several government ministries and agencies, for the National Forest Program implemented by the Technical Working Group Forest and Environment gathering the Forestry Administration, the Ministry of

Environment and all donors working in Cambodia, for the Cambodia REDD+ roadmap designed by an inter-ministry taskforce supported by some donors.

In Cambodia, valuation of ecosystems has been also studied and practiced in several projects and specific types of ecosystems for the last decade. In 2007, a study of ES valuation was performed in two protected areas in Great Mekong Sub-region (Phnom Aural and Phnom Samkos Wildlife Sanctuaries) taking into consideration only sustainable timber harvesting, agriculture, non-timber forest products (NTFPs), and carbon storage (Grieg-Gran, 2008).

Beside that there have been many studies attempting to place values on provisioning services natural ecosystems, regulation and maintain services, and cultural services (see, for example, De Lopez *et al.*, 2001; Hansen and Top, 2006; Chervier, Neang and Depres, 2010; Soussan and Sam, 2010; Dararath, Top and Lic, 2011; Yoeu and Pabuayon, 2011; Neang, Aznar and Vollet, 2015). Based on a country report of USAID (2015), however, as the decision makers in Cambodia consider use of ES valuation studies in the years ahead, there are three key points to keep in mind:

- (i) the importance of ES cannot be under re-emphasized;
- (ii) there are many policies and investments that have the potential to affect the quantity and quality of ES provision; and
- (iii) while the field of ES valuation is relatively new, it has now matured to point where there is a wealth of detailed technical guidance manuals from which to draw on as well as a rich portfolio of ES valuation studies in the region that can be helpful.

2.4.3 Land Use in Cambodia

Cambodia is blessed with ample land and water resources, which if properly developed and managed can be harnessed to expand its agricultural sector, increase rural incomes, and improve the national economy as a whole. With a rapidly growing, impoverished, and largely agrarian population, Cambodia would benefit greatly from development that would result in optimally productive use of the land. The total land area of the country is estimated at over 18 million ha (Table 2-1), with only 2.7 million ha or 15 percent currently being devoted to agriculture, predominantly rice farming (USDA, 2010).

Table 2-1. Cambodia land use 2004 (Area in million ha)

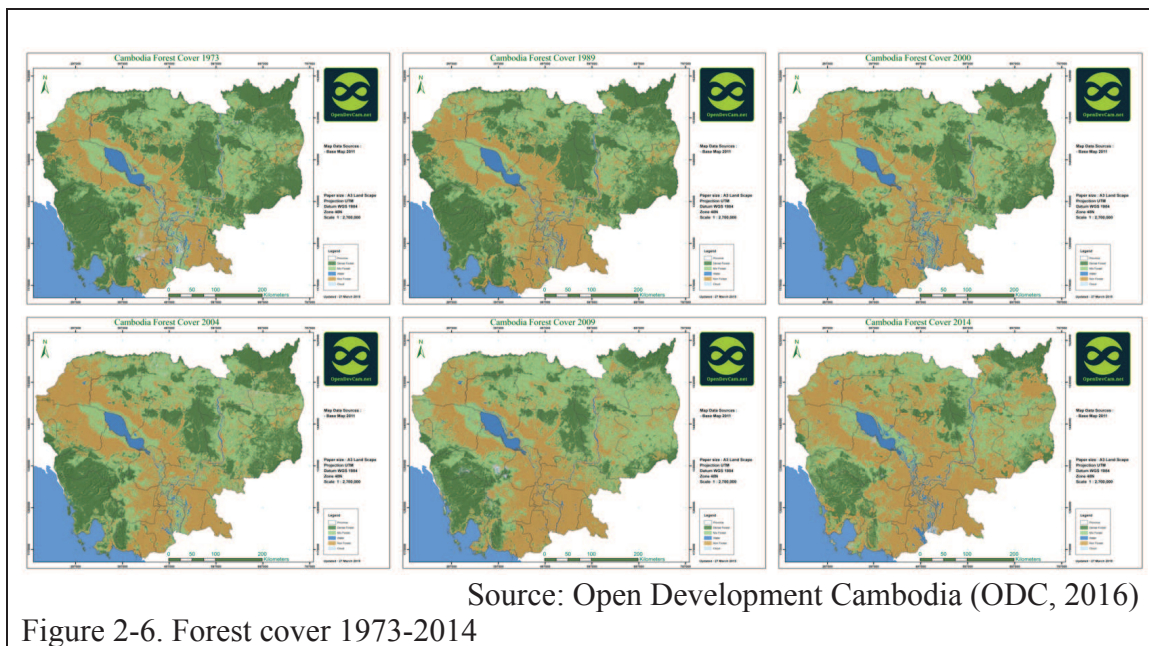
Land classification	2004	
	Area	Percentage

Forest and protected areas	8.0	44.4
Forest and agricultural concessions	3.9	21.7
Agricultural land	2.7	15.0
Scrub land	1.7	9.4
Urban and infrastructure	1.1	6.1
Fishing concessions	0.5	2.8
Land mine contaminated areas	0.1	0.6
Total	18.0	100

Source: World Bank(2004);
Data: Ministry of Agriculture, Forestry and Fisheries (MAFF, 2004);
Independent Forest Sector Review (ISFR, 2004)

As of 2004, the nation's forest lands were estimated by the World Bank at 8 million ha (44.4 percent of total land area), down 5.1 million or 39 percent from levels recorded in 1970 (World Bank, 2004). The illegal extraction of timber has been rife for decades, while clear-cutting of land devoted to forest or agricultural concessions has also contributed to the significant reduction in the nation's forest resources. The second largest land use behind forest cover is actually land devoted to economic concessions, or private sector company development. The concessions are typically located on previously forested or degraded government (state-owned) land and often devoted to plantation-style industrial agro-forestry production of trees suitable for building material, pulp and paper, or for rubber. Cassava production is the single largest crop grown from land concessions devoted to agriculture, with total field crop agricultural concessions estimated to be only 0.8 million ha or 21 percent of total concession lands (ISFR, 2004; MAFF, 2004; World Bank, 2004; USDA, 2010).

In 1973, forests covered an estimated around 70 percent of the country's territory. To monitor the loss of forestland, the Forestry Administration (FA) conducted a series of forest cover assessments in 1993, 1997, 2000 (partial), 2002 and 2006 (FA, 2010). Results revealed that Cambodia's forest cover had declined to an estimated 59 percent of the total land area in 2006 (Figure 2-6). The loss of forest cover is consistent with land use and land cover change patterns associated with demographic growth and economic development in most areas of the countries(ODC, 2016).



2.5 THEORETICAL FRAMEWORK

The research has been conducted based on the following steps and conceptual framework:

- Step 1: Identify geographic focus to understand the characteristics of land use systems, socio-economic conditions, and the drivers of change in land use of the study area.
- Step 2: Identify the potential cropping systems and ES to be assessed through field study and consultation with stakeholders and experts.
- Step 3: Develop valuation methods of the selected ES based on the available valuation methods and data.
- Step 4: Correct required data for valuation through field consultation and secondary literature review of local studies.
- Step 5: Apply the valuation methods and calculate the value for each selected ES.
- Step 6: Develop scenario analysis based on different land use options and sensitivity analysis to deal with uncertainties of results.
- Step 7: Document the findings and analyze policy implications

2.5.1 Valuation of Ecosystem Services Provision

The Millennium Ecosystem Assessment(MA, 2005) harmonized these diverse strands of science into a consistent typology of ‘ecosystem services or ES’ as a basis for assessing the status of global ecosystems and their capacity to support human wellbeing. The MA

grouped ES into four main categories (Figure 2-7): provisioning services, regulatory services, cultural services and supporting services. Provisioning services are those things that can be extracted from ecosystems to support human needs, more or less synonymous with a prior definition of ecosystem ‘goods’ and including such tangible assets as fresh water, food (crops, fish, etc.), fiber and fuel, and so forth. Regulatory services include those processes that regulate the natural environment, including the regulation of air quality, climate, water flows, erosion, pests and so on. Cultural services include diverse aspects of aesthetic, spiritual, recreational and other cultural values. Supporting services do not necessarily have direct economic worth but include processes essential to the maintenance of the integrity, resilience and functioning of ecosystems, and so the delivery of other benefits, including matters such as soil formation, photosynthesis and water recycling.

We in particular focus on change in factor that indirectly affect ecosystems, such as population, technology, and lifestyle (upper right corner of Figure 2-7 designed by MA 2005), can lead to changes in factors directly affecting ecosystems, such as the catch of fisheries or application of fertilizers to increase food production (lower right corner). The resulting changes in the ecosystem (lower left corner) causes the ES to change thereby affect human well-being. These interactions can take place at more than one scale and can cross scales. For instance, in conceptual framework of MA (2005), a global market may lead to regional loss of forest cover, which increases flood magnitude along a local stretch of river. Likewise, the interactions can take place across different time scales. Actions can be taken either to respond to negative changes or to enhance positive changes at almost all points in the framework.

According to Farber, Costanza, and Wilson (2002), the terms ‘value system,’ ‘value’, and ‘valuation’ have a range of meanings in different disciplines. ‘Valuation’ is about assessing trade-offs toward achieving a global. ‘Value systems’ refer to intrapsychic constellations of norms and precepts that guide human judgment and action. They refer to the normative and moral frameworks people used to assign importance and necessity to their beliefs and actions. Because ‘value systems’ frame how people assign rights to things and activities, they also imply practical objectives and actions. All decisions that include trade-offs involve valuation, either implicitly or explicitly (Costanza *et al.*, 1997).

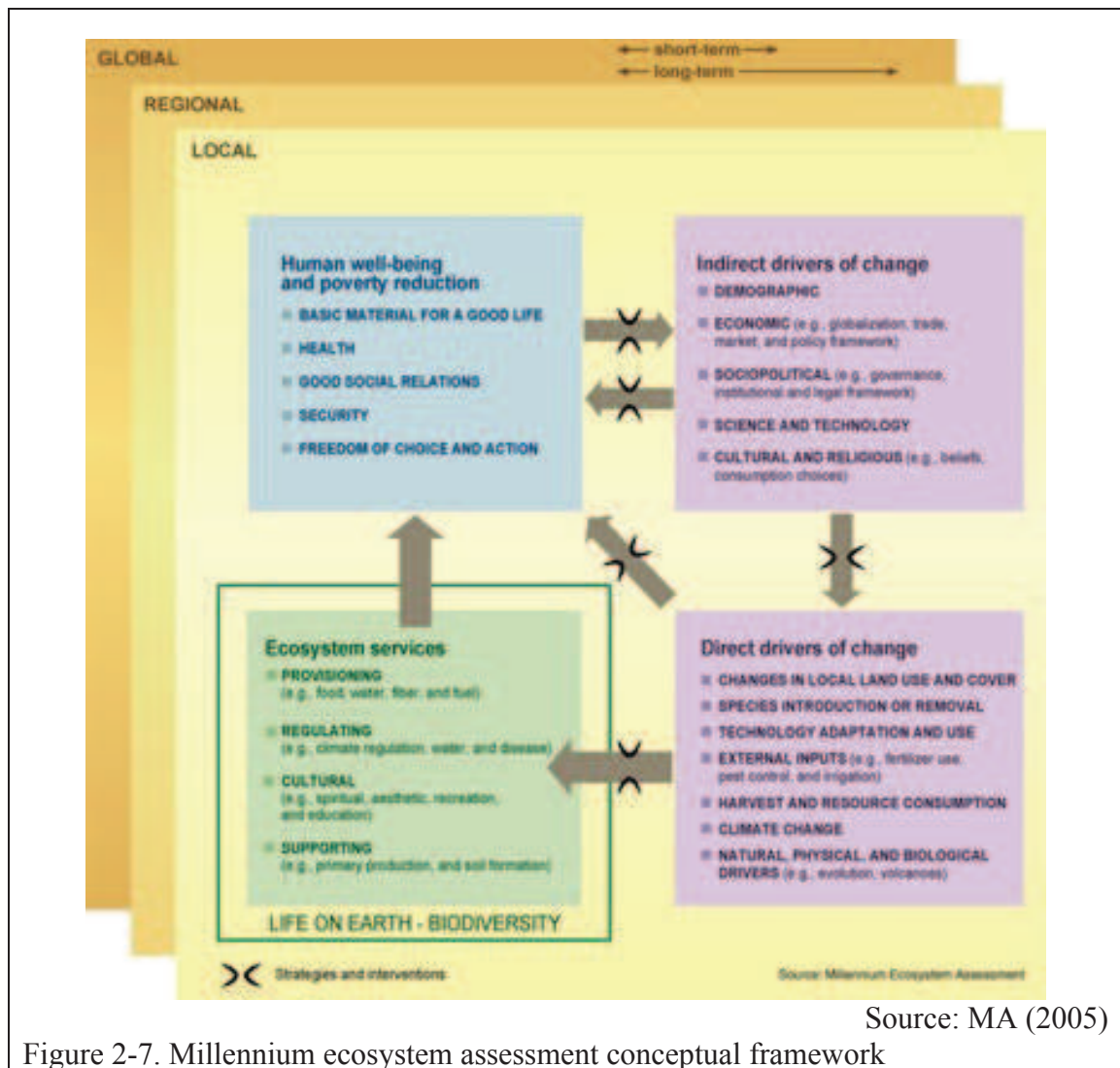


Figure 2-7. Millennium ecosystem assessment conceptual framework

ES are defined as the benefits people derive from ecosystems; the support of sustainable human well-being that ecosystems provide (Costanza *et al.*, 1997; MA, 2005). Therefore, the value of ES is the relative contribution of ecosystems to that goal. There are multiple ways to assess this contribution, some of which are based on individual's perceptions of the benefits they derive. Conversely, the support of sustainable human well-being is a much larger goal and complicated (Costanza, 2000) and individual's perceptions are limited and often biased (Kahneman, 2011). Here, Robert Costanza (2000) furthermore include methods to assess benefits to individuals that are not well perceived, benefits to whole communities, and benefits to sustainability. This is a challenge in ES valuation, but even some of the existing valuation methods are not depend on individual perceptions of value.

There are two ways that something can be valuable: instrumentally or intrinsically. The economic approach to ecosystems is one of anthropocentric instrumentalism. Ecosystems

and their services are valuable if they serve and satisfy the human well-being (Goulder and Kennedy, 1997; Meffe and Carroll, 1998). The choice of valuation methods generally depends on the type of service, availability of resources, time and data for the study as well as its purpose. Some of the commonly used valuation methods to quantify or estimate the different value components of the Total Economic Value (TEV) are illustrated in Figure 2-8. Direct use values tend to be the easiest to account for, because they are often part of formal markets. Non-use values are particularly challenging; they are the most difficult to quantitatively measure, and have the greatest uncertainty attached to them (Hawkins, 2003).

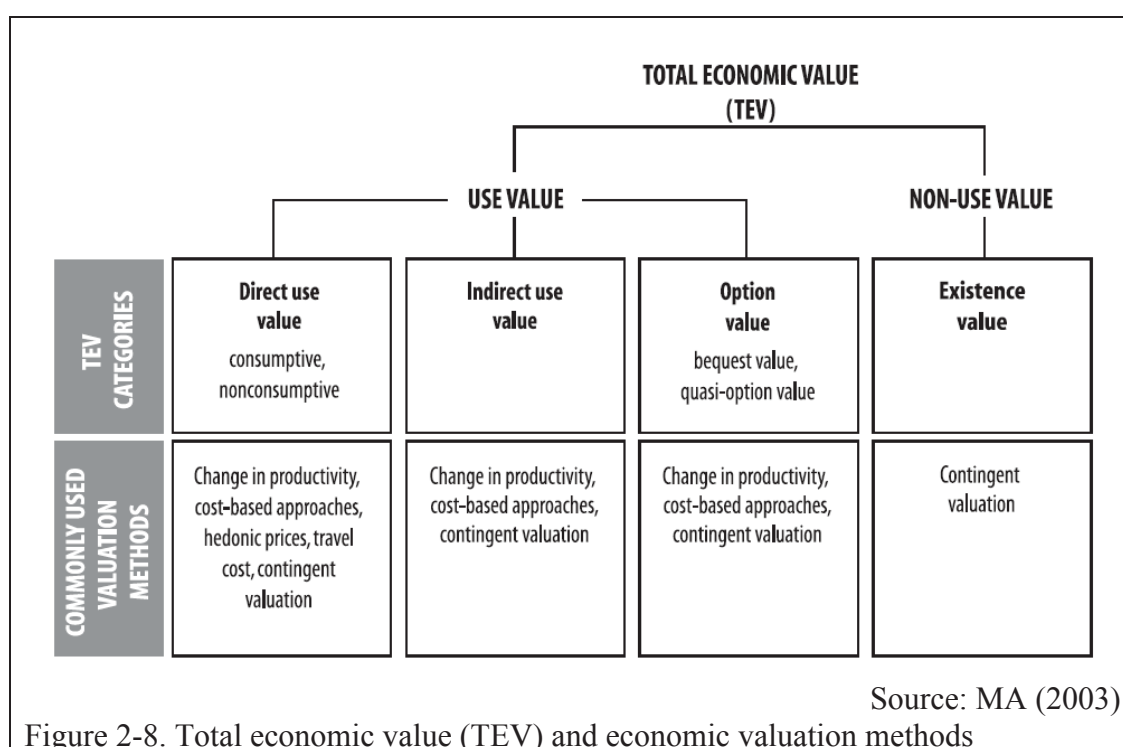
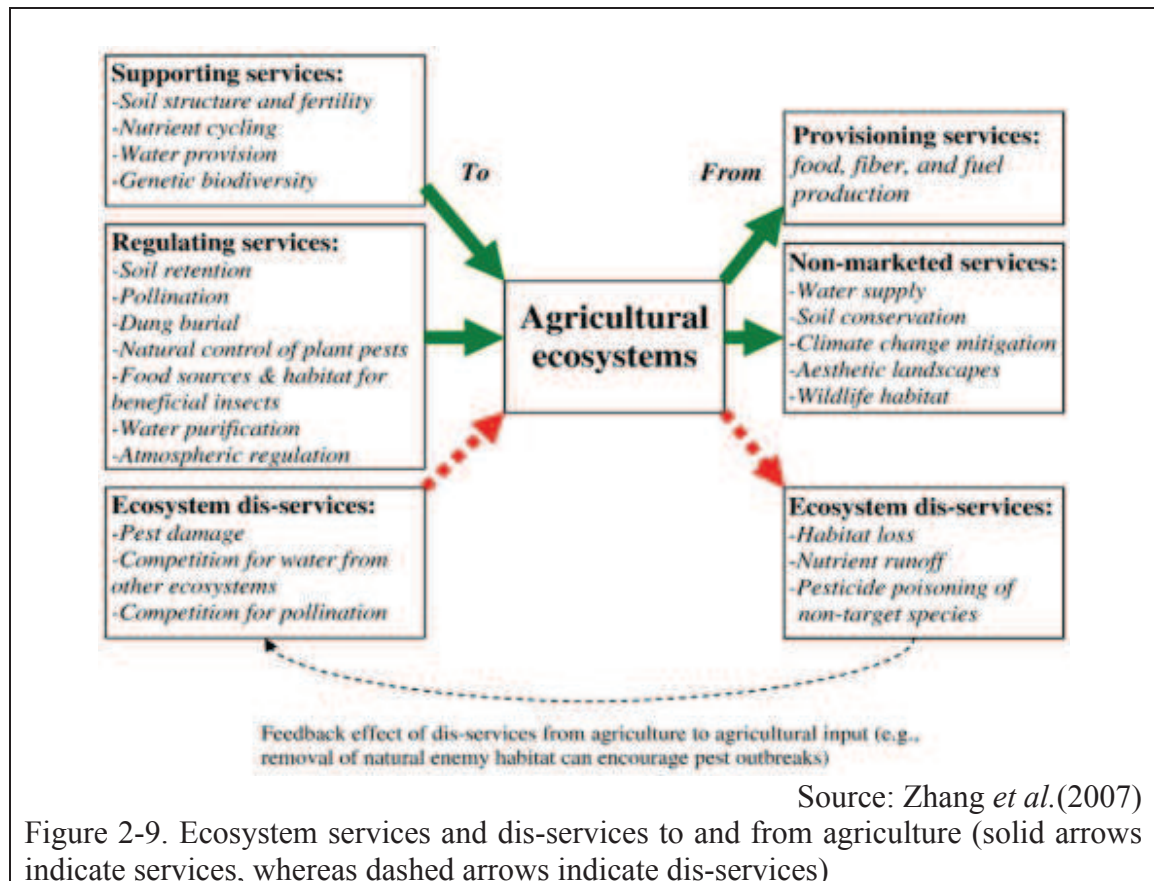


Figure 2-8. Total economic value (TEV) and economic valuation methods

2.5.2 Valuation Ecosystem Services (ES) and Dis-services (EDS) to Agriculture

A wide variety of ecosystem services (ES) and dis-services (EDS) to agriculture confer benefits and costs, respectively. These are supplied by varied species, functional groups, and guilds over a range of scales and influenced by human activities both intentionally and unintentionally. Figure 2-9 describes the range of major ES and EDS to agriculture (Zhang *et al.*, 2007). In this context, the calculation of productivity represents an important analytical and monitoring tool. The explicit incorporation of environmental considerations into productivity measures, especially for the agriculture, would support a more

understanding of the factors that derive output and input growth and hence support the development of more integrated policy responses (Obst, 2015).



2.5.3 Land Use Change Models

Land use change models are often used by researchers and professionals to explore the dynamics and drivers of land use or land cover change and to inform policies affecting such change. A broad array of models and modeling methods are available to researchers, and each type has certain advantages of models as mean of exploring the functionality and ability of different approaches. A review of different types of models as means of exploring the functionality and ability of different approaches has been illustrated here. Models are used in a variety of fields, including land use change science, to better understand the dynamics of systems, to develop hypotheses that can be tested empirically, and to make predictions and/or evaluate scenarios for use in assessment activities (Brown *et al.*, 2004).

Modeling is a significant component of each of the three foci outline in the science plan of the land-use and land cover change (LUCC) project (Turner *et al.*, 1995). In Focus 1, on comparative land use dynamics, models are used to help improve our understanding of dynamics of land use that arise from human decision-making at all levels, households to nations. These models are supported by surveys and interviews of decision makers. Focus 2 emphasizes development of empirical diagnostic models based on aerial land satellite observations of spatial and temporal land cover dynamics. Lastly, Focus 3 specifically discusses on the developments of LUCC that can be used for prediction and scenario generation in the context of integrative assessments of global change.

Literally, hundreds of models of LUCC have been described in the literature on landscape ecology, geography, urban planning, economics, regional science, computer science, statistics, geographic information science and other fields. Due to differing disciplinary thoughts, as well as differing methodological approaches, data availabilities, and modeling goals, attempts to categorize models are complicated by a relatively large number of dimensions on which the models vary. A brief summary of several of these efforts, and outline of the categories of models are discussed in Brown *et al.*(2004) as the followings.

Perhaps Baker(1989) is the first of these reviews in the context of landscape ecology, so its focus was on land cover change. Entire landscape models seek to model change in some aggregate attribute or state of the landscape over time. Distributional models describe changes in the proportion of the landscape in each of number of land cover classes. Spatial landscape models describe the location and configuration of changes in land cover. The paper by Baker(1989) did not discuss models as it was on landscape ecological processes that include explicit representation of human decision-making.

In the late 1990s, Lambin(1997) described models of observed land cover change that used mathematical, empirical or statistical, and spatial simulation models, whereas Kaimowitz and Angelsen (1998) focused on land use change models that were developed to describe micro-, regional-, or macro-economic aspects of the deforestation process, using similar methodological categories. Later, Irwin and Geoghegan(2001) compared and contrasted non-economic models, which included many of the approaches described by Baker(1989) and Lambin(1997) but also included cellular automata (CA), and economic models of LUCC, which were divided into non-spatially explicit and spatial explicit models.

Several reviews provide an alternative typology of land use change models. Agarwal *et al.*(2002)described 19 models that were arranged on dimension of space, time, and human decision-making. Models were characterized on these three dimensions according to both the scale at which they operated and the degree of complexity in the representation. The attention to the ways in which human decision-making is represented, in both the reviews by Kaimowitz and Angelsen (1998) and Agarwal *et al.*(2002), draws attention to the need for models that represent human decision-making explicitly. Parker *et al.* (2003) focused on agent-based models as tools for representing human decision-making and simulating the aggregate outcomes that result from decisions made by many individuals. DeAngelis and Gross (1992) discussed on agent-based models represent a qualitatively different approach to the mathematical and statistical approaches that pervaded the earlier reviews, and offer potential for new LUCC models, similar to approach to ecological modeling offered by individual-based models. It is argued by Parker *et al.*(2003) that combining agent-based models, to represent human level decision-making, with cellular models, to represent biophysical landscape change, offers a promising approach for future model development in LUCC.

However, types of LUCC differ depending on the types of agents that are active on the landscape. In a large and/or heterogeneous region, different agents may be active in different areas, which add spatial complexity to any attempt at causal explanation(Walker, Moran and Anselin, 2000). Further complicating the matter is that LUCC may be substantially affected by dynamic interactions, among agents or between agents and their environment (Geist and Lambin, 2001). The deforestation literature has long recognized interactions between loggers and follow-on farmers, for example (Walker, 1987; Walker, Moran and Anselin, 2000).

Recent developments and application of LUCC models have addressed a number of key conceptual and methodological issues that have limited these models in the past (Brown *et al.*, 2004). For instance, an important distinction that is made in only a few of these reviews is that between models of land use change and model of land cover change. While the reviews by Kaimowitz and Angelsen(1998), Irwin and Geoghegan(2001), and Agarwalet *al.*(2002) explicitly emphasized on models of land use change, those of Baker(1989) and Lambin(1997) are oriented towards models of land cover change. Parker *et al.*(2003) review to be the first to address both land use and land cover change, though it has a specific focus on agent-based models. The distinction is important because it

affects both the data requirements for calibration and validation and the process representations required.

At a very elementary level, land use and land cover change means (quantitative) change in areal extent (increases or decrease) of a given type of land use or land cover, respectively (Briassoulis, 2000). Importantly, it requires to note that, even at this level, the detection and measurement of change depends on the spatial scale; the higher the spatial level of detail, the larger the changes in the areal extent of land use and land cover which can be detected and recorded.

In the case of land cover change, the relevant literature distinguishes between two types of change: conversion and modification (Skole, 1994; Turner *et al.*, 1995). Land cover conversion involves a change from one cover type to another. Land cover modification involves alterations of structure or function without a wholesale change from one type to another; it could involve changes in productivity, biomass, or phenology (Skole, 1994). Specifically, Meyer and Turner (1994) suggested that land use (both deliberately and inadvertently) alters land cover in three ways: converting the land cover, or changing it to a qualitatively different state; modifying it, or quantitatively changing its condition against natural agents of change.

Conversion of land use and its effects (CLUE) serves as a tool through which the various biophysical and human land use drivers can be combined and interacted in determining land use within a region. To demonstrate the potential of CLUE applications, various illustration assumptions about most discussed drivers have to be made and incorporated with the prototype. Both the simulated example region and the simulated time span are currently dimension neutral. This requires careful turning of both spatial and temporal scales for further calibration and application (Veldkamp and Fresco, 1996). However, due to the qualitative approach, the adaption and tuning procedure of CLUE to any specific region should not pose too many difficulties, but still requires a large amount of data on various subjects within the selected region.

2.5.4 General Principles of Land Drivers

From land evaluation and agronomic research indicated potential biophysical factors that are well-known (FAO, 1976, 1993). On the other hands, human factors in respect to land use are less well systematic described and investigated (Gallopín, 1991) although Turner *et al.* (1993) have pointed out a complete list. Therefore, it is almost unanimously accepted

that there are main categories: biophysical and socio-economic drivers (Briassoulis, 2000). The biophysical drivers include characteristics and processes of the natural environment such as: weather and climate variations, landform, topography, and geomorphic processes, volcanic eruptions, plant succession, soil types and processes, drainage patterns, availability of natural resources. In addition, the socio-economic drivers comprise demographic, social, economic, political and institutional factors and processes such as population and population change, industrial structure and change, technology and technological change, the family, the market, various public sector bodies and the related policies and rules, values, community organization and norms, and property regime, etc.

2.5.5 Institutional Economics Perspective

We adopted a multi-scale and interdisciplinary framework anchored in institutional analysis and political economics, which allows the simultaneous examination of the influence of institutions, discourses, and socio-economic context on actors' decisions. In the 1980s, Kiser and Ostrom (1982) developed the Institutional Analysis and Development (IAD) framework providing useful means to assess the causes of policy gaps and link multiple governance levels, namely (i) the operational level when the decisions directly affect resources management; (ii) the collective choice level when decisions affect the rules in use at operational level; and (iii) the constitutional level when decisions affect who decides and how decisions are made in the collective choice arena (Ostrom, 1999). Ostrom (2005) considered institutions as "the prescriptions that humans use to organize all forms of repetitive and structured inter-actions". Institutions do not only cover written legal documents but also informal rules which have been orally agreed upon.

Institutional analysis is particularly relevant since we assume that the recent changes in the land and forest policies-making arena in Cambodia significantly impacted the set of actors and rules governing land access and land use. The ELCs and CF determine unambiguously new rules of land ownership, access and use. In addition to introducing explicit institutional components, the given land concession and collective land rely on its execution on the establishment or enforcement of existing rules on land classification, land ownership and land use.

2.5.6 Social Drivers of Land Use Change

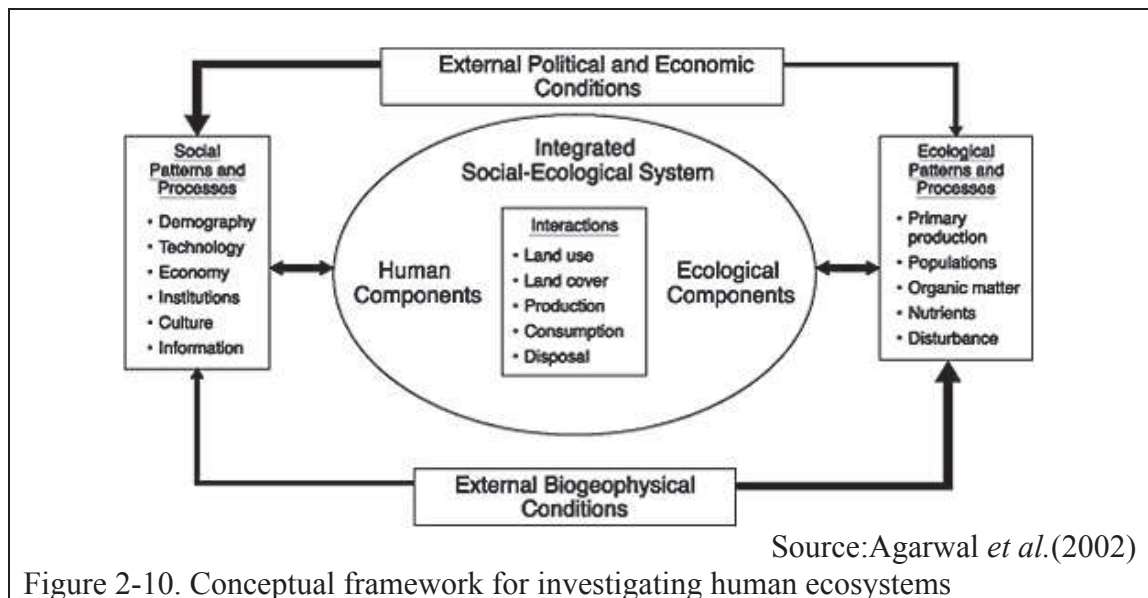
Agarwal *et al.* (2002) proposed a more dynamic framework that explicitly links what often divided into separate "natural" and human systems into a more integrated model (Figure

2-10). This framework emphasizes dynamic linkages by focusing on the interactions at the interface of human and ecological components of any human ecosystem. To emphasize linkage, Redman *et al.*(2004) focused on the interaction as the specific activities that mediate between the social and ecological elements of the broader social and ecological systems, including:

1. Land use decisions, especially those relating to the built environment;
2. Changes in land cover, land surface, and biodiversity;
3. Production systems;
4. Consumption patterns; and
5. Disposal networks.

The use of the Long-Term Ecology Research (LTER) reported various lists of social patterns and processes as a practical guide for incorporating social processes in modeling land use change (Grimm *et al.*, 2000). These lists include: demography; technology; economy; political and social institutions; culturally determined attitudes, beliefs, and behavior; and information and its flows. Agarwal *et al.*(2002) advocated a more comprehensive and systematic approach to include social drivers of land use change with the context of National Research Council (NRC) and LTER reports and existing social science efforts.

This conceptual framework is further illustrated for investigating human ecosystems, and examining the simplified, which describes a general, traditional, conceptual framework that may many ecologists have used to study ecosystems. Although this conceptual model is powerful in its inclusion, long-term ecosystem dynamics are absent. An activity such as land use, traditionally seen as a driver, also can be viewed as the result of more fundamental social and ecological patterns and processes. Incorporating greater contributions from social sciences with existing biophysical or ecological models could greatly enhance our understanding of global change in general, and land use change in particular.



2.5.7 Other Drivers of Land Use Change

Beside social drivers of land use change, Geist and Lambin (2002) analyzed on the frequency of proximate causes and underlying driving forces of deforestation, including their interactions, as reported in 152 subnational case studies. They showed that tropical deforestation is driven by identifiable regional patterns of causal factor synergies (Figure 2-11), of which the most prominent are economic factors, institutions, national policies, and remote influence (at the underlying level) driving agricultural expansion, wood extraction, infrastructure extension (at the proximate level). Each land use category was further subdivided; for instance, agricultural expansion was divided into permanent cultivation, shifting cultivation, cattle ranching, and colonization. Each was further subdivided into specific factors; for example, cultural or sociopolitical factors were partitioned into public attitudes, values and beliefs, and individual or household behavior (Ledec, 1985; Lambin, 1994, 1997; Ojima, Galvin and Turner, 1994; Turner *et al.*, 1995; Contreras-Hermosilla, 2000).

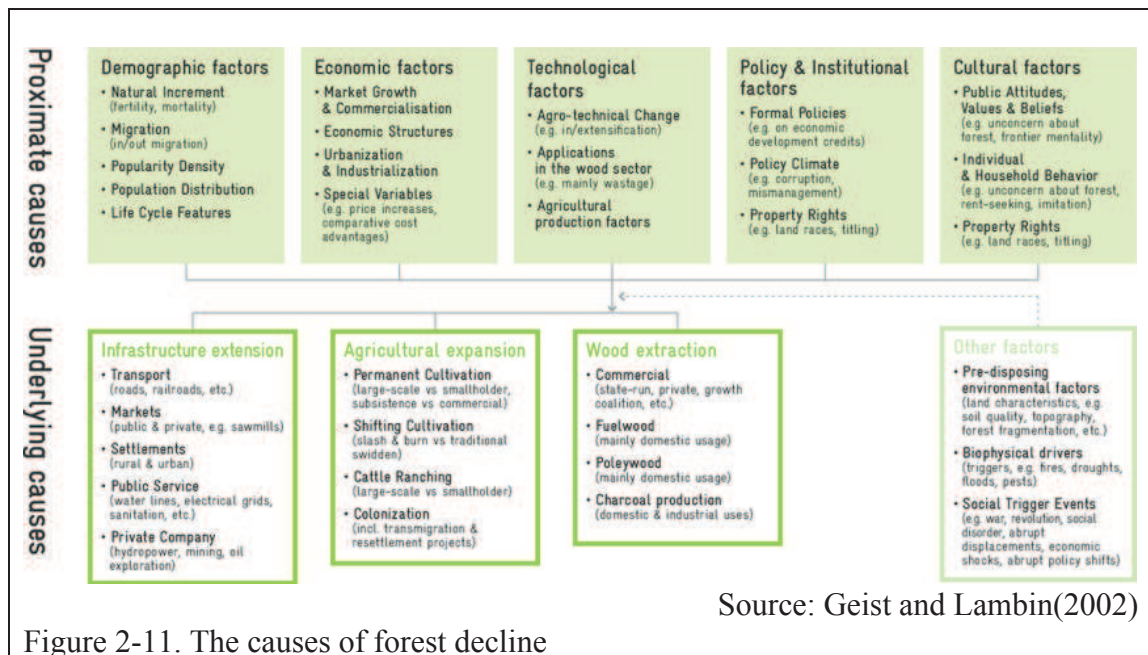


Figure 2-11. The causes of forest decline

Further explanation by Geist and Lambin(2002) is that not only are multiple causal factors at work, but their interactions also lead to deforestation, which is why it is important to understand the systems dynamics. The analysis revealed that, in most cases, three to four underlying causes are driving two to three proximate causes. In addition, a frequent pattern of causal interaction stems from the necessity for road construction that is associated with wood extraction or agricultural expansion, which is mostly driven by policy and institutional factors but also by economic and cultural factors. Pro-deforestation state policies aimed at land use and economic development (e.g. credits, low taxation, incentives for cash cropping, legal land titling) lead to the expansion of commercial crops and pastures in combination with an extension of the road network. Another pattern, seen mostly in Africa, comes from insecure ownership related to uncertainties of land tenure, which drives the shift from communal to private property and underlies many cases in which traditional shifting cultivation is a direct cause of deforestation. Policies facilitating the establishment of state agricultural and forestry plantations lead to deforestation in both insular and continental Asia. Agricultural colonization in Latin America is often favored by land policies that are directed towards deregulation of land access, transfer of public forestland to private holdings, and state regulations in favor of large individual land holdings.

2.5.8 Land Rent and Incremental Value

Generally, land use changes go hand in hand with higher land rents and an incremental increase in land value. Basically, Ricardo's capitalization formula, the value of land V can be explained by the discounted land rent: $V=R/i$, where R is the annual rent and i is the discount rate. Holland *et al.*(2000) further discussed in a more complex explanation, the flexibility value of an unimproved site could be added to obtain an 'extended present value'; the real-option approach does this. The land rent can be expressed as a 'differential rent', that is a function of location (von Thünen, 1842), the quality of the land (Ricardo, 1821) and varieties in the intensity of cultivation or use. Rents on unimproved land are generally not based on labor input, but on random factors such as location and quality (Löhr, 2010).

These theories were originally created for agricultural land, they can however be applied to any kind of land if certain modifications are made. The most important realization is that any R is much higher for construction land (e.g. settlements, industrial areas) than agriculture land(Löhr, 2010). Having said that, in Cambodia for example, land is often given to long-term leaseholders almost for free. As an illustration, in Monduliri province the price of one hectare of agricultural land peaked at USD 1,000/ha in 2009. In contrast, the fees for land concessions were only between USD 0 and USD 10/ha/year. Therefore, even if the costs of private provision of infrastructure and other expenses are taken into account, the value of the land (e.g. calculated by using the residual value approach) and the rents of the improved land are definitely higher than the (discounted) fees paid. This demonstrates that in reality, the government subsidizes the holders of ELCs.

2.5.9 The External Effects

From an overall economic point of view, land use changes only make sense as long as the marginal social benefits exceed the marginal social costs of land conversion. Therefore, higher rents and values, if caused by land use changes, are not an issue of concern per se. Unfortunately, from an economic overview, all benefits and costs have to be considered, not only the private benefits and costs. Löhr(2010) provided a few examples of different types of externalized costs derived from land use changes. Dislocation, land disputes, deforestation and ecological degradation due to cash cropping in large-scale monocultures have been reported (World Bank, 2009a).

In fact, in Cambodia for example, the external benefits of land use changes have also to be taken into account in this section. Firstly, the private investment on land uses may create jobs and increase the income of local people. The private provision of infrastructure as a precondition for economic development is particularly important if the state is too weak or unwilling to do this. Secondly, foreign direct investments pause to export revenues and thus have a positive impact on national trade balance (Löhr, 2010). Such aspects are strong arguments in political debates and also play a role in the decision-making of local governments. In contrast, blanket subsidies (e.g. low leasing fees for ELCs) are not an adequate compensation for such external benefits-instead there should be clear and transparent compensation rules in order to contribute to good governance.

2.6 RESEARCH METHOD AND STUDY AREA

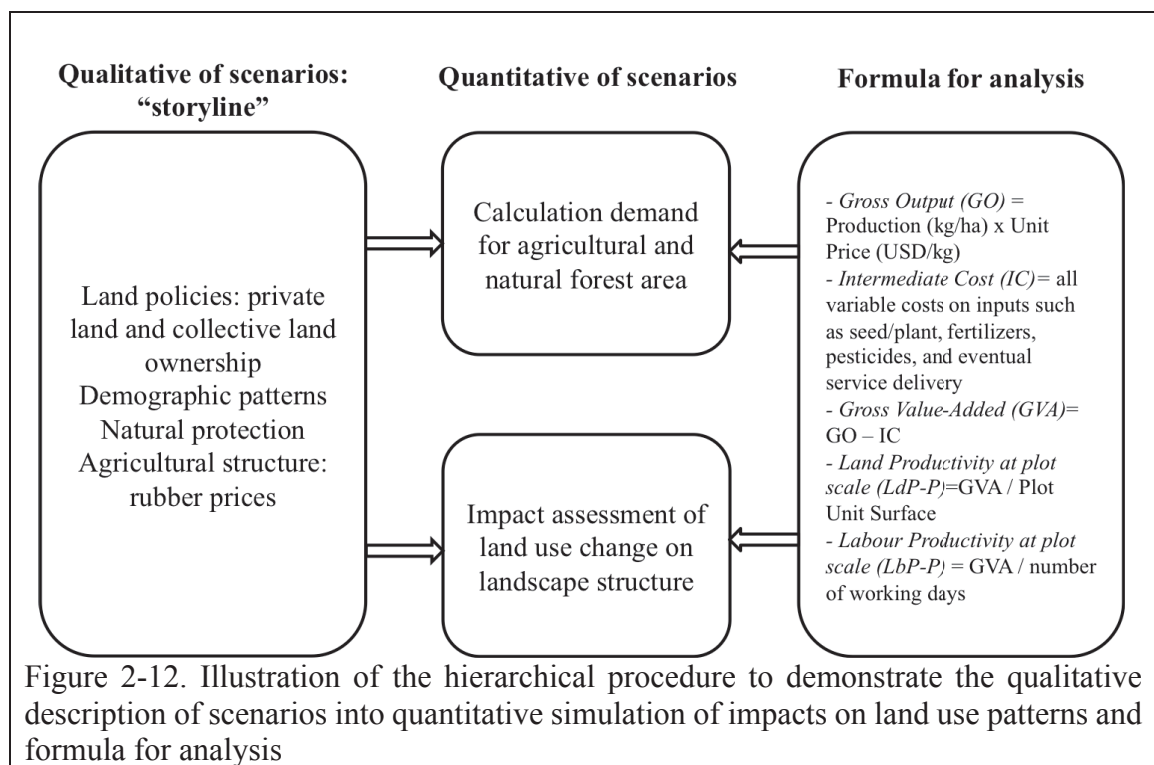
This section describes the overall design of research, including the selection of the study area, the three case-study villages, and the analytical framework. An overview is then given of the study area, that is, Mondulakiri province, where the three case-study villages are located. The profiles of the villages are presented as the followings. This part then provides details of research methods and techniques use to collect quantitative and qualitative information for each case-study village, and an overview of the methods of analysis.

2.6.1 Development of Scenario of Land Use Change

2.6.1.1 Overview Approach

The study of land use and land tenure changes in Ratanakiri province published in the early 2008s (Fox *et al.*, 2008) proposed four land use change scenarios for Ratanakiri that mainly focused on traditional agroecosystem, plantation economy, diverse agroecosystem and service parks. The current study aims at presenting the optimized options for Cambodian land use given a set of goals and policy objectives. In addition, this study intends to provide a procedure to visualize and explore different, plausible, developments in land use in upland Cambodia. Hence, a scenario-based approach was chosen. Scenarios follow the concept storylines of the IPCC Special Report on Emission Scenarios (SREAS) (IPCC, 2000) that are structured along two axis yielding four scenarios distinguishing globalization from regionalization; and development pursuing narrowly defined economic objectives from more broadly defined economic, social and environmental objectives.

The storylines of the scenarios were scaled down to assess the effects on land use patterns by a series of simulation models that account for hierarchical structure of land use driving factors. Power of rubber prices and political structures may be important factor explaining differences in agricultural and industrial development in the country while land use policy variations in social and biophysical conditions are main determinants of landscape patterns and variability. Nassauer(1995) and Naveh (2001) indicated the driving factors of landscape pattern are often region-specific as a consequence of different contextual conditions, specific variation in the socio-economic land biophysical conditions, and the influence of land use history and culture. Figure 2-13 presents the different processes consistently a sequence of models was used. The demand for agricultural production, development production levels in agriculture, demand for economic plantation area and changes in acreage of natural areas were calculated on a provincial scale interaction. The purpose was significantly made of combination of a microeconomic model and integrated assessment model (Van Meijl *et al.*, 2006).



i) Social data and analysis

To understand both the nature and extent of land use and tenure changes, a series of focus group discussions (FGDs), reviewing relevant documents, semi-structured interviews, field observations, and individual interviews were conducted in the selected villages representing the varying degrees of land use and land tenure changes. Participatory rural appraisal (PRA) at individual level and FGDs were conducted with the needs of mapping the historical changes in the study area. FGDs were carried out with about ten participants per village including village heads, elder farmers and immigrants from other villages, and asking them to draw maps and describe the context of land use changes through each regime. In-depth interviews were conducted with experts in land governance on analysing the impacts of economic concessions. Data for this study was collected during two field visits to the selected villages. The first visit was mainly for FGDs with community members in each of village, followed by individual interviews. The discussions also aimed at revealing areas of allocations and conflict surrounding land and natural resources and at assessing the status of private and collective land tenure as reflected in incidence of land sales, land grabbing, and efforts by the community to preserve their lands. Additional effort was made to determine changes over time in social conditions and economic and/or food security status that might serve as a metric in measuring the social impact of observed changes in land use and land tenure.

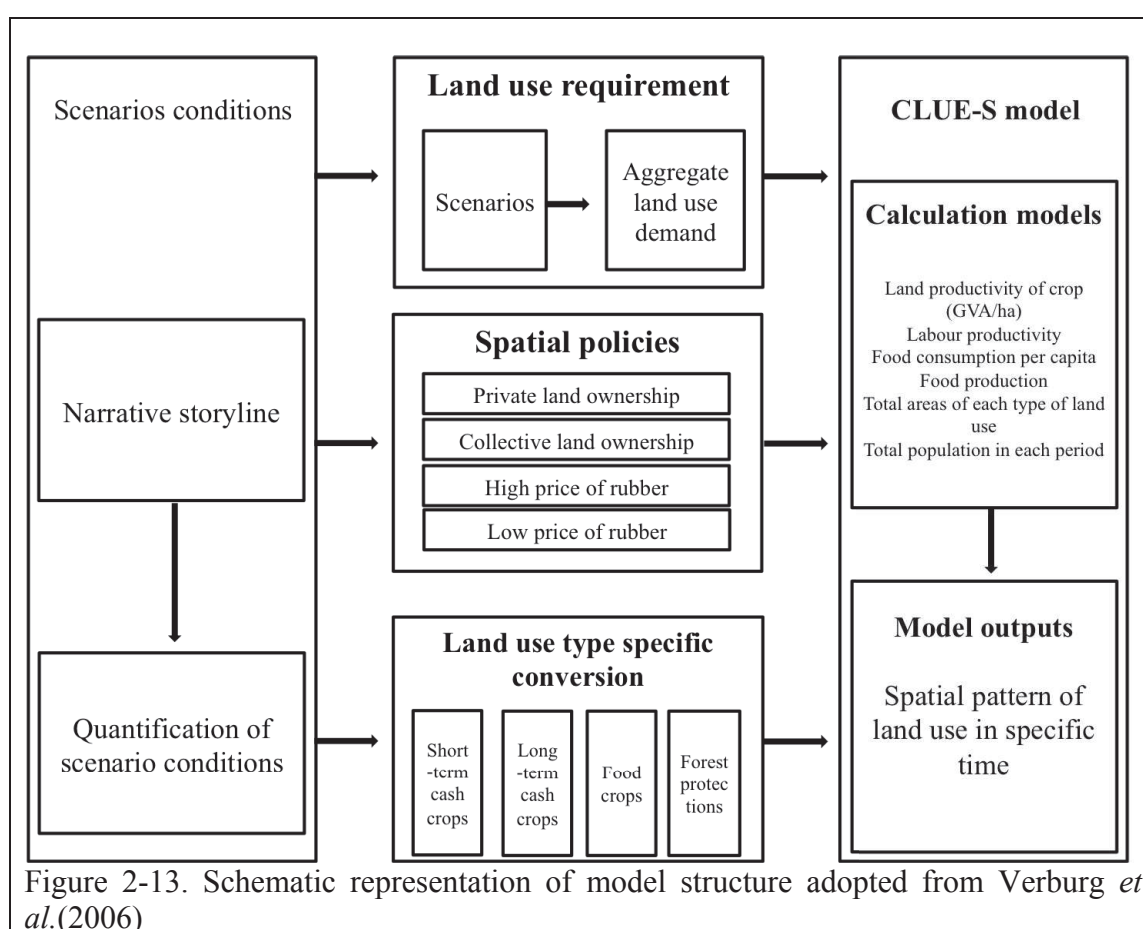
ii) Economic data and analysis

Individual interviews were conducted to provide concrete examples of individual practices surrounding land use, and to identify the actual prevailing conditions and procedures by which land is either converted to other uses or transferred to new owners. These interviews aimed at selecting the family's economic status and possible impacts of their particular changes in use or availability of resources. A second field visit was carried on as means to both clarify data surrounding changes in land use as well as economic data of cropping systems. Crop data (yield of production, price of products, intermediate costs of production) were collected during field surveys with household interviews devoted to the current agricultural practices. Then we calculated the land productivity (gross value-added of production in USD/ha), labor productivity (USD/man-day) and required labor (man-day/ha) for all identified crops¹.

¹For more details, see, Yoeu, Pillot, and Salles, 2016

2.6.1.2 Land Use Change Model

Over the past decade, the land use and land cover change research community has developed a broad range of spatially explicit changes in land use models. Briassoulis(2000), Verburg *et al.*(2002, 2004, 2006) provided reviews CLUE-s Model (Conversion of Land Use and its Effects models) differ in the spatial resolution and extent, underlying concept and the range of applications. For this study, the conversion and its effect model has been chosen because of its flexibility in configuration, and the ability to specify scenario conditions in detail (Verburg *et al.*, 2002, 2006; Verburg and Veldkamp, 2004).



The model is based on the dynamic simulation of rubber prices and land tenure policies. Data inputs and variable setting were consistently used to generate the outputs of scenarios (Figure 2-14). The calculation of total gross value-added (GVA) of agriculture was derived from GVA of each crop production (USD/ha) multiplies by total each type of agriculture. Number required worker in each system from the economic analysis were used to compute for total number of employment in different scenarios with regard to total land use change. For quantity of paddy rice consumption and paddy production in each

scenario, we mainly required important data including the average consumption of rice per people per day, mean production of rice per ha, average size of household members in family. Number of population is taken from data of census and further projected based on the economic power in different scenarios.

2.6.2 Agrarian System Approach in Combination with Ecosystem Service Provision Framework

The activity aims to link the technical and social transformation in the rural society study with changes in social, economic and political context at local, national and sometimes international level. To reach this step, the concept of agrarian system is used; this concept guides one grasp and describe how a rural society makes use of resources in its environment, and how these have changed throughout the past (Barral *et al.*, 2012).

Cochet (2004) and Mazoyer and Roudart (2006) defined an agrarian system is ‘the state of the farming sector of a society at a given point in its history, along with the way it functions and conditions for it to be sustainable.’ The concept of farming system includes: the way the ecosystems are put to use and the way they are sustained; the social relations which govern the forms of production and exchanges (agricultural institution), and which have contributed to the set-up and development of this agrarian system; economic and social conditions, and especially the system of relative prices, which fix the conditions for the greater or lesser integration of the local farming system into the world market.

Agrarian historical comprehensive interviews were carried out for diagnosis agrarian system in the study area. “The questionnaire provokes an answer; the interview helps to build a structured formulation of one’s thoughts” (Blanchet and Gotman, 2007). Interviews with the oldest farmers are one way of finding out about the change in farming over the past two or three generations. In addition, interviews with younger farmers can also provide necessary to obtaining finer of more recent events with which older farmers are less in touch. Open interview will be one way of collecting information. This way is to conduct the interview looking at the landscape, which serves as a common reference for both the interviewer and the farmer.

Analytical steps in applying this agrarian system approach is starting with landscape reading and qualitative interview with elders allow a better understanding of land use change in study zone that help to identify ES and EDS provision from agro-ecosystem. Determine ES and EDS provision from production systems, we initially began identifying

main cropping systems in order to construct comprehensive system modeling. Based on farmers' practices and techniques allow us to identify ES and EDS related those household farm strategy models. Finally, we valued performance economic of production model. We ended up the comparison of performance economic (added-value) and defined the opportunity cost of conversion from forest to potential crops.

2.6.3 Valuation of the Provisioning Services Approach

Ecosystem processes and services are typically most strongly expressed, are most easily observed, or have their dominant controls or consequences at particular spatial and temporal scales. They often show a characteristic scale; typical extent or duration over which process have their impacts. Spatial and temporal scales are often closely related. By understanding the characteristic of landscape and specific agrarian systems in the study area, a series of ES had been identified as shown in Table 2-2:

Table 2-2. Type of ecosystem services in Mondulkiri landscapes

Direct use values	Indirect use values	Non-use values
- Agricultural production	- Climate regulation	- Existence value
- Timber forest	(carbon sequestration)	- Culture/spiritual value
- Non-timber forest products (NTFPs) (i.e. food, medicinal plants, fuel wood, materials)	- Water regulation (watershed protection, storage, water quality regulation)	
- Recreation and tourism	- Soil erosion protection	
- Plant genetics	- Micro climate functions (temperature/humid prevention)	
- Agro-biodiversity	- Air purification	
	- Pollination	
	- Biodiversity	

Due to the data availability and time limit, only a few major ES are selected to be included in this valuation study. The selected ES provision and their valuation methods are presented in Table 2-3.

Table 2-3. Valuation methods for selected provision ecosystem services

Ecosystem services	Valuation methods	Data requirements	Data collection
Agricultural production	Market analysis (value-added)	Yield production data Cost inputs	Local survey and studies

		Price of outputs	
NTFPs	Market analysis	Quantity of products Cost inputs Price of outputs	Benefit transfer adapted data from study of Hansen and Top (2006)
Timber product	Market analysis	Biophysical data Cost inputs Prices of outputs	
Carbon sequestration	Cost saving	International carbon sequestration Areas of the ecosystems Mean value of carbon stock	Benefit transfer adapted data from Ziegler <i>et al.</i> (2012)
Watershed protection	Cost saving	Area of ecosystems Existing data of watershed value	Benefit transfer adapted data from Guo <i>et al.</i> (2001)
Soil conservation	Damage cost	Area of ecosystems Cost of 1 ton sediment removal	Adapted data from The (2001)

2.6.4 Research Design

Rather than attempt to cover all the upland of Cambodia, a small study area was selected that included various land use types of different districts in one province of northeastern Cambodia, Mondul Kiri province (Figure 2-15). Mondul Kiri is the most sparsely populated province in Cambodia (5 persons/km²) with a total area of 14,288 km² making it the largest province in the country. Since the province is located in mountainous and hilly region with plenty of natural resources such as fertile land and water resources, agriculture and agro-industry are its main industries. The province also has significant potential for developing various mining resources and for building medium and large-scale hydropower projects in the future.

As the focus of the research was to understand the current landscape situation in the study area, reasons behind change in land use, farmers' management choices, and the processes of change in farming and livelihood systems, a case study approach was therefore chosen. As defined by CDRI (Hansen and Top, 2006), a case study aimed at introducing a framework and associated value flow model designed to analyze financial and economic aspects of forest conversion to assist land use planners in balancing environmental, social and financial aspects of land use changes. Adding what are lacking

2.6.5.2 Demography of Mondulkiri

Mondulkiri province has a population of 67,305, comprising 33,254 males and 34,051 females in 2011 (Table 2-4)(Provincial Department of Planning and Statistic, 2013). The province consists of 5 districts, 21 communes and 98 villages. The population of this province constitutes 0.3 percent of Cambodia's population (NIS, 2008). The population distribution among the districts in 2010 is depicted.

During the Khmer Rouge or Pol Pot Regime, people were evacuated to different parts of province, for instance, people in Srae Ampum, Sen monorom, and Dakdam communes were moved to Kaoh Nheaek district. The Pol Pot regime was collapsed in 1979. In 1981 the people returned to their native villages. From year to year, the people in this province increased (Table 2-4). Comparing the population in 2002 to 2011 showed that:

- In 2002, the total population was 40,194 people with total number of families were 8,784 families
- In between 2002 and 2011, immigration activities in the area from Kampong Cham, Prey Veng, Svay Reang, Pursat, Koh Kong, Kampot, Kampong Thom, etc. came to settle in the villages causing a major population increase
- In 2011, the total population increased to 67,305 people equaling to 14,283 families

The population growth is a main issue everywhere. A growing numbers of people dramatically caused increased need for basic materials, and foods for livelihoods. Without doubt, population growth in Mondulkiri has caused the increased need for food. Such shifting cultivation alone could not support enough of food for the increased population. Therefore, they need to clear the forest to expand plots and increase agricultural production to respond to their need for food. As a result, this causes also provided negative impacts on dense and semi-dense forest in the province.

Table 2-4. Population from 2002-2012, Mondulkiri Province

Year	Total number of families	Total population (person)	Total number of females (person)	Total number of males (person)	Number of female headed household families
2002	8,784	40,194	20,364	19,830	996
2003	9,455	43,067	21,637	21,430	1,212

2004	9,864	47,391	23,406	23,985	1,262
2005	10,351	49,612	24,978	24,634	1,210
2006	10,929	50,958	25,438	25,520	1,412
2007	11,299	53,246	26,685	26,561	1,368
2008	12,149	56,443	28,418	28,025	1,417
2009	12,567	57,666	28,810	28,856	1,534
2010	13,257	62,218	31,012	31,206	1,415
2011	14,283	67,305	34,051	33,254	1,422
2012	15,558	70,439			

Source: Provincial Department of Planning and Statistic (2013)

2.6.5.3 Climate of Mondulkiri

Local temperature in Mondulkiri fluctuates from minimum 16°C to maximum 38.20°C. The average temperature is between 25°C, 26°C, and 28.70°C(FA, 2012). Table 2-5 shows about the annual temperature from 2004-2007 in Mondulkiri. The climate of Mondulkiri is similar to Cambodia climate dominated by monsoons, which are known as tropical wet and dry due to the distinctly marked seasonal differences.

Cambodia has two distinct seasons. The rainy season, which runs from May to October, can see temperatures drop to 22°C (71.6°F) and is generally accompanied with high humidity. The dry season lasts from November to April when temperatures can rise up to 40°C (104°F) around April. Disastrous flooding occurred in 2001 and again in 2002, with some degree of flooding almost every year.

Table 2-5. Annual temperature from 2004-2007 (°C)

Year	Maximum	Minimum	Average
2004	37.80	16.00	26.90
2005	38.20	16.60	27.40
2006	33.31	16.00	24.65
2007	33.60	16.60	25.10

Source: FA (2012)

2.6.5.4 Agricultural Productions' Activities in Mondulkiri Province

The ethnic minority people in Mondulkiri province practices traditional shifting cultivation. This cultivation is done on forestland by slashing and burning the forest for growing rice and various crops such as maize, bean, cassava, and diversified vegetables for 2 to 3 years before moving on to new location. Beside shifting cultivation, the farmers are also practicing other crops such as rice production, secondary crops, agro-industrial crops, and permanent crops. In 2012, agricultural production especially rice production was started very late in the beginning of rainy season, but the farmers still carried on their

plans more than prediction. Based on the data in Table 1-6, the total land of rice production was 22,669 ha, secondary crops with 13,170 ha, agro-industrial crops with 5,447 ha, and permanent crops with 1,444 ha; mostly farmers are able to grow these kinds of crops only in rainy season(Provincial Department of Agriculture, Forestry, and Fisheries 2013).

Specifically, there are different types of rice cultivation in upland area. For example, majority of rice production is *chamkar* rice that ethnic Phnong or Bunong are using the traditional seeds with low yield return.

Table 2-6. Agricultural planting activities and production in 2012, Mondulakiri province

No.	Production planting activities	Land productivity (ha)	Total yield (ton)	Average yield (ton/ha)
1	Land preparation for wet season rice	22,737		
	- Plowing by cattle/buffalo	2,331		
	- Plowing by tractor/thriller	20,406		
2	Direct seedling	1,170		
3	Rice production	22,669	7,403*	2.475
	- <i>Chamkar</i> rice (traditional rice plantation/shifting cultivation)	4,034		
	- Upland rice	18,635		
	➤ Light/early rice (2,316 ha)			
	➤ Medium rice (9,812 ha)			
	➤ Heavy/late rice (6,507 ha)			
4	Secondary crops	13,170		
	- Maize	436	2,361	5.415
	- Cassava	9,391	145,240	15.466
	- Diversified vegetables	410	601	1.466
	- Mungbean	2,933	3,409	1.162
5	Agro-industrial crops	5,447		
	- Peanut	3,680	4,693	1.275
	- Soybean	1,747	2,173	1.244
	- Sesame (white/black)	7	5	0.710
	- Sugarcane	3	-	-
6	Permanent crops	1,444		
	Cashew	395		
	Pepper	39		

Table 2-7. Agricultural planting activities and production in 2012, Mondulakiri province (continue...)

No.	Production planting activities	Land productivity (ha)	Total yield (ton)	Average yield (ton/ha)
	Coffee	39		
	Coconut	37		
	Banana	137		

Mango	566
Avocado	18
Durian	21
Rambutan	12
Citrus	31
Custard-apple	39

Source: Provincial Department of Agriculture, Forestry, and Fisheries (2013)

* Rice production: total harvest was 22,660 ha

2.6.5.5 Rice Production Yield in Wet Season 2012

According to the report of Monduliri Provincial Agriculture Department, the average yield of light or early rice is 2.62 ton/ha, medium rice with 2.82 ton/ha, heavy or late rice with 2.63 ton/ha, and *chamkar* rice with 1.02 ton/ha, respectively (Table 2-7). For instance, there is no heavy rice cultivation in Ou Reang district. The highest average yield of rice production was in Kaoh Nheaek district: light rice(3.40 ton/ha), medium rice (3.60 ton/ha), and heavy rice (3.50 ton/ha), whereas the average yield of *chamkar*rice in this district get the lowest with 0.90 ton/ha (Provincial Department of Agriculture, Forestry, and Fisheries 2013).

The rice cultivation was started late from the beginning of wet season in 2012 due to late rainfall coming. However, the farmers faced the drought at the end of wet season which damaged the rice production especially in six communes of Kaoh Nheaek district. Based on the first step of survey in 2012 showed that the rice yield decreased to 0.33 ton/ha compared to 2011 (rice yield in 2011 was 2,62 ton/ha and 2012 was 2.28 ton/ha) (Provincial Department of Agriculture, Forestry, and Fisheries 2013).

Even though the rice cultivation has been planted anywhere of the province, but the rice yields could not support enough for the whole community. Due to increasing in population, natural disaster (drought) and poor agricultural techniques, the food security in this province will still need to fulfill and improve.

Table 2-8. Rice production yield in wet season 2012

No	District's name	Average yield of rice production			Average yield of <i>chamkar</i> rice (ton/ha)
		Light rice (ton/ha)	Medium rice (ton/ha)	Heavy rice (ton/ha)	
1	Keo Seima	3.10	3.40	2.05	1.00
2	Kaoh Nheaek	3.40	3.60	3.50	0.90
3	Ou Reang	1.80	2.20	NA	1.05

4	Pech Chreada	2.40	2.60	2.50	1.10
5	Sen monorom	2.40	2.30	2.50	1.05
Total		2.62	2.82	2.63	1.02

Source: Provincial Department of Agriculture, Forestry, and Fisheries (2013)

2.6.5.6 Forestry Sector in Mondulkiri Province

Equity and equality of using the forest resources is the priority challenge that Forestry Administration (FA) in Mondulkiri province has already set up in the action plan for 2013. This is very essential to include the local people participate in forest management and improve livelihoods. From supporting and cooperation between FA and non-governmental agencies, 12 community forests in Mondulkiri have been established that covered by 31,228 ha with 2,583 members (1,426 females) equal to 1,314 families of 15 villages and six communes and in process for recognition from MAFF.

2.6.5.7 Employment in Rubber Companies

With regard to the employment of concession companies in Mondulkiri, totally 3,534 workers were employed by eleven rubber companies; 3,375 workers are Cambodian and 179 workers are foreigners (Table 2-8) (Provincial Department of Employment and Vocational Training, 2013). The workers came from different provinces: Kandal, Prey Veng, Svay Reang, Kampong Cham, Koh Kong, Kampot, Takeo, Kampong Chhnang, Pursat, Battambang, Kampong Speu and Kratie. The workers stay inside the farms where the companies have provided the accommodations for them. Some companies have also given some land for gardening to the workers. In addition, the elementary schools were built by companies (i.e. Dak Lak Mondulkiri Aphivath Cautchouc Co., Ltd) for the children of workers; the children can go to school without any payment since the companies invited some teachers from government and they also provided some additional incentive to them. The materials and clothes were provided by the companies for the workers at farm activities.

Table 2-9. Employment workers in rubber companies, Mondulkiri province

Rubber companies' names	Employees and workers						
	Total	Cambodian			Foreigner		
		Total	Male	Female	Total	Male	Female
1. Sok Fine KCD	1,128	1,122	653	475	6	5	1
2. DTC Group Co.,Ltd	386	386	256	130	16	16	0
Krongteh	270	270	170	100	0	0	0
3. Unit Green Resource Co.,Ltd	50	35	23	11	16	16	0

4. Dak Lak Mondulkiri Aphivath Cautchouc Co.,Ltd	171	150	80	70	24	22	2
5. Coviphama Co.,Ltd	60	40	31	9	20	20	0
6. Ochisan	50	50	35	15	0	0	0
7. Ho Chi Ling	35	35	29	6	0	0	0
8. Khmer Angkor Agriculture Co.,Ltd	25	16	12	4	9	9	0
9. Germadapt	1,311	1,224	699	525	87	87	0
10. Do Well Plus	28	27	27	0	1	1	0
11. Flower Farm	20	20	16	4	0	0	0
Total	3,534	3,375	2,031	1,349	179	176	3

Source: Provincial Department of Employment and Vocational Training (2013)

2.6.6 Household Surveys

Household surveys were carried out in three villages between 2012 and 2013.

2.6.6.1 First Household Survey

In the first household survey, the respondents were divided into two groups based on purposive and stratified sampling and they comprised as the followings: the first group - 20 key-informants included eight government officers (MAFF, MLMUPC, MoE and MRD); three commune heads, three village heads, and four NGOs staffs; the second group - the villagers included the indigenous group, permanent farmers, medium- and large-scale farmers, and the settlements; the third group - the total number of respondents for this group was determined based on Slovin's equation as shown below:

$$n = \frac{N}{1 + Ne^2}$$

where n is a sample size, N is total population size from four villages (N=359 households), and e is allowable error of seven percent (7%). Thus,

$$n = \frac{359}{1 + (359)(0.07)^2} = 130 \text{ Respondents}$$

Based on this computation, the desired sample size of respondents is 130 households. The number of respondents from each village was calculated through a proportionate sampling was 130 divided by 359 equal to 36.21 percent (Table 2-9).

Table 2-10. Matrix of sampling size, Mondulkiri province, Cambodia, 2012

Village	Total number of households	36.21% included in sample
Pu Chhorb	113	41

Pu Trom	136	49
Pu Radet	110	40
Total	359	130

2.6.6.2 Demographic of Selected Villages

a. Pu Chhorb Village of Dakdam Commune

Pu Chhorb village is in Dakdam commune, Ou Reang district, Mondulkiri province. This village is located 15 kilometers from Sen monorom town and takes around 30 minutes to reach there. The new road is connected from the town to border of Vietnam nicely constructed in just recently. Along the way is fully viewed of beautiful mountainous landscapes that are covered by plants and trees, i.e. new grown pine trees and green grass. People nowadays are more easily to go to Pu Chhorb village.

There are shorted houses with some few small trees surrounding there. The cows, buffalos, chickens, and pigs freely walk around the houses. Since this area is mountainous or high hills, the houses are built along the slope (up and down). The big and nice houses belong to new comers who just recently moved to live in this village. For the IP, the houses are common, small and almost look similar from one another. It is exceptionally beautiful landscapes especially during the rainy season; everywhere is green and fresh. Some gardens are designed for growing the vegetables. Moreover, the fruit trees such as jackfruits, mangos, bananas, avocados, guavas, etc., are also planted. There are also some local shops that are selling the grocery products; no one of indigenous group operates this kind of business, only Khmer people do.

Dakdam commune is comprised of three villages namely Pu Chhorb, Pu Roleh, and Pu Treng. The villages are close to each other. There is one waterfall is called Chrey Thom that can attract the locals and tourists who come to visit there. Numbers of red soil roads were well constructed that make people living there have a mean of good transportation from place to place. Most of people use more motorbikes to travel everywhere rather than cars. There are some wells that people use for daily cleaning, washing and drinking.

A forest community was established for preventing anybody from any taking over land by force of the companies, conserving the forest for young generation, reducing the illegal logging and hunting the wildlife, and continuing to allow the community to extract the non-timber forest for supporting their home consumption.

There are 90 percent of Phnong minority people and the rest are Khmer people who are living in this commune. There are 371 families in the commune. According to the commune head, there are five kinds of land types: agriculture, forest, community protected forest, flooded land, grass land and residence. The forest and natural resources have been extremely declined due to population growth, agriculture lands expansion and other hunting activities, i.e. wildlife.

Ninety-five percent of farmers are doing the slash and burn cultivation that is the most common traditional activity in the past. They prepare the land by slash and burn because they think so that the ashes fertilize the soil, and the fire also destroys the useless insects. They grow mixed crop in the same field like rice, corn, pumpkin, cucumber, soybean, and some vegetables.

b. Pu Radet Village of Srae Ampum Commune

Pu Radet village is located in Srae Ampum commune, Pech Chreada district about 35 kilometers from Sen monorom town and along the road that going to Bou Sra waterfall. To the north is Pu Kreng village, to the west is Pu Chrey commune, to the south is Pu Krouch village, and to the east is Bou Sra commune. There are two schools in the community: a primary and secondary schools. There are several small local shops surrounding the village. There is also one pagoda. The people are using the well as the main source of water by pumping from underground. There are three bridges located towards the forest area of the village and it spans over three of the running streams that can be found in the area. In total, there are eight streams running through the village. The community forest area is located between the Keut Aid stream and the Play stream.

The road is partially asphalt paved(rubber road) and partially red soil surface. During the rainy season, the transportation does not work well since the red soil road is slippery and sticky; for those people who travel by motorbike is dangerous. During the dry season, the dust makes the air difficult to breathe;the pumping water from wellcan also become complicated. It takes about 30 minutes from Sen monorom town to Pu Radet during the dry season, but it takes much more longer to reach there in the rainy season. Some houses are along the road and the rest are along the red soil road connected to Pu Kreng village.

Currently, there are 118 families and 533 people are living in 111 households in the village. The increase in numbers was due to the migration of Khmer communities from other provinces throughout the country; the Khmer people saw the available or unoccupied

land that could potentially be used for agriculture and thus they decide to migrate in. Over the years, the number of cash crops such as mango, banana, and jackfruit trees has steadily increased.

The Community Forestry (CF) of Pu Radet village was completely established in 2009 and fully recognized by Ministry of Agriculture, Forestry, and Fishery (MAFF). A Community Forestry Member Committee (CFMC) was elected by the members for implementing and managing the forest resources. The resources from CF are used for both personal consumption and income generating activities, however, the people use the resources more for personal consumption than for selling locally at the village level. The CF is approximately five kilometers away from the village. Much of the land that lies between the CF and the main part of the village (where most of the houses are located) is used for farm land and growing such things as yam, cassava, nuts, and vegetables.

c. Pu Trom Village of Romnear Commune

Pu Trom village is located in Romnear commune, Sen monorom district, Monduliri province. This village is located very close to Sen monoromtown just takes about 15 minutes by motorbike or car. In this village, two specific areas were provided namely Pu Trom Thmey and Pu Trom Chas. Travelling to Pu Trom village firstly arrived Pu Trom Thmey where most of Khmer people have newly sheltered and about 15 minutes later Pu Trom Chas is found.

The infrastructure is quite good especially the road condition (red soil road) is smooth. There are two elementary schools; the students are strongly encouraged to enroll. There are some home gardens growing avocados, bananas, and some other fruit trees as well as cassava fields along the road. Some water pumps are installed by the NGOs as well as by the community itself. Some local grocery stores can be also found in the village. The cars, trucks, and motorbikes are busily passed by this village.

There are several beautiful waterfalls that many tourists always come to visit there. There are many private resorts currently operating their services such as elephant ride, home-stay, restaurants, camping, and elephant performance, etc.

Ninety percent of people in this village are Phnong people who are currently doing shifting cultivation. About 30 families are the new residents who migrated from other provinces: Takeo, Kandal, Kampong Cham, Svay Reang, Prey Veng, and Stung Treng.

They bought the land to build the houses and do farming. Some crops such as rice, cassava, cashew, beans, fruit trees, and vegetables were tremendously grown in this village.

Some issues were encountered in this village such as land conflicts, illegal logging and wildlife hunting, poor relationship between Khmer and Phnong group, illiteracy, and health problem. These alarming issues brought the attention of several agencies to come and help them to solve out. Consequently, a number of technical trainings on agriculture, health, literacy class, water and sanitation, conservation programs, and social conflict solutions have been provided to the community.

2.6.6.3 Socio-Characteristic of Sample Respondents

The socio-demographic-characterization of the Khmer and Phnong people was drastically conducted in the study. The comparative mean test such as age, education, household size, family labor force, gross income, land size of farming and land size of shifting cultivation of the sample respondents are presented in Table 2-10. The Khmer group's average age was 37.46 years old and the Phnong group's age was 38.15 years old with no significantly difference between the Khmer and Phnong.

In terms of educational attainment of the sample respondents, the average number of years in school was 1.96 and 1.51 for the Khmer and Phnong group, respectively. The difference was statistically significant at one percent level, which implies that the Khmer group has higher education than the Phnong group. The average household size was 4.96 and 5.76 for Khmer and Phnong, respectively. The difference was statistically significant at five percent level, which indicates that the Khmer group has smaller household size than the Phnong group. The difference of family labor force between Khmer and Phnong group was not significant. The average family labor force was similar 4.96 and 5.76 for the Khmer and the Phnong group. The average gross income of the Khmer group has 9,095,000 Riels (USD 2,273) per season that was higher than the Phnong group with 2,650,157 Riels (USD 663) per season. The difference was statistically different at one percent level.

Table 2-11. Socio-demographic characteristic of the sample respondents

Characteristic	Khmer group		Phnong group		Difference (3=1-2)
	Mean (1)	St.dev.	Mean (2)	St.dev.	
Age (years)	37.46	11.12	38.15	10.87	-0.69
Education (years)	1.96	0.63	1.51	0.66	0.45***
Household size (persons)	4.96	2.06	5.76	2.22	-0.80**

Family labor force (persons)	2.07	0.90	2.42	1.02	-0.35
Gross income (Riel per season)	9,095,000	13,020,000	2,650,157	2,000,717	6,444,843***

Note: *** and ** refer to significance at 1% and 5% level, respectively, using the F-test

2.6.6.4 Second Household Survey

A second survey was then organized in the same three villages to measure the efficiency of the cropping systems and to identify how they were combined inside production units led by the households. The number of respondents was not accurately determined before the interviews were conducted. Rather, we chose to multiply the interviews until it became obvious that no additional type of strategy could come out from more interviews. In practice, there were 21 respondents in Pu Radet, 22 respondents in Pu Chhorb and 23 respondents in Pu Trom, mainly selected for the study based on purposive selection within the broader random sample. We undertook a historical survey in parallel on agrarian systems, based on FGDs and in depth interviews with key-informants and randomly selected of sample respondents. The main objective was to discuss on the changes over time underway in Mondulkiri, to make sense of the cultural dynamics, to understand the land tenure situation and the way ‘economic development’ is being implemented in this study area.

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CHAPTER 3: LAND POLICIES FOR UPLAND CAMBODIA: HISTORICAL PERSPECTIVE AND IMPACTS ON LAND USE

LAND POLICIES FOR UPLAND CAMBODIA: HISTORICAL PERSPECTIVE AND IMPACTS ON LAND USE

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ABSTRACT

The dual population and land situation in rural Cambodia is likely to generate important migrations, with an important impact on the deforestation and land use in general. This situation is also a result of the institutional reforms promoted since early 2000's (Land Law, Forestry Law, and the decrees and regulations following them). Based on field surveys from 2011-2013 done in Mondulkiri, this article analyzes the major changes in the land use as a result of the successive public policies in upland Cambodia. Considering the diverse strategies of local stakeholders previously identified in the Province, the paper also elaborates on four scenarios of further transformations foreseen in the next ten years. The findings show that the policies favoring large-scale concessions may result in several positive effects, while only when rubber prices are high. On the contrary, policies more favorable to the rights of indigenous communities and of individual immigrants lead to higher employment creation and better balanced food security. Based on these findings, the paper offers a critical discussion of Cambodia land concession policy, analyzing how far the multi-functionality of rural areas should be considered to achieve rural development targets. In all these cases, the scenarios may serve as a framework to ensure that decisions are based on assessments that take into consideration ecosystem trade-off in the future.

Keyword: Land concession, employment opportunities, land strategy and policy, indigenous people, Cambodia

3.1 INTRODUCTION

From the late 1940s to the late 1980s, the countries and localities of Southeast Asia experienced upheavals due to a state of almost constant warfare within the region. These troubles were reflected in the local populations' land use changes across the region, including in remote upland areas.

Since then, the development of large-scale land concessions, mostly driven by foreign direct investment, has been quite massive in the Mekong region countries, more specifically Cambodia, Lao PDR, and Myanmar (Castellanet and Diepart, 2015). Rudel and Roper (1996) described a process of frontier colonization with sequences of poverty (refers to the ecological marginalization of farmers who have lost their resource entitlements) and capital driven deforestation (refers to public or private investments to develop the frontier for political, economic, or social reason).

Most proposed causal variables of land use change are proximate factors (Turner, Lambin and Reenberg, 2007), for instance immigration, subsistence farmers' impacts, deforestation, or local common property resource management strategies (Lambin and Geist, 2006) and more distant factors, such as national policies, that tend to be difficult to connect empirically to land use change outcomes.

National government policies to liberalize trade and market access to/from the villages have been the most active triggers initiating land use change in upland areas (Fox, Vogler and Poffenberger, 2009; Mellac, 2014). For instance, land governance is a significant scaled issue, involving broad level influences at the global, regional, national and local scales (Hirsch and Scurrah, 2015). Number of land grabbing and conflicts have increasingly gained attention over the last years (Bues, 2011). Various factors have for sure increased the problems, such as poorly defined access rights to land for different stakeholders, or overlapping responsibilities of the public institutions to issue concessions (Un and So, 2011; Sperfeldt, Tek and Billy, 2012). These conflicts and attention have raised the image of this far-east as either a battlefield for land or a desert of institutions in which a handful of capitalist entrepreneurs were competing for logging the forest, and, occasionally, for planting rubber in the deforested lands.

In this context, Geist and Lambin (2002a) show that deforestation is best explained by multiple factors and drivers acting synergistically rather than by any single factor, with more than one-third of the cases they look at being driven by full interplay of economic institutional,

technological, cultural and demographic variables. Institutional factors are involved in 78 percent of the deforestation cases. These mainly include formal pro-deforestation measures such as policies on land use and economic development as related to colonization, transportation, or subsidy for land-based activities. As a general cause of deforestation (e.g. Deacon, 1994; Mendelsohn and Michael, 1995), property rights issues tend to have ambiguous effects upon forest cover: insecure ownership, quasi-open access conditions, maladjusted customary rights, as well as the legalization of land titles, are all reported to encourage deforestation.

In such a regional context, Cambodia has often been described as a demographically saturated “inner country”, on the alluvial plains of the Mekong and the Tonle Sap Lake, with less than one hectare of land available per rural family, surrounded by an upland “empty Cambodia” where the population density was, before 2002, ten times lower. As a consequence, the forest cover in Cambodia has long been mainly located in the north, the east and in the south-west of the country where the population densities were lower.

The development of large-scale land concessions, largely driven by foreign direct investment, has been quite massive in the Mekong region countries, more specifically Cambodia, Laos, and Myanmar (Castellanet and Diepart, 2015). In Cambodia, the land conversion is mainly for industrial investments, plantation or industrial farming-involving high specialization, high input of capital, mass production and application of modern techniques- a completely different system compared to small-scale farming. The so-called ‘Economic Land Concessions’ (ELCs) were created by the Land Law (2001) and Sub-Decree No. 146 (2005) for this kind of investment. The government has claimed that agricultural development was a priority, citing the aims of ensuring food security, providing raw materials for industry, increasing exports and creating employment (Sokheng, 2009).

Rubber plantations in countries such as Cambodia pose a serious threat to the region’s wildlife and wider ecosystem, especially concessions have been given to rubber producers in supposedly protected areas. For instance, according to World Resource Institution, global rubber prices were surging around 2010, the year Cambodia lost the greatest forest cover, and peaked in 2011 before falling again (as cited in Harfenist, 2015), whereas the ELCs have been given and issued to investors and smallholders. Despite the promising trends in the country’s rubber industry, a number of challenges could weaken the competitiveness and marketability of Cambodian rubber. One such issue is the growing surplus of rubber worldwide, which is steadily decreasing the demand for Cambodian rubber (Natividad, 2015). As overall

observation, rubber prices are now very low that many economic players-industrial as well as small stakeholders-are starting to convert their rubber fields to crops that are currently experiencing high prices such as pepper or cassava (Khum, 2016). These have been concerned what will happen if the price does not pick up over the next few years?

Meanwhile, in an attempt to control illegal logging, the government also introduced a concession system in the forest areas. Whereas investors have demonstrated ability to promote their own interests, these have rarely been in line with the production of common goods. The consequences of the extension of the concessions included widespread damage to these forests (World Bank, 2000) and cost to the indigenous groups, since it accelerated legal and illegal logging, and it threatened the access of indigenous people (IP) to their traditional land, with consequences on their traditional culture and livelihoods. During the first half of 2010, more than 3,500 families were affected by land grabbing (Human Rights Watch, 2011).

Located on the eastern border of Cambodia near the Vietnamese border, predominantly populated by indigenous people, Monduliri province has experienced unprecedented changes in land use over the past two decades, and this has raised a certain attention. However, the roles of the concession policies for the deforestation and for the extension of plantations are not yet well understood, and the impacts of land policies on the livelihood of indigenous people remain to be assessed.

This article analyzes the major changes in the land use in upland Cambodia as a result of the successive public regulations issued. Considering the diverse strategies of local stakeholders identified in the studied province, we elaborate on four scenarios of further transformations foreseen in the next ten years. We seek explanations for changes in land and forest management practices in social, economic, and demographic factors. Empirically, the study aims to answer the following questions: why and how the current situation has been historically generated; what were the consequences of the successive policies on the land rights of the stakeholders, hence on the migrations and the population growth, and finally how one can use this knowledge to assess the potential political choices by looking forward to their possible impacts.

3.2 THEORETICAL AND CONCEPTUAL FRAMEWORK

3.2.1 Development of Scenarios

Throughout Cambodian landscape, upland areas are being transformed as new infrastructures create market access. Traditional forms of agriculture and forests are replaced by commercial plantations and conservation areas. Such transformation of land use and land tenure in the country raises numerous questions regarding impact on the local culture, economy, and environment. Hence, the conceptual framework is mainly focused on the extent to which these upland transitions can be guided in ways more in favor of social equity and environmental services goals depends to a great extent on the effectiveness of land use policies formation and implementation combined with change in rubber prices. The current land use situation in Mondulkiri carries a number of potential sources of land conflicts that the institutional framework, while it has been much developed since the 2000, may be unable to regulate.

Indeed, all the necessary legal tools do already exist; they are available to support any policy orientation. The economic land concessions (ELCs) framework can be used to support a vigorous development of capitalist holdings based on various companies employing laborers on rubber plantations of several thousands of hectares. On the other end, the Collective or Communal Land Title (CLT) is also available to protect the access to land of the local communities. In other words, the national institutional framework has produced rules and regulations that can support the development of the large scale concessions as well as the protection of the land access of the local indigenous population. By doing so, it actually leaves the largest freedom to the local governance levels to determine the policy they wish to support.

In these conditions, enlightening the possible impact in the future of different policies, also depending on the possible economic stimulations from the market, by modeling the results of various scenarios, may influence the balance of powers locally. To illustrate this assumption, we propose here to assess the possible impact over ten years of two opposed policy options, each of them being implemented in two different economic contexts. This exercise may not offer precise prediction, but it indicates the outer limits of hypothesis on the possession of land and the transformation of the economic land use.

3.2.1.1 An Institutional Economics Perspective: The Land Ownership Policy Options

Using the case study of upland Cambodia, this paper identifies precisely the drivers of land use change, and the gap between policy intentions and their outcomes. The analysis mainly focuses

on the implementation of private and collective land titles, economic transformation (agricultural market citation) and infrastructure development. These factors significantly influence farmers' land use decisions and value of ecosystems from various land use and strategies, which are particularly important in Cambodia.

We adopted a multi-scale and interdisciplinary framework anchored in institutional analysis and political economics, which allows the simultaneous examination of the influence of institutions, discourses, and socio-economic context on actors' decisions. In the 1980s, Kiser and Ostrom (1982) developed the Institutional Analysis and Development (IAD) framework that provides useful means to assess the causes of policy gaps and link multiple governance levels, namely (i) the operational level when the decisions directly affect resources management; (ii) the collective choice level when decisions affect the rules in use at operational level; and (iii) the constitutional level when decisions affect who decides and how decisions are made in the collective choice arena (Ostrom, 1999). Here we consider institutions as “the prescriptions that humans use to organize all forms of repetitive and structured interactions” (Ostrom, 2005). Institutions do not only cover written legal documents but also informal rules which have been orally agreed upon.

Institutional analysis is particularly relevant since we assume that the recent changes in the land and forest policies-making arena in Cambodia is significantly impacting the set of actors and rules governing land access and land use. ELCs and community forest determine unambiguously new rules of land ownership, access and use.

With respect to tenure security, Article 1 of the 2001 Land Law guarantees ownership rights and other relevant rights in accordance with the 1993 Cambodian Constitution. The Sub-Decree on the procedure of land registration of the IP also aims at guaranteeing land tenure security¹. For compliance with the 2001 Land Law, Sub-Decree on ECLs in 2005 aims to determine the criteria (Articles 3 and 4²), procedures (Article 5), mechanism and institutional arrangements (Articles 10³ and 14) for initiating and granting new ELCs.

Taking into account that the current policy on private land ownership (private concessions) and collective land ownership (indigenous land ownership) have yet been unclear and

¹ Sub-Decree on the Procedure of Land Registration of Indigenous People, No.83ANK/BK, June 9, 2009, art. 2.

² Article 4 of the ELCs requires any proposal to meet the conditions before approval

³ Article 10: The Technical Secretariat shall widely disseminate the Notice for Solicited Proposals and shall also send the Notice to the Council for the Development of Cambodia.

insufficiently justified, our research envisages different scenarios based on two opposed options in the future:

- In *Hypothesis A*: We assume that policies at national and provincial levels would clearly support large estates land ownership and concession rights compared to collective land ownership of the IP and recognition of smallholders' rights. In case of conflicts, local public institutions, based on a favorable interpretation of the ELCs regulations would support the concession rights rather than the traditional access of the IP.
- *Hypothesis B*: In contrast to the previous option, the policy would strongly support the rights of the local communities and collective land ownership when opposed to ELCs' ownership, using legal tools such as the Forestry Law Article 37 or Land Law Article 25. The 2001 Land Law promised that IP could register their collective ownership to protect their traditional shifting cultivation. Indeed in 2009, the Sub-Decree on procedure for registration of land of indigenous communities was approved. Indigenous community land includes residential and agricultural land and encompasses land reserved for shifting cultivation. Under these laws, indigenous communities may continue to manage their community land according to their traditional customs

3.2.1.2 The Economic Environment Options

In Cambodia, since the 2000's until 2011, rubber has been the most dynamic investment in long term crops supported by exceptionally encouraging prices on the market. Recently, the government has expressed its strong commitment to promoting ELCs and rubber development. These rubber plantations would be used as tools for generating income for the State, stimulating private enterprises, and creating jobs for rural communities. Currently, in addition to existing private industrial plantations, more privately owned plantations are granted under the ELCs scheme, initiated by government since 1992. Up to 2012, the government has contracted ELCs to 118 companies of the total land area of 1,200,000 ha (MAFF, 2015b). Most of rubber plantations have been converted from forestland. In 2013, the total of Cambodian rubber plantations covered on 328,770 ha, an increase of 153 percent compared to what of 2009 which was only 129,290 ha. The number of plantation areas includes 55,908 ha of Rubber Estates (the former Rubber State Owned Enterprise), 135,444 ha developed by ELCs, and 137,417 ha of household rubber plantations (MAFF, 2014). This paper did not consider other possible options like cassava prices changes or other annual crops since changes in the extension of rubber

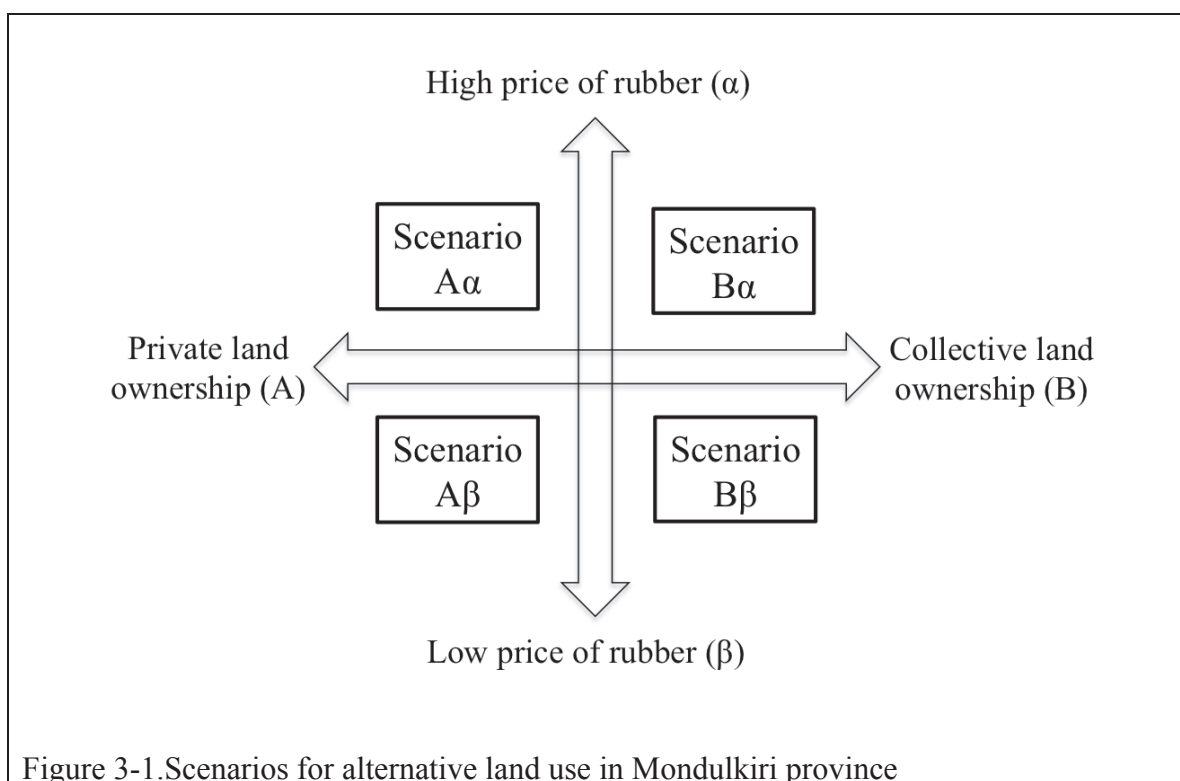
plantations are far more structural than what it can be for annual crops, due to the long and costly investment in the initial plantation (seven years without production).

Rubber being the major commodity envisaged by the concessions in Mondulkiri, we have regarded the price of rubber as the major driver that can encourage plantations (when it is high) or slow down the expansion of concessions and immigration (when it is low). Prices of rubber are indeed highly variable. In 2011, the world price of rubber peaked up high around USD 5,100/ton and then dropped down to USD 2,200/ton. Noticeably, in Cambodia price of rubber at farm gate could range from USD 1,350/ton (in 2014) to USD 5,000/ton (in 2010) (source: World Resources Institute as cited in Harfenist, 2015).

Starting from the prices in 2015, we have chosen two opposed hypotheses of rubber price trends that could characterize the possible economic environment of the local economic stakeholders in Mondolkiri for the next ten years.

- In *Hypothesis α* , the farm gate prices, after four years of decrease to a low point at USD 1,800/ton in 2013, would increase again linearly up to USD 4,000/ton in 2023. This corresponds to the maximum that could be obtained in the top of the cycle in 2011. This is a realistic option in case of continuous industrial growth in the world, since natural rubber remains compulsory in a number of industrial goods whose markets are in continuous extension, whereas the recent drop of the price has discouraged new plantations to be done.
- On the contrary, in *Hypothesis β* , the prices would remain low, considering that the recent drop is explained by a structural surplus on the international market, following the huge number of new plantations implemented in the 2000s, that cannot easily stop their production whatever the level of prices might be. The low price of natural rubber USD 1,500/ton at farm gate price corresponds to the minimum that was offered in the low part of the cycle in 2014.

By crossing the two policy options with the two levels of rubber prices allows us to elaborate the four following scenarios for modeling the future land use changes in Mondulkiri province up to 2023 (Figure 3-1).



3.2.2 The Definitions for Land Use Analysis

In the analysis that follows, **legal framework** is mainly based on the Cambodian Constitution stipulating that all persons, individually or collectively, have the rights to land ownership, so long as it is not in conflict with public interests. All Cambodian citizens known as Khmer legal entities and citizens of Khmer nationality have the right to own land. Foreigners are not allowed to own land in Cambodia but may own a limited number of units in a co-owned building provided that the units are above the ground floor and the building is not within 30 kilometres of a border. Foreigners can hold up to 49 percent interest in Cambodian corporations (Royal Government of Cambodia, 1993, 2001a, 2001b).

Land policies refer to the 2001 Land Law, the 2008 Land policy, Sub-decrees, regulations, directives or commands, and so on. The 2001 Land Law focuses on private landownership right residential and agricultural land, establishes a systematic titling of land and creates a comprehensive dispute-resolution system. The law also governs the lease rights (Royal Government of Cambodia, 2001a).

Land Administration and Institutions. The Ministry of Land Management, Urban Planning and Construction (MLMPUC) is the government body with first responsibility for land management, including policy and coordination of land registration and administration, land use planning, geodesic and cadastral surveying, mapping, and property valuation (Phann,

2006). Other ministries participate in land administration such as the Ministry of Agriculture, Forestry and Fisheries (MAFF) and Ministry of Environment (MoE). MAFF is responsible for agriculture development and for overseeing Economic Land Concessions (ELCs). The MoE is the lead agency responsible for environmental protection and natural resources conservation and for assessing and mitigating potential environmental impacts related to ELCs (GTZ, 2006; Phann, 2006).

Land concession means economic land concession authorized by the government to an investor that has fulfilled the conditions required by the laws of the Kingdom of Cambodia (Royal Government of Cambodia, 2003).

‘Land cover’ is the biophysical state of the earth’s surface and immediate subsurface (Turner *et al.*, 1995 cited by Briassoulis, 2000). In other words, land cover ‘describes the physical state of the land surface: as in cropland, mountains, or forests’ (Meyer 1995 cited in Moser 1996). Meyer and Turner (1994) add that it embraces, for example, the quantity and type of surface vegetation, water, and earth materials. Moser(1996) notes that the term originally referred to the type of vegetation that covered the land surface, but has broadened subsequently to include human structures, such as buildings or pavement, and other aspects of physical environment, such as soils, biodiversity, and surface and groundwater.

‘Land use’ involves both the manner in which the biophysical attributes of the land are manipulated and the purpose for which the land is used (Turner *et al.*, 1995). Similarly, Meyer(1995) states that ‘land use’ is the way in which, and the purpose for which, human beings employ the land and its resources (Meyer 1995, cited in Moser 1996). Land use briefly denotes the human employment of land (Meyer and BL Turner, 1994). Furthermore, Skole(1994) expands and states that ‘land use’ itself is the human employment of a land-cover type, the means by which human activity appropriates the results of net primary production as determined by a complex of socio-economic factors. Lastly, FAO (1995) defines that land use concerns the function or purpose for which the land is used by the local human population and can be defined as human activities which are directly related to land, making use of its resources or having an impact on them.

3.3 MATERIALS AND METHODS

We have identified changes in the land cover, and conducted in-depth interviews with communities, to understand why changes in land use and tenure are occurring and to assess

social implications of these changes. For this reason, the methodology was mainly based on the combination of both qualitative and quantitative methods with several steps as below:

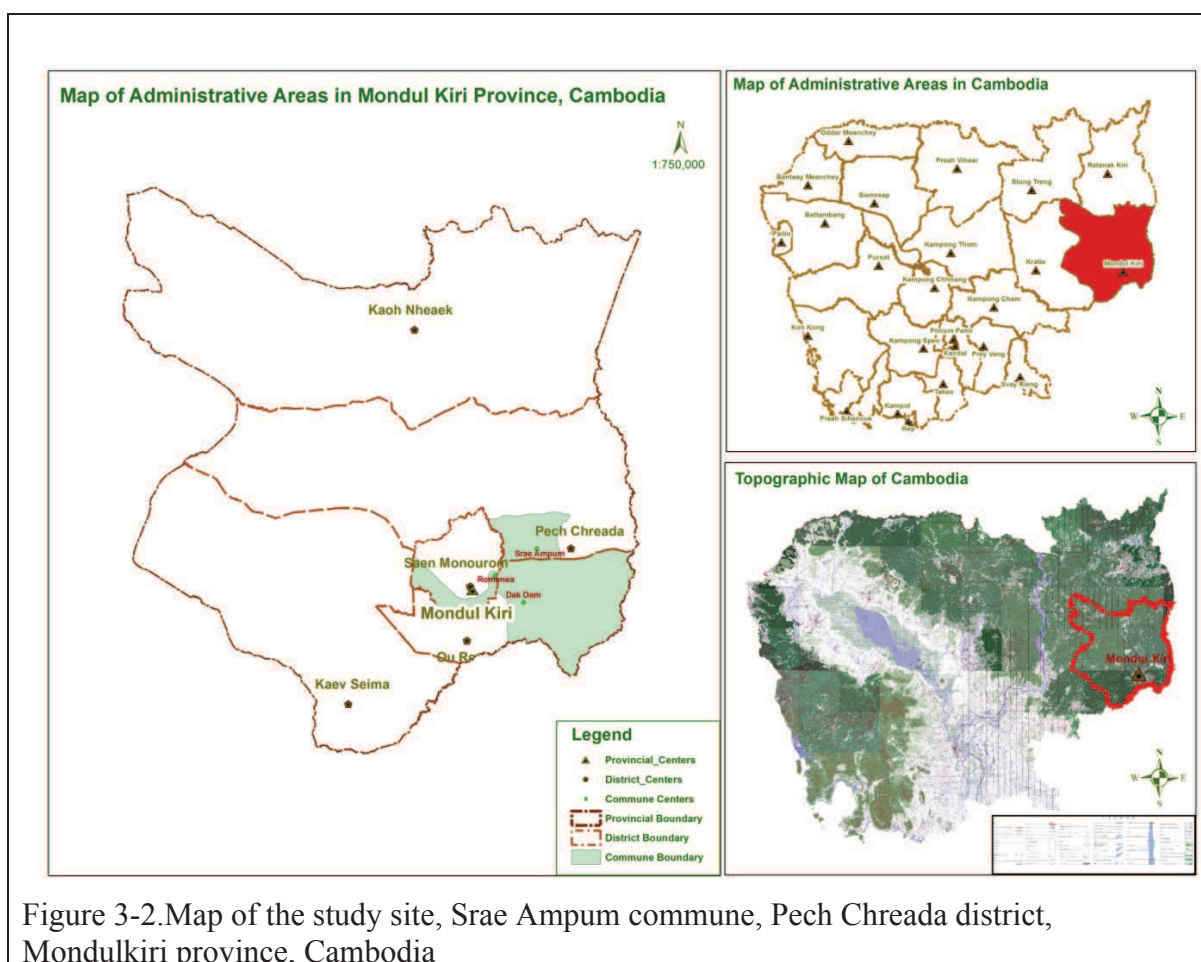
3.3.1 Target Area Selection

Fieldwork was conducted in one region of Cambodia where the forest cover remains the most important: Mondul Kiri province, which is bordered by Kratie to the west, Steung Treng to the north-west, Ratanak Kiri to the north and Vietnam to the east and south. It is the most sparsely populated province in the country, despite being the largest in area. The ethnic minority people living in the province are mostly known as “Phnong⁴” who used to practice traditional shifting (slash and burn) cultivation. The choice of the Mondul Kiri province in the far North-East of Cambodia (Figure 3-2) is considered by several reasons:

- The promotion by government of the north-eastern region of the country as one of pillar of national economic development, which should justify a special attention for the public intervention in the area;
- The region is especially diverse in terms of natural conditions, infrastructure and market: the interactions between the policies and the natural conditions can hence be enlightened; indeed there are places with favorable conditions and those with unfavorable conditions for shifting agriculture, or places favorable or unfavorable conditions for other land use alternatives;
- An important demographic change as indigenous population becomes a minority and Khmer culture becomes dominant;
- Highly market-oriented crops tend to replace the existing shifting systems and forest.

Specifically, three villages (Figure 3-2), namely Pu Chhorb (Dakdam commune), Pu Trom (Romonear commune) and Pu Radet (Srae Ampum commune), where 70 stakeholders (local villagers, three village chiefs, three heads of departments, and three local/international NGOs) were randomly selected for the survey about their general structural indicators. The main historical land use changes were studied in more depth in Pu Radet; since the village has experienced a rapid movement of lowland people coming in, infrastructure development, establishment of a new community forest while the village is surrounded by concession companies.

⁴ The Phnongor Bunong people appear to have lived in the provincial area for about 2000 years. In this article we generally refer to Phnong people rather than indigenous people since by far this group is the most represented, while in reality the population is ethnically more diverse than just one group.



3.3.2 Data Collection

To understand both the nature and the extent of land use and tenure changes, a series of focus group discussion (FGD), reviewing relevant documents, semi-structured interviews and field observations were conducted in the selected villages representing the varying degrees of such changes. Participatory Rural Appraisal (PRA) at individual level and FGDs were carried out for the needs of mapping the historical changes in the study area. FGDs were conducted with about ten participants per village including village heads, elder farmers and immigrants from other villages, and asking them to draw maps and describe the context of land use changes through each regime. In-depth interviews were also conducted with experts in land governance on analysing the impacts of economic concessions.

Data for this article were collected during two field surveys in the selected villages. The first visit was mainly focused on group discussions with community members in each of the villages, followed by individual interviews. The discussions also aimed at revealing areas of allocations and conflict surrounding land and natural resource, and at assessing the status of private and collective land tenure as reflected in incidence of land sales, land grabbing, and

efforts by the community to preserve their lands. Additional effort was made to determine changes over time in social conditions and economic/food security status that might serve as a metric in measuring the social impact of observed changes in land use and land tenure. Lastly, a second survey was then organised in the same three villages to measure the efficiency of the said cropping systems and to identify how they were combined inside production units led by the households.

Understanding contemporary landscapes in the study areas requires multiple sets of spatially and temporally compatible data that allow integrate historical land use patterns and disturbances to land cover. We focus on historic mapping to link spatial and temporal data for agro-ecosystems and apply their use in the region. Mapping of the forest cover at different moments was done using ArcGIS 9.x for Srae Ampum commune, Pech Chreada district, whereas the data were provided by the Ministry of Land Management, Urban, Planning and Construction and DLMUPC⁵.

Using available time series of maps and data, including 1993, 1997, 2002, 2006 and 2009, GPS field data of Srae Ampum commune, the classification maps was simplified into several classes, including forest (deciduous and primary evergreen), young fallow (includes shrub/scrub and grass), non-paddy agriculture, concession companies, paddy, settlement, wetland and water. Finally, land cover class area and percent cover statistics from different year class maps were calculated, summarized and compared by specific land use planning zones demarcated for the province. This allow for assessing overall province land cover change and also in analysing the extent to which each managed its land according to its respective participatory land-use plan.

3.3.3 Modeling for Scenarios Analysis

Following this analysis, the development of foresight assumptions using both external and internal factors was mainly based on expert opinions and followed the following steps (Pillot *et al.*, 2000):

- Describing the major evolutions in the local economy and farming systems;
- Analysing the present situation for each farming system in the study area. The capacity of each farming system to support population growth was discussed

⁵Department of Land Management, Urban Planning and Construction

between experts, according to four scenarios. A partial conclusion was then drawn regarding the major challenges that each type will face in the next decade.

- Elaborating four scenarios for the evolutions in landscape, based on the major possible economic changes in the environment and on the types of policies and that government may decide to implement in the future.

Modeling the structural process that underlies these land use changes has several benefits. First, by modeling impact of the land policies, the underlying spatial and temporal dynamic processes associated with the economic environment could be made explicit. This allows considering the cumulative effect of factors over time on individuals' decisions over land use and also the potential spatial interactions among economic agents. Finally, the impacts of each of the scenarios on the gross value-added (GVA), employment (workers), paddy rice consumption, paddy rice production, and population are illustrated.

3.3.3.1 Basic Assumptions

Based on the identification of the strategies of the main groups of stakeholders⁶, we have assumed their reactions to the different situations formulated in the scenarios. Thus, the policy favoring the concession holders (Hypothesis A) in a context of high prices of natural rubber (Hypothesis α) would encourage them to turn a higher proportion of their lands into rubber production. This would also impact the ability of some of smallholders⁷ to shift part of their land from cassava and paddy rice as well as the concession companies to cultivate all remaining land from total concessions into rubber. Shifting cultivation would come to an end in $A\alpha$; since the access of the IP to land would be even more reduced than today. On the contrary, shifting would continue at the same level in the opposite Hypothesis $B\beta$, or would be slightly reduced in the intermediary scenarios $A\beta$ or $B\alpha$). All land use assumptions made for building the four scenarios are summarized in Table 3-1.

⁶ See Yoeu, Pillot and Salles (2016) which details a typology of the local stakeholders.

⁷ The group of those, mostly Khmer immigrants, who are the most sensitive to the market and have the financial capacity to invest in plantations. For details on the typology of farmers in Monduliri Yoeu, Pillot and Salles (2016)

Table 3-1. Assumption of scenarios on cultivated lands, Mondulkiri province

Area planted in	Baseline: cultivated area (ha) in 2013	Assumption of cultivated area (ha) in 2023			
		Scenario A α	Scenario A β	Scenario B α	Scenario B β
Rubber	83,531	100% of total granted concessions* and 10% of cassava's baseline and 20% paddy's baseline are shifted to rubber	10% of paddy surfaces from baseline are shifted into rubber	10% of collective land concessions* plus 10% of paddy are shifted to rubber	same as baseline
Cassava	10,271	90% of cassava's baseline, plus 50% of paddy rice remains in cassava	20% of paddy rice surfaces from the baseline are shifted into cassava	90% of cassava baseline remains in cassava whereas 90% of collective land concession and 30% of paddy rice are shifted to cassava	100% of collective land concession plus 30% of paddy rice are shifted into cassava
Paddy rice	22,893	30% of paddy rice remain in paddy rice	70% of paddy rice baseline remain in paddy rice	60% of paddy rice remain in paddy rice	70% of paddy rice remain in paddy rice
Shifting	8,468	0	80% of shifting remains	50% of shifting remains	10% of shifting remains
Forest area ⁸	1,290,506	Increases by 100% of the shifting baseline but decreases by 55,799 ha to rubber	Increases by 20% of shifting baseline	Increases by 50% of shifting baseline but decreases by 16,740 ha giving to IPs	Increases by 90% of shifting baseline but decreases by 16,740 ha giving to IPs
Wage rate	USD 5/mnd	USD 10/mnd	USD 6.5/mnd	USD 7.5/mnd	USD 7.5/mnd

* Total granted concessions are 128,341 ha in 2013 and remain 55,799 ha is not cleared for planting yet

⁸According to Provincial Forest Administration in Mondulkiri, total forest covers in 2010 was 1,234,707 ha consisting of 160,822ha of evergreen, 176,214ha of semi-evergreen, 876,923 of deciduous, and 20,748 ha of other forests. In addition, there was area of 55,799 ha (deciduous) that was already given to concessions but was still not been cleared for planting, so we considered to include it as forest area in total of 1,209,506 ha.

*** 30 percent (16,740 ha) of unplanted area of concessions are taken off and given back to indigenous people as collective land*

3.3.3.2 Economic Calculation

Crop data (yield of production, price of products, intermediate costs of production) were collected during field survey with household interviews devoted to the current agricultural practices. Then we calculate the land productivity (gross value-added of production in USD/ha), labor productivity (USD/man-day) and required labor (man-day/ha) for all identified crops⁹. A value-added concept of output, concept of gross outputs, the form of capital-labor-energy-materials, value-added of labor productivity are chosen because these are useful indicators in assessing an economy's underlying productive capacity, itself and important measure of the growth possible of economies and of inflationary pressures. The value-added of productions reflect and characterize large shared of household's production, small household rubber and companies in the study area. The formulas for analysis of economic performance of cropping systems (plot scale) are as below:

- *Gross Output (GO-USD/ha)* = Production (kg/ha) x Unit Price (USD/kg)
- *Intermediate Cost (IC-USD/ha)* = all variable costs on inputs such as seed/plant, fertilizers, pesticides, and eventual service delivery (USD/ha)
- *Gross Value-Added (GVA-USD/ha)* = GO – IC
- *Land Productivity at plot scale (LdP-P)* = GVA / Plot Unit Surface
- *Labor Productivity at plot scale (LbP-P)* = GVA / number of working days

The model is based on the dynamic simulation of rubber prices and land tenure policies. The calculation of total gross added-value of agriculture were derived from gross added-value of each crop production (USD/ha) multiplies by total each type of agriculture. Number required worker in each system from the economic analysis were used to compute for total number of employment in different scenarios with regard to total land use change. For quantity of paddy rice consumption and paddy production in each scenario, we mainly required important data including the average consumption of rice per people per day, mean production of rice per ha, average size of household members in family. Number of population is taken from data of census and further projected based on the economic power in different scenarios.

The changes in the land use according to the scenarios, particularly the possible extension of the rubber and cassava productions, could lead to an increased demand for labor which in

⁹For more details, see, Yoeu, Pillot and Salles (2016)

turn would boost the wages and would encourage immigration from the inner Cambodia. In turn, the different increases in population would lead to different demands for food. We have calculated the impact of the scenarios on the labor requirements and the production of wealth by using our data from personal surveys as published in Yoeu and al¹⁰, which presents economic outputs of each main cropping system represented in the area. These results are summarised in Table 3-2. For instance, the yields in paddy in the lowland paddy systems and in the shifting systems are in average 1.7 ton/ha and 0.78 ton/ha of paddy, respectively.

Table 3-2. Economic performance of cropping systems (Source: Yoeu, Pillot, and Salles 2016)

Itemise	Shifting systems	Cassava	Paddy rice	Rubber plantations*¹¹
Total Gross Output-GO (USD/ha)	369	801	424	2,664
Intermediate Cost-IC (USD/ha)	21	28	159	270
Required labor (man-day/ha)	227	209	163	80
Land productivity (USD/ha)	348	773	264	2,394
Labor productivity (USD/man-day)	1.53	4.74	1.26	29.91

* Source: Hansen and Top (2006)

Referring to these data, we have also calculated the total labor requirements that correspond to the different surfaces in the various crops, and derived from this, the total manpower that each scenario would require. The corresponding population in 2023 was estimated by multiplying the number of workers by 2.5¹². In turn, the food consumption of this total population can be calculated, according to an estimation of paddy rice consumption of 228 kg per capita per year¹³.

¹⁰ See Yoeu, Pillot, and Salles (2016)

¹¹ Average yield of rubber was 1,332 ha over 25 years, average intermediate cost was USD 270/ha from study of Hansen and Top (2006) and the price was taken around USD 2/ha in 2012

¹²Based on the assumption that 40 percent of the population is active

¹³According to Cambodia CFSVA (Santacroce, 2008), the per capita consumption of milled rice was significantly lower in urban areas (9.5 kg of rice on a monthly basis) than in rural ones (nearly 13 kg of rice per capita per month). Maclean and Dawe (2002) found that rice consumption in 2009 was 160.3 kg milled rice per person per year in Cambodia.

3.4 RESULTS AND DISCUSSION

3.4.1 Case Study: Change Overtime for Mondulkiri Province

The history of Mondulkiri province was strongly influenced by Cambodian regulatory policies (Figure 3-3). The historical change in the land use in Pu Radet village is presented in this section. Four periods are identified, linked with the influence of land concession policies, demographic factors, and the whole evolutions of the country.

1990	2005	2010	2014	Present
Collectivism	Open economy and increasing commercial outlet	Corresponding arrival of local land game	Exploitation of concession companies	Deep institutional reform
<ul style="list-style-type: none"> Population limited Shifting cultivation with long fallows and NTFPs collection 	<ul style="list-style-type: none"> Movement of loggers New permanent agriculture 	<ul style="list-style-type: none"> Movement of Khmer peoples Setting down of concession Massive cassava cultivation 	<ul style="list-style-type: none"> Implementation of concession companies Processing dried cassava 	<ul style="list-style-type: none"> Movement of labor forces Agro-industrial plantation as small families (pepper, rubber)
<ul style="list-style-type: none"> Traditional equipment 	<ul style="list-style-type: none"> Introducing new tillers 	<ul style="list-style-type: none"> Renting hand tractors or tillers for land preparation 	<ul style="list-style-type: none"> Utilizing more hand tractors and tillers Initial applying chemical fertilizer, pesticide, herbicide 	<ul style="list-style-type: none"> Cassava processing by machine Increasing chemical fertilizer, pesticide, herbicide
<ul style="list-style-type: none"> Mutual labor exchanging within IPs shifting framings 	<ul style="list-style-type: none"> Involving in permanent agricultures 	<ul style="list-style-type: none"> Starting selling labor for cassava production at USD 2.5/day 	<ul style="list-style-type: none"> Demanding for labor working at concession companies Increasing labor wage rate to USD 4-5/day 	<ul style="list-style-type: none"> High demand for outsider labors from concession companies More intensive labor forces on other agricultural productivities
<ul style="list-style-type: none"> Customary law 	<ul style="list-style-type: none"> The 1994 land law The 2001 land law The 2002 forestry law 	<ul style="list-style-type: none"> The 2005 sub-decree The 2009 sub-decree Establishing community forestry in 2007 	<ul style="list-style-type: none"> Implementation land tenure Directive 01BB 	<ul style="list-style-type: none"> Holding more individual land title No existing communal land title of IPs
<ul style="list-style-type: none"> 94% of forest land Available of vacant land 	<ul style="list-style-type: none"> Logging forest by army troops Still remaining some vacant land 	<ul style="list-style-type: none"> Occupying and logging forest from companies and Khmers Narrow land space Land lost of some IPs families 	<ul style="list-style-type: none"> Land saturated and no vacant land Land conflicts and disputes 	<ul style="list-style-type: none"> Movement of labor forces Agro-industrial plantation as small families
<ul style="list-style-type: none"> Poor infrastructure 	<ul style="list-style-type: none"> Starting to develop infrastructure Arrival of NGOs 	<ul style="list-style-type: none"> New red-soil roads connected Schools, health center, pagoda Available bicycles, motorbikes 	<ul style="list-style-type: none"> Better road conditions Available mobile phones, cars, trucks 	<ul style="list-style-type: none"> Well development of infrastructure More modern vehicles

Figure 3-3. History summary of Pu Radet community, Srae Ampum commune, Pech Chreada district, Mondulkiri province

In 1979, four families (out of the five living there before) returned back to the village after the Khmer Rouge regime had forced them to move to the lowlands of Kaoh Nheak in the 70s. These original four families grew up to 60 households in 1982 and to 90 households in 1984 when other Phnong families having met them at Kaoh Nheak¹⁴ decided to join them in Pu Radet (later on this village was divided into three villages). During that time, for security and control reasons, Phnong people were encouraged to move their villages to the valleys; the area remained isolated and insecure after the Khmer Rouge right up to 1990s (Colm, 1996; Ironside,

¹⁴ Kaoh Nheak is one district of Mondukiri province, where the landscape is more suitable than anywhere else in the province for low land rice cultivation, agricultural crops and other agro-industrial crops. Irrigation systems have been built there for rice cultivation during the Khmer Rouge regime.

2010). At this period, the migration of “Khmer from lowland” remained limited, as well as the installation of private companies for logging or agro-industrial plantations (e.g. rubber, coffee, sugar palm tree, soya, etc.), whereas it may have started at the same moment in more accessible places especially in Rattanakiri province (Pillot, 2007). A few ranking militaries from the Cambodian army sent in Mondulkiri to control the area started, however to log trees in parallel out of the forest and partially settled down in the place.

With the peace coming back slowly after 1991, remote upland areas such as Mondulkiri first slowly opened up to incoming migration and limited development of agro-industry which speeded up at the end of the decade. Lowland migrants rapidly moved in to settle down, called by the first loggers who were also their relatives. Some specialized chains of immigration arose, linking each district or village of Mondulkiri to a specific village or district from one of the provinces of the inner Cambodia. Making the difference with the former period, the newcomers did not lean on logging for making their living, but directly on agriculture. Local Phnong people easily sold to them their access rights to land, especially the deforested plots after a few years of paddy rice and maize cultivation, which normally should have been left back to fallow. These exchanges were facilitated by the fact that, in most of the cases, the sellers did not lose any access to land on the short term, as far as they would have to move their shifting cultivation to other places anyhow. They were also facilitated by the growing monetary needs in the indigenous community themselves, with the arrival of the first motorbikes in 1993, followed by televisions in 1996.

As shown in Figure 3-3 in the case of Srae Ampum, the commune of Pu Radet village, a limited extension of the cultivated land occurred in 1997 compared to 1993. This was followed in 2002 by a more significant change in the nature of the forest (from evergreen and semi-evergreen to deciduous forest), the result of a strong reduction of the fallow period in the slash and burn systems. The nature of the cultivation also changed, moving from the traditional upland rice and maize cultivated within slash-and-burn systems to by the Phnong people to cassava cultivated permanently on the plots bought by the Khmers immigrants.

The introduction of power tillers in 1996 strongly increased the land exchanges. By facilitating the land preparation and the weed control in permanent cassava cultivation, motorization allowed the Khmer immigrants to significantly increase the area that they could cultivate. From that moment, the increase of demand for land resulted not only from the arrival of new waves of immigrants, but also from the rapid boost of the land holdings of those who had already settled.

After 2005, a third wave of immigration started with the arrival in Srae Ampum of capitalist investors seeking investment in large holdings of several thousands of hectares for plantations. Up to 2009, 1,800 ha of the forested area were cleared by such concession companies. In 2009, according to the district governor, eight additional concessions were officially granted in Pech Chreada district for a total area of 30,000 hectares, mostly taken from forests and previous shifting areas cultivated by the Phnong. Remarkably, at that moment, the impact on the shifting systems remained not visible since most of the areas granted to the companies were left to the cultivation of the local farmers or were just young fallows that still would not be cultivated in the next years. However, after a few years, it became obvious that the agricultural holdings of the Phnong people had become narrow and the duration of the fallows were becoming shorter accordingly. Furthermore, the NTFPs resources were significantly decreased while the areas were restricted for hunting by the companies as well as the number of collectors or hunters also increased.

In fact, a Community Forest (CF) was established in Pu Radet village in 2009 with the strong support from the Forestry Administration (FA) and the FAO¹⁵ and it is now fully recognized by MAFF. Formerly considered as state ownership, it thus became a collective ownership of Pu Radet indigenous community.

The deforestation undertaken by the companies attracted new waves of Khmer immigrants who in turn tried to buy land from the local people. The cassava cultivation expanded even more, encouraged also by the extension of soil road connections built or renovated by the concession companies.

The most distinct changes in the indigenous community lifestyle have been seen in this period. The Phnong traditionally cultivated upland rice with extensive shifting cultivation systems giving low yields. Only few indigenous families used to plant inundated lowland paddy, generally far from the village. Home gardens were rarely found around the villagers' houses, even though they had space for such garden, and the soil was good for vegetable plantation. With less land available for the shifting cultivation, the Phnong and other IP groups could no longer supply their family consumption with just the upland rice. This was a major reason for the extension of permanent inundated paddy rice cultivation in the lowlands of the village.

¹⁵ The community forest is approximately five kilometers away from the village. Much of the land that lies between community forest and the main part of the village (where most of the houses are located) is now used for farm land and growing cassava, nuts and vegetables.

After 2010, some of the concessions granted in the previous period started to plant, hence subtracting these lands from the traditional shifting by the native communities. Land became scarce and the first conflicts arose. In the meantime, the high prices of cassava after the 2008 food crisis, and the good yields obtained at the beginning on the newly deforested plots, encouraged not only the cultivation by the Khmer immigrants, but also, by imitation, by some “modern fringe” of the native people. Wage labor employment in the concessions or even more often, in the cassava plots of the Khmer immigrants, slowly replaced the traditional labor exchange within the Phnong communities. Consequently, the wage rate rose from USD 1/day in the 90s to USD 4 to 5/day in 2013.

In conclusion, the population doubled from 2005 to 2014 in Srae Ampum commune, while the forested area dramatically decreased after 1993 down to 65 percent¹⁶ in 2009 (Figure 3-4). The conversion of forests was mainly done for agricultural purposes such as agro-industrial plantations from the concession companies (e.g. rubber, pine tree and so on). In most cases, the land has been cleared, but the plantations have not been made yet or at least not in production. Beside this, smallholders have also played their role in the deforestation. The Khmer immigrants, on their side, did not directly deforest but they rather bought the already deforested land from the local people, forcing these to increase the pressure of cultivation on the slopes under remaining shifting cultivation, accelerating the cycles and thus degrading the forest cover.

¹⁶This figure is not actually accurate since data source of maps were taken from different places and types of forest were categorized in different ways in each implemented designation of producing map.

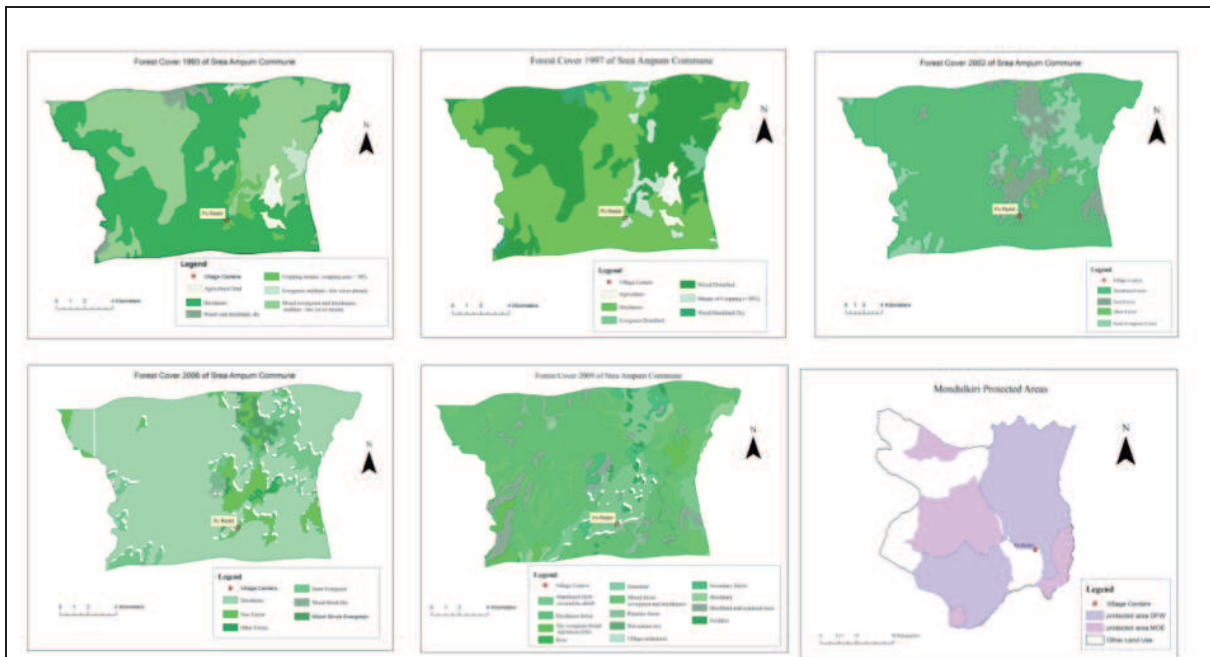


Figure 3-4. Map of forest cover of Srae Ampum commune in 1993, 1997, 2002, 2006 and 2009 and Mondulkiri protected areas (deciduous¹⁷, evergreen¹⁸, semi-evergreen¹⁹)

3.4.2 Force Driving of Land Use Changes and Its Consequences

Land use practices are changing rapidly in the uplands of Southeast Asia that reflects a broader agricultural transition (Fox and Vogler, 2005). Part of this has been occurring in the upland of Cambodia. Similarly, Fox *et al.*(2008) explained that the traditional forms of subsistence agriculture that relied on a cycle of farming followed by lengthy fallow periods are being placed by sedentary, market oriented farming systems. While a large rubber companies were established in upland areas, the advent of cash crop farming by indigenous communities has largely emerged since 1993 when Cambodia opened up for international investments and new road networks began to reach further into rural upland areas.

Based on the result of focus group discussions, in depth interviews with key actors as well references from scholars, driving forces that affect the land use changes include national policies to liberalize trade and markets, and high market prices for rubber and cashews. Population of Mondulkiri rose from 32,000 to 61,000 people which corresponded to two capita per km²(NIS, 1998, 2009), with an annual growth rate of 6.3 percent. Most of the immigrants

¹⁷ Deciduous forest is a type of forest characterized by trees that seasonally shed their leaves

¹⁸ Evergreen forest is a primary forest that has never been logged and has developed following natural disturbances and under natural process, regardless of its age.

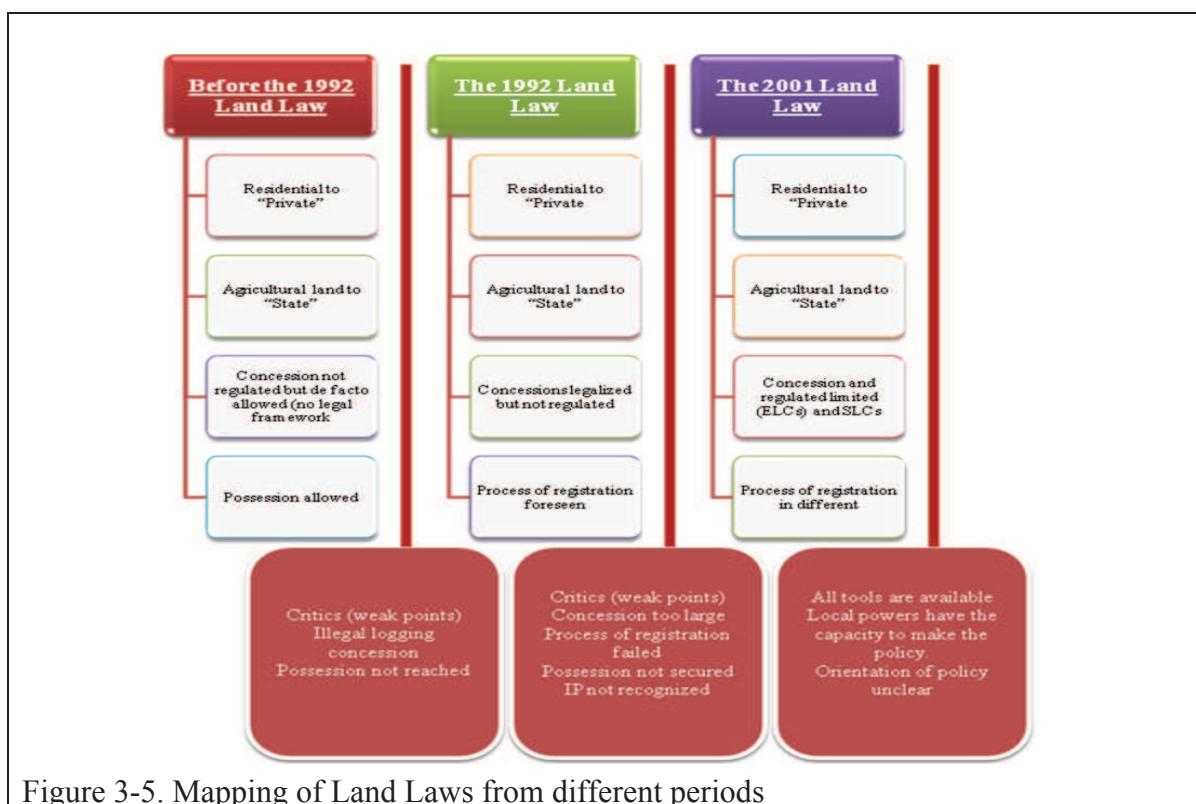
¹⁹ Semi-evergreen is adapted to reasonable amounts of rainfall in a highly, seasonal pattern, is unique to mainland Southeast Asia. It is a secondary forest that has been logged and has recovered naturally or artificially.

to upland provinces are coming from the provinces of Kampong Cham, Prey Veng, Svay Reang, Pursat, Koh Kong, Kampot, Kampong Thom. As results from group discussions, in Srae Ampum commune, the sold lands were mostly plots where the local Phnong people practiced traditional shifting systems with long fallow periods. This suggests that population pressure may have been one of the force driving land use intensification in the study area as well as for upland (Fox *et al.*, 2008). Other forces that affected the villages differently include the development of road infrastructure that made it much easier to get to the areas, illegal logging which occurred primarily and the active engagement of NGOs for the exploitation of non-timber forest products (NTFPs) that assisting villagers to develop land-use plans, and to promote education.

Perhaps the most significant common denominator among the study areas from the perspective of land use change is the nearly universal reliance on cassava and rubber production as the primary source of cash income. While members of communities continue to rely on upland rice farming and rainy season rice farming as their primary means of food production, virtually every family depends heavily on profit from cassava and NTFPs sales to supplement their family's food needs. Therefore, they indicate that they are in better economic position today than they were in the 1990s, and they point to cassava and rubber production as main factor for this relative increase in prosperity.

In addition, the critical force driving of land use change is the successive policies. The history of the Cambodian regulatory frameworks has been marked by the various political changes that the country has experienced (Figure 3-5). The Land and Forestry Laws, Cambodian land administration has met very critical changes since the introduction of land privatization in 1989. Before the 1992 Land Law, there was no significant legal framework concerning the access to land, whereas the possession of land, and the right to cultivate, was *de facto* recognised. This was seen as a limitation for the investments in agriculture, since the security of the possessors' access to land could be easily contested, and that the land could not be used as collateral for getting bank loans. In fact, the 1992 Land Law did mainly offer a legal basis to the existing framework. The price and the complexity of the registration process highly limited the advantages related to the improved tenure security. Some individual benefited however from these conditions; mainly in urban areas and often through speculative purchase, but very few rural households finally manage to prove their land possession rights. The question of the protection of the indigenous people (IP) rights through collective land titles generated lot of political pressure from the international donors and the civil society. The 1992 Land Law did not secure at all the access rights to the traditional lands exploited under slash-and-burn

systems by the indigenous groups. For instance, according to MAFF (2006), from 1996 until 1999, seven companies were granted 44,000 ha, while none of these concessions was in Mondulkiri, and this had no impact on the land use in the study area yet.



The 2001 Land Law did not either succeed to regulate the granting of land concessions for forestry or agricultural purposes. Between 2000 and 2005, more concessions were given in Mondulkiri, but without any transparency, and compromising the rights of local communities and threatening natural environment. In 2009, the government initiated a process of reviewing the status of ELCs and cancelled some concessions which did not meet the requirement of the law, keeping asking for delay of guarantee deposits, or undertaking inappropriate action (MAFF, 2006). Illegal logging from powerful people remained frequent in the study area.

On the contrary, these were threatened by the extension of the concessions which started to develop in the meantime. Since the 2001 Land Law, the IP have been able to formalize their customary land ownership by obtaining Communal or Collective Land Titles (CLTs), yet they may still not clearly understand all their rights. For instance, more IP's land was sold to outsiders after the law was published, and their traditional land use was largely abandoned before the approval of the Sub-Decree on Procedures for Registration of Land of Indigenous Communities in 2009.

Unregistered land held in shifting cultivation by indigenous communities is still considered as collective possession on state public land. Communal land titles (CLTs) are often limited to surfaces which are insufficient for traditional agricultural practices, or that include other conditions which make them inappropriate (Rabe, 2013). To date, there is no CLTs granted to indigenous communities in Srae Ampum, though donors have been working with government to develop processes and institutions to map indigenous land and register indigenous communities. Experience from these processes has shown that the formalization of the land rights of local community requires a significant long-term commitment of resources, with particular need that NGOs, relevant stakeholders, and individuals working in communities would join to help building their capacity to assert and enforce their rights effectively (USAID, 2011).

Despite the efforts for registration that followed the Directive 001BB, local disputes still continue due to tenures that are not registered or recognized yet, leaving them vulnerable to claims from external parties, including well-organized land grabbers. Particularly, traditional shifting areas located at long distance from the village of Pu Radet have not been mapped and registered. Many villagers who had made complaints against either Khmer individuals or companies in the Provincial Court have not received any result yet. Experience in Srae Ampum community also shows that landless Phnong people are still remaining.

3.4.3 Impacts of the Scenarios on the Land Use

Scenario A α :

Considerable policy that would favor private land ownership (Hypothesis A) in a context of high prices of natural rubber (Hypothesis α) would encourage ELCs companies to completely valorize their existing concessions into rubber plantations. This would first have a major impact on the labor demand, leading to a sharp increase in the prices of the wages, growing from USD 5 to 10/man-day. Second, the increase of population would encourage both Phnong and Khmer people to also invest on agricultural crops on their lands. Third, forest cover decreases by the area of unplanted concessions. Smallholders would however shift 20 percent of cultivated paddy rice and 10 percent of cultivated cassava into rubber plantations, a phenomenon that has already started at the moment of high rubber prices in 2011. Encouraged by the higher labor productivity of cassava (triple than paddy rice²⁰), Phnong farmers would finally transform 50

²⁰Cassava production takes of 209 mnd/ha, paddy rice 105 man-day/ha, and shifting 227 man-day/ha (Yoeu, Pillot and Salles, 2016).

percent of remaining paddy rice fields into this crop so that they can spend less time on their own crops and devote more time as part-time laborers in extended concession plantations²¹.

This price of labor would grow up to a higher level than the current labor productivity of paddy rice, shifting systems, and cassava productions (USD 1.26/man-day, USD 1.53/man-day, and USD 4.74/man-day, respectively²²), competition would become acute between these annual crops and working at the companies. Shifting systems would be totally abandoned, since their productivity would be even more lowered by the reduction of the areas available for this and the longer distances of the remaining potential. Therefore, there will be increasing land cultivated for rubber plantation (144,936 ha) and cassava (20,690 ha) but decreasing forest (1,243,180 ha), paddy rice (6,868 ha) and no shifting cultivation by 2023 (Table 3-3).

Table 3-3. Baseline (2013) data and projection data (2023) of areas in types of land uses based on assumptions

Scenario	Year	Planted rubber (ha)	Cassava (ha)	Paddy rice (ha)	Shifting (ha)	Forest area (10 ha)
A α	2013	83,531	10,271	22,893	8,468	129,051
	2023	144,936	20,690	6,868	-	124,318
A β	2013	83,531	10,271	22,893	8,468	129,051
	2023	85,820	14,850	16,025	6,774	129,220
B α	2013	83,531	10,271	22,893	8,468	129,051
	2023	88,521	31,178	13,736	4,234	127,800
B β	2013	83,531	10,271	22,893	8,468	129,051
	2023	83,531	33,879	16,025	847	128,139

Scenario A β

Would the rubber price go down to USD 1,500/ton (Hypothesis β), there would still be an increase of population, since the policy would still encourage private land ownership of new Khmer immigrants. Recent experiences of low prices of rubber show that small farmers may decide to destroy their rubber plantation and to replace them by short-term cash crops that they expected the crops will help to repay the former rubber plantation credit that they owe to the bank. Concessions however would not consider to extending their rubber plantations at all and will not call for more laborers. The Khmer immigrants, on the contrary, will be attracted by cassava as a short-term crop with rapid-return and higher labor productivity than the wage rate;

²¹ Shifting to cassava production is more possible than shifting to rubber production due to the 7 years long unproductive investment needed for this latter option.

²² Wage rates, however, are then still lower than or equal to labor productivity of rubber production calculated in USD 29/man-day over 25 years, according to the system of production and rubber price at USD/kg (Hansen and Top, 2006).

farmers would thus shift 20 percent of their paddy surfaces to cassava. Whereas the prices of the rubber are lower than in the previous scenario, the most market oriented Phnong farmers and Khmer immigrants would still shift 10 percent of the paddy surface to rubber, following the strong encouragements from the policy for private holdings. Shifting will decrease by 20 percent of its area, which will go back to forest. The forest cover will still gain but at a lower level than in the scenario A α (Table 2-3).

Scenario B α

In this scenario, the price of rubber would increase to USD 4,000/ton, but the land policy context for this condition would then be much less favorable to the concessions than in A α . In contrast, the local administration would rather protect the access of indigenous smallholders to their lands especially in case of conflicts with the concessions. In that case, it is assumed that the concessions would not be encouraged to expand their plantations; they would even loose 30 percent of their unplanted land which would be transferred back to the Phnong people. They would however use 10 percent of the remaining surface to plant rubber tree whereas the rest (90 percent) will be cultivated in cassava. Ten percent of the current surface of cassava would be planted into rubber by Khmer farmers eager to benefit from the high prices of this commodity, while the Phnong people would still transform 30 percent of their paddy field into cassava. Fifty percent of the area of shifting cultivation would remain whereas the other 50 percent will be abandoned and may turn back to forest.

Even though the concessions would not extend their holdings, however the immigration will still continue due to the new plantations (partially rubber and mainly cassava) in the already existing properties. The demand from these new plantations would lead to raise the wage rate to USD 7.5/man-day which would still higher than the current labor productivities of paddy rice, shifting, and cassava productions²³, while lower than the productivity of rubber production. By 2023 there will be increasing the area in rubber (88,521 ha) and cassava (31,178 ha) but the area in forest, paddy rice, and shifting will be decreasing 1,278,000 ha, 13,736 ha, and 4,234 ha, respectively (Table 3-3).

Scenario B β

In the last scenario, Phnong people would recover 30 percent of current areas in concessions since the policy would strongly use the new existing instruments for supporting the collective

²³ When we consider that the price of the cassava would also raise during the same period

land ownership. All this taken land would be planted with cassava since the price of rubber would decrease to USD 1,500/ton (Hypothesis β). The expansion of cassava production by individual private farmers would then require employing workers for production. The price of wages would increase to USD 7.5/man-day, leading to an encouragement to additional immigrants, and resulting in an increase the total population.

In this scenario, the area of cassava plantations would be extended due to shifting to this crop from both all the recovered concessions areas and 30 percent of the former paddy area. The rubber concessions and smallholder rubber plantations would remain the same. Since the labor productivity of paddy and shifting cultivation would still be lower than the wage rate in a context where agricultural land would more than double²⁴ (the expansion from taken areas of concessions), 70 percent of paddy rice area would remain and 10 percent of the shifting would also be maintained. However, the rest of the shifting area (90 percent) would get back to forest (Table 3-3).

3.4.4 Outputs of the Scenarios

The results of the four scenarios presented above are assessed with regard to four economic outputs that are of the most importance in the economic situation of the peripheral provinces of Cambodia (Table 3-4):

- the gross value-added (GVA) from agricultural crops and land use, as an expression of the production of wealth by agriculture;
- the number of jobs created by the various activities developed, measured by adding the labor requirements of the different surfaces of crops resulting from the scenarios;
- The local production of food, measured by the production of paddy rice, the rice consumption of the increasing population and the balance between them;
- The total forest area, as an indication of the environmental services still provided by the local ecosystems.

²⁴The 30 percent of the concession land given back to the local people would represent 38,502 ha whereas to be compared to 23,000 ha paddy rice and 10,000 ha cassava cultivated in 2013.

Table 3-4. The economic impact of the four scenarios for the year 2023, Mondulkiri province

Impacts	Scenario A α	Scenario A β	Scenario B α	Scenario B β
Gross value-added of agriculture ²⁵ (10,000 USD)	69,900	16,809	44,042	17,497
Employment (workers)	52,295	41,688	48,283	46,932
Paddy rice consumption (ton/capita)	29,808	23,762	27,521	26,751
Paddy rice production (ton)	11,675	29,885	25,002	27,573
Population (person)	130,497	104,221	120,707	117,330

3.4.4.1 Impacts of Policy A and Prices of Rubber (A α and A β)

The combination of high rubber prices and policy favorable to concessions (A α) is certainly the scenario that allows by far to get the highest value-added. However, this higher result is more due to the high level of prices than to the positive policy toward concession investments. Indeed, given the high prices of rubber, all relevant stakeholders converted a part of their croplands either to rubber plantations or to high return crops like cassava.

Therefore, high rubber prices (α) multiply the GVA by 4 in case of Hypothesis A and by 2 in case of B policy (Table 3-4), compared to low prices (β). In the meantime, policy A multiplies the value-added (compared to B) by only 1.5 in case of high prices.

In case of policy A, the sensibility of the indicators of wealth to the rubber price is important, since this is the driver that encourages concessions and smallholders to extend the cultivated area. The policy A tends to create additional employment for 52,295 workers in case of high prices of rubber, mostly on plantations (Table 2-4), hence leading to more than doubling the total population of the province in 2023 compared to 2013. As a result of the unhindered flow of capital, commodities, and eventually labor for agriculture, individual locations and commodities swing through boom-bust cycles production highly dynamic agricultural landscapes (Glassman, 2001; Rice, 2003). Over time, intensification, precision, and mechanization of agriculture reduce the labor requirements per unit production. This, however, does not lead to major unemployment because rapid fertility transitions over the previous

²⁵Gross value-added (land productivity) of cassava, paddy and shifting were USD 773/ha, USD 264/ha and USD 348/ha, respectively.

decades have resulted in ageing populations and a declining overall labor in many locations (Lebel, 2006).

The global balance of production and consumption of paddy rice and food crops is almost equilibrated when the prices of the rubber are low (Aβ). On contrary, in case of high prices of rubber, the shifting of surfaces from food crops to rubber production would strongly decrease food production, leading to a situation where the local production only covers 25 percent of the consumption (Table 2-4) and where imports from other provinces or Vietnam would need to provide 75 percent of the diet. In microeconomic terms, high income from market crops (rubber and cassava) would have to be partly used to purchase food for the daily home consumption. This scenario could reflect anti-globalization movements, dwindling agricultural trade, and an expansion of local exchange systems. Some of the implications of this scenario could be food security problems and land conflicts, as well as rediscovery of local knowledge and appropriate technologies (Lebel, 2006). Because they have allocated much of their food production land to this crop and reduced the number of productive species from several dozen to a single cash crop, Fox *et al.* (2008) concluded that they may have actually decreased their food security, becoming more vulnerable to climatic and market uncertainties.

The development of rubber plantations and the conversion of forests into cash crops are generally considered as one of the major causes of deforestation and land use changes in developing countries. Since large number of concessions fall within areas covered by natural forest, the policies that multiply the encouragements for rubber plantations can be seen as one of the major threats to natural forests of Cambodia as a whole. World Bank (2009) reported that in Cambodia, dislocations, land disputes, deforestation and ecological degradation due to cash cropping in large-scale monocultures.

The conditions of productivity of shifting agriculture, much lower than the wage rate in all scenarios, are such that the Phnong will be strongly encouraged to stop the indigenous systems and NTFPs collection that used to be an important source of livelihoods in the past. Even when the price of rubber remains low, the productivity of labor in shifting cultivation remains six times lower than what it is in rubber plantations, and three times lower than the wages in the plantations. Such difference leads to foresee a decline of the shifting cultivation, faster or slower according to the scenarios, but unavoidable on the long term. This impact would threaten the cultural identity of traditional shifting practice of the Phnong group. Another question raised deals with the form of this reduction, since a part of the losses in surface can be compensated by a reduction of the duration of the fallows, while certainly at high environmental costs.

Indeed, in the scenario A β , a number of the private smallholders would still be attracted by the productivity of the rubber, which is expressed by the 10 percent of the paddy surfaces which are turned into rubber plantations even though the prices are not attractive. This is subject, however, to an active encouraging policy, going beyond just giving the land security, to also address the financial needs linked with the specific investment in the plantations²⁶.

3.4.4.2 Impacts of Policy B and Prices of Rubber (B α and B β)

In circumstances of policy more favorable to smallholders (B), these invest more on cassava and paddy rice than in rubber, and hence the high prices of rubber have a more limited impact on the gross value-added (still multiplied by 2 however) than with policy A. In case of low prices of rubber, the policy B creates more added-value than the policy A.

The creation of employment is the highest with policy B, what the price of the rubber may be. Policy B encourages more the cassava and the smallholders' paddy rice production which requires less labor per unit of land than the rubber produced by concessions. However, the prices of the rubber have no effect on the final demand of employment in Hypothesis B, the demand of cassava compensating the lower of demand in the rubber plantations. Therefore, the scenario B α is the one would boost the population in 2023 the most, compared to all tested scenarios (around 140,100 habitants).

The choice of policies favorable to smallholders (Hypothesis B) would be insufficient to encourage the level of rice production up to the level of consumption. The deficit persists, while there is an excess of production in case of low prices (Table 3-4). However, the deficit with policy B (less than 25 percent) would be lower than with the policy A (more than 50 percent in case of high prices of rubber).

Except in A α , an active promotion of sustainable innovations in the rice based systems, both in shifting and in permanent lowland production, should allow to overcome the deficit, since a number of government and non-governmental agencies are currently working on this topic in the province. The policy B could be envisioned as leaving local people on their land to practice traditional land use practices (Fox *et al.*, 2008). Due to market power, the ability of local people to control their own lives, however, might be constrained and questioned.

²⁶Especially credit systems adapted to the investment on a crop that need seven years of care before starting offering economic return

3.5 CONCLUSION AND RECOMMENDATIONS

The history of land use in Mondulakiri province clearly relates forestland conversion to the increase of land concessions and to the arrival of migrants from the more populated provinces of central Cambodia. However, while having doubled the population in the last ten years, immigration has not led yet to acute problems of integration. The same villages host the two populations of migrants and the IP. While their livelihoods is clearly different, the two populations have somehow mutually benefited from each other: the Phnong have sold a part of their already deforested land to the arriving Khmer while they moved to more permanent cultivation or accelerated cycles of shifting systems. These latter found there an easily accessible resource to develop the cassava production and benefited from most of the remaining fertility rent after the deforestation.

The situation is different with the ELCs. Most of the concessions lands have been awarded on main surfaces that obligatory included a high proportion of forests. The deforestation of the concession lands, while still not followed by effective plantations, is responsible for most of the forest cover loss of these last ten years. Mostly done in a period when the institutions on land were not so developed, the award of these concessions now carry the risk of key land conflicts with the populations who considered they had formerly access rights there, and that they have not sold them yet.

In the meantime, a succession of significant institutional developments has been achieved in the 2000s, following the Land Law in 2002, the Forest Law in 2003 and the subsequent decrees based on them. Far from being a desert of institutions, the Far East is on the contrary rather rich in legal regulations, at least on the paper. However, the successive layers of institutions have created a legal framework that can still be used in any direction, either to reinforce the position of the concessions or, on the contrary, to protect, or sometimes to restore, the access rights of the local communities.

The recent failure of the directive 001BB, that intended to clarify the access rights of the various stakeholders in Mondulakiri, particularly when collective properties were involved, has confirmed that the unstable land tenure situation was not secured by the recent progresses of the legal framework. Especially, the collective land titling could not be achieved; the overall land registration process, while totally free of charge, is still convoluted, time-consuming and finally not encouraging landholders to participate in the land registration. Without strong

support from NGOs agencies on collective registration, communities cannot claim for collective duly recognized land titles.

In parallel with these movements, the high prices of rubber, which have been the engine of the interest of concession companies, have decreased since 2011, so that the future plantations on the concession lands are now in question. The future of the territory is hence at a crossroad. Very different scenarios look possible, going from a large development of the plantations in the concessions up to a partial retrocession of the concession lands to the local communities, and a land use more oriented on cassava and rice crops. Four of these scenarios have been assessed; based on the most expected reactions of the various stakeholders to different policies implemented by the local administrations and to different economic market conditions.

The findings of this foresight indicate that the policy favoring large scale concessions may result in several positive effects, while only when the rubber prices are high. The analysis shows that the economic returns from annual crop productions would be lower than from rubber when the market is favorable, but would be higher when the prices are low. The most important benefits from a rubber plantation extension will go to concession companies rather than individual smallholders. On the contrary, policy more favorable to the rights of indigenous communities and of individual immigrants leads to higher employment creation and better balanced food security.

The analysis for land use foresights based on various tested scenarios and their impacts suggests that in some cases the value-added of crops may be high enough to generate a positive income, but the compensation for environmental losses and opportunity costs are still undefined and uncertain. This seems to be particularly the case of rubber compared to other alternative land uses including forest or shifting cultivation. The future of shifting systems, squeezed between the expansion of concessions and the development of permanent cultivation of paddy and cassava, raises also questions, since the reduction of the surfaces or of the duration of the fallows can have a major impact on the total land use. In all these cases, the scenarios can serve as a transparent framework to ensure that decisions are based on assessments that take into consideration ecosystem trade-off in the future.

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Annexe of Chapter 3

Table A 3-1. Baseline data (2013) data and projection data of areas in types of land uses based on assumptions

Scen ario	Year	Rubber of concessions (ha)	Rubber of smallhol ders (ha)	Planted rubber (ha)	Cassav a (ha)	Paddy rice (ha)	Shiftin g (ha)	Forest area (10 ha)
A α	2013	72,542	10,989	83,531	10,271	22,893	8,468	129,051
	2023	128,341	16,595	144,936	20,690	6,868	-	124,318
A β	2013	72,542	10,989	83,531	10,271	22,893	8,468	129,051
	2023	72,542	13,278	85,820	14,850	16,025	6,774	129,220
B α	2013	72,542	10,989	83,531	10,271	22,893	8,468	129,051
	2023	72,542	15,979	88,521	31,178	13,736	4,234	127,800
B β	2013	72,542	10,989	83,531	10,271	22,893	8,468	129,051
	2023	72,542	10,989	83,531	33,879	16,025	847	128,139

CHAPTER 4: UNDERSTANDING FARMERS' STRATEGIES, INNOVATIONS AND CHANGES IN UPLAND CAMBODIA

UNDERSTANDING FARMERS' STRATEGIES, INNOVATIONS AND CHANGES IN UPLAND CAMBODIA

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ABSTRACT

This paper aims at analysing the transformations of the land use in the forest margins of upland Cambodia, with a special interest to the economic outputs of the various cropping and farming systems resulting from the strong dynamic of immigration coming from the central part of the country. Field interviews and observations of a total of 66 farmers from three different districts of Monduliri province have been selected using combination of quantitative and qualitative methods. Six types of farm strategies were identified in relation to main historic milestones, interactions within households, family projects, strengths and constraints. The traditional shifting cultivation systems are compared to the innovative ones being extended together with the immigration, notably the permanent lowland paddy rice cultivation and the mono-cropping of cassava. Economically, permanent cultivation of cassava demonstrates the highest land or labor productivity, and pulls the demand for labor. The majority of the households now invest on market-oriented crops, whatever their ethnic origin. However, these transformations are highly driven by market incentives that can change. The question of the possible impact of market changes suggests that shifting cultivation can be possibly disappeared or re-appeared, and that the conditions of regulation by the public policies should be prepared.

Keywords: Land use changes, shifting agriculture, farm income, fertility rent

4.1 INTRODUCTION

The overwhelming majority of farmers in mountainous areas of Southeast Asian countries are subsistence farmers, most generally working on less than two hectares of land. These farmers are recognized to have a sophisticated knowledge of the local conditions for agriculture and natural resources management, a basis which is highly needed to more eco-friendly sustainable land uses (Clarke, 1996). They also strongly rely on wealth of natural resources, including globally valuable stock of forests and biological diversity; it is home for a rich heritage of indigenous cultures and it is also source of water systems useful for millions of people.

As global economy grows by introducing cash crops (e.g. coffee, rubber, cassava) and expanding the production of traditional subsistence crops on a commercial scale, today, some farmers have given up their traditionally varied subsistence crops especially shifting cultivation to grow just one or two commercial crops, which are generally considered as offering higher income return. Some ethnic farmers appear to maintain some elements of shifting although they live in rapidly developing economies with ample job opportunities and lucrative markets (Hansen and Top, 2006). In other cases, farmers abandon shifting cultivation in favor of more permanent land use (Guo *et al.*, 2002; Eder, 2006; Heppell, 2009; Cramb and Sujang, 2011). Based on an analysis of overall political economic trends and a series of case studies, Fox *et al.* (2009) concluded that there are six main factors that have driven the change in shifting systems in Southeast Asia: (i) classification of shifting farmers as ethnically different and even primitive; (ii) the non-appearance of the shifting agroforestry system on maps showing forests and agriculture; (iii) state control and conservation efforts in forested area where shifting is practiced; (iv) resettlement of immigrants; (v) privatization efforts that contrast with communal and customary forms of land tenure; and (vi) the promotion of industrial and market-driven agriculture.

Therefore, the question is raised to identify what are the drivers that generate changes and innovation in these farming systems. In the Malthusian perspective, primarily focused on the population growth and its relationship with a limited availability of resources; in a closed environment and without major innovation breakthrough, population tends to increase at a faster rate than its food supply (van de Walle, Malthus and Appleman, 1977). The agricultural system changes overtime to increase production of food but globally labor productivity decreased. Indeed, decreasing labor productivity and shortened fallow periods have often been used as the main motivation for improvement of shifting cultivation farming practices,

which are seen as vital to prevent the system from breaking down (Greenland, 1975; Grandstaff, 1978; Kleinman, Pimentel and Bryant, 1995; Juo and Manu, 1996; van Vliet *et al.*, 2012). This trend of change leads to crisis when this is no longer possible to work more or when the resources are exhausted. Among another important body of the literature, Boserup (1965) is more optimistic, claiming that population pressure is the impetus which drives smallholder farmers to innovate and to intensify their agricultural production to meet growing subsistence needs (Ruthenberg, 1980; Barlett, 1982; Netting, Stone and Stone, 1989; Stone, Netting and Stone, 1990; Netting, 1993). Some innovations, like crop rotation, intercropping, and shorten fallows are minor adaptations to the population growth, but the availability of labor itself may allow investments on the land that multiply the productivity instead of lowering it. These major intensifications can be characterized by various land use practices including terracing, development of irrigation, plantation, integration of livestock to crops, and development of fodder crops and manuring (Snyder, 1996).

The main drivers of changes and their economic consequences have not been precisely identified and measured in the case of upland Cambodia provinces where the demographic movements and market incitation have forced the agricultural land change overtime; especially the traditional systems of shifting cultivation have been converted into permanent crops. Whether these transformations are of Malthusian nature or rather correspond to Boserupian innovation is more than a question of curiosity. In the first case, the future of agriculture of these areas would be strengthened by raising opportunity costs for the labor in the large deltaic plains around. On the contrary, in the second case, the potential of further deforestation and extension of agriculture would be confirmed.

Cambodia is rich in natural resources that play an important role to support the livelihoods of local people, particularly in the remote rural communities in the northeast provinces of Mondulakiri, Ratanakiri, Stung Treng, and Kratie. Rapid agrarian change is currently underway in these areas. The current changes in Mondulakiri may be representative of similar processes in many parts of provinces in northeast Cambodia, of southeast Asia, and other areas (Turner and Doolittle, 1978; Shiva, 2003; Akram-Lodhi, 2005; Nevins and Peluso, 2008).

In fact, upland crop production already plays a key role in contributing to household incomes in upland areas of Cambodia, accounting for about four percent of national GDP (ADB, 2007). However, recent adoption of mono-cropping of market oriented crops such as cassava has generated increased concerns about food security and sustainability of agriculture

while the population grows. Attempts to increase production to meet demand could generate more environmental damages. Understanding the relation among population, technology, and resources embedded in the interpretation of such agricultural intensification remains a fundamental problem confronting the human sciences. These relationships are critical to the question of agricultural change in Mondulakiri province of Cambodia. What are the factors of the changes? What are the natures of changes? Are those changes the same for everyone? What are the impacts and will the changes be sustainable? This paper explores the agrarian changes, the strategies of the stakeholders and their consequences, and finally the future of agriculture of these areas.

4.2 MATERIALS AND METHODS

The study is conducted in Mondulakiri province in the far northeast of Cambodia (Figure 4-1) for several reasons:

- The promotion by government of the northeastern region of the country as one of pillar of national economic development;
- Policy, infrastructure and market conditions: places with favorable conditions and those with unfavorable conditions for shifting agriculture; places with favorable conditions for various land use alternatives;
- An important demographic change as indigenous population become a minority to be replaced by Khmer dominant culture;
- High market-oriented of cash crops to replace the existing shifting systems and forest

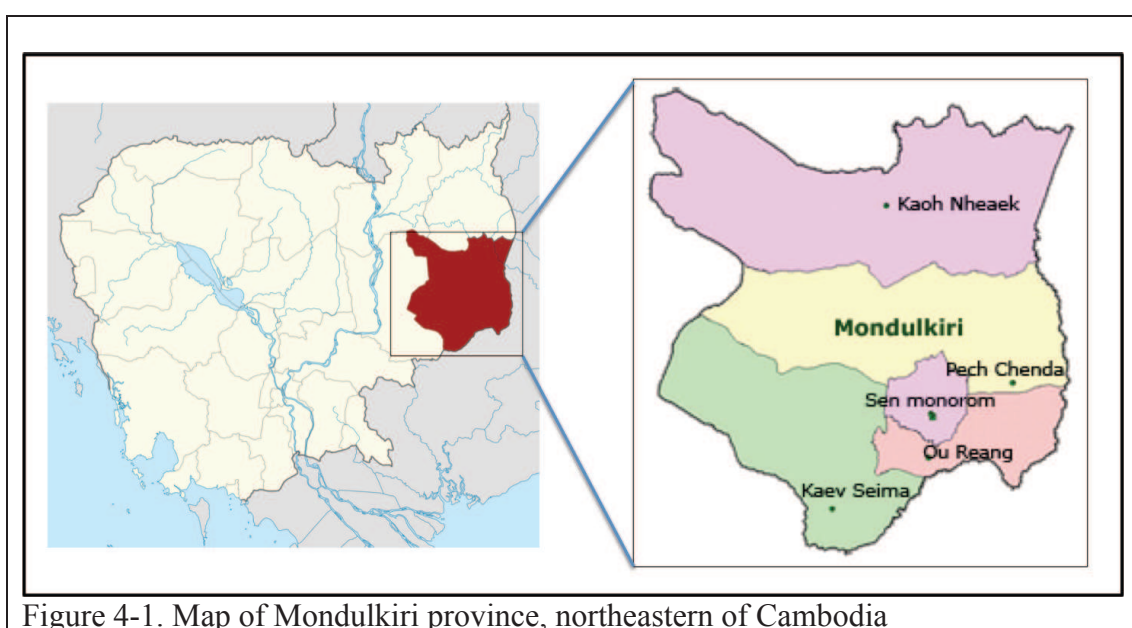


Figure 4-1. Map of Mondulakiri province, northeastern of Cambodia

Two different field surveys were conducted in Pu Radet village of Pech Chreada district, Pu Chhorb village of Ou Reang district, and Pu Trom village of Sen monorom district, Mondulkiri province (Figure 4-1).

1- Firstly, a primary data was gathered from a total of 130 sample respondents through direct interviews. This survey mainly focused on general information of farmers' decision making on using the land. A structured questionnaire was also tested before the interviews. Based on the results, five main cropping systems were identified as being the basis of the main agricultural productions in the area: shifting cultivation, paddy rice, cassava mono-cropping, rubber plantations, beans and peanuts based systems. Livestock rearing systems appeared as being marginal and were not considered as one of these major activity systems.

2- A second survey was then organized in the same three villages to measure the efficiency of the said cropping systems and to identify how they were combined inside production units led by the households.

Since it was assumed that the main reasons behind the farmers' practices would stand among their economic performances¹, a production function-based valuation approach was used to specify the feasible output of goods and services that could be produced in each cropping system, with a given set of inputs (labor, machinery, natural resources, etc.). Production function-based valuation approaches are based on the contribution of a given ecosystem services to the production of commodity that is traded on existing market (Tallis and Polasky, 2009). At the plot scale, economic performance of cropping systems is measured by the land productivity, defined as the gross value-added (GVA) produced per unit of land, or the labor productivity, defined as GVA produced per unit of labor (Benkahla, Ferraton and Bainville, 2003). At the farm level, the outputs of farming systems can also be assessed by the labor productivity, considering the whole agricultural GVA produced at the level of one household, the farm income or the land productivity at the level of the whole exploited area (Ferraton and Cochet, 2002; Barral *et al.*, 2012).² Table 4-1 summarizes the indicators used.

¹We do not ignore that a number of practices and strategies also relate to social or cultural values, especially when these practices require collaboration between the stakeholders (collective actions). However, we clearly limit our analysis to the economic justifications of the choices made by the stakeholders. We also consider the relation of choices made, while we consider that these social or cultural values, when they are the result of a long traditional culture, often correspond to economic foundations.

²For the combination of cropping and farming systems economic appraisal, see Nicolas Ferraton and Hubert Cochet, *Emarche D'étude des Systèmes de Production de 2 Villages au Nord de Man (Gbatongouin et Mélépleu) en Côte d'Ivoire*, 2002)

Table 4-1. Analysis of economic performances at farm and plot scale

Analysis of economic performances of cropping system (Plot scale)	Analysis of economic performances of farm (Farm scale)
<ul style="list-style-type: none"> - <i>Gross Output (GO)</i> $GO = \text{Production} \times \text{Unit Price}$ - <i>Intermediate Cost (IC)</i> IC = all variable costs on inputs such as seed/plant, fertilizers, pesticides, and eventual service delivery - <i>Gross Value-Added (GVA)</i> $GVA = GO - IC$ - <i>Land Productivity at plot scale (LdP-P)</i> $LdP-P = GVA / \text{Plot Unit Surface}$ - <i>Labor Productivity at plot scale (LbP-P)</i> $LbP-P = GVA / \text{number of working day}$ 	<ul style="list-style-type: none"> - <i>Gross Output (GO)</i> $GO = \text{Production} \times \text{Unit Price}$ - <i>Gross Value-Added (GVA)</i> $GVA = GO - IC$ - <i>Net Value-Added (NVA)</i> $NVA = GVA - \text{Depreciation Costs (DC)}$ - <i>Farm Income (FI)</i> $FI = NVA - (\text{Land rent} + \text{Taxes} + \text{Duties} + \text{Loan interest} + \text{Salary}) + \text{Direct subsidies}$ - <i>Land Productivity at farm scale (LdP-F)</i> $LdP-F = NVA / \text{Total area exploited}$ - <i>Labor Productivity at farm scale (LbP-F)</i> $LbP-F = NVA / \text{Total number of working days}$

At the level of the farm or households, identifying different types of farming systems was sought, or even livelihood systems if we include the non-farm and off-farm activities, in order to characterize their economic strategies especially with regard to the land use. The ambition there was to identify the land use strategies associated with each major type of stakeholders, but not to quantify their impacts. Hence the representative of the sample chosen for the interviews of this second survey was not an n issue. The number of respondents was not accurately determined before the interviews started. Rather, we chose to multiply the interviews until it became obvious that no additional type of strategy could come out from more interviews. In our work, this ended with 21 respondents in Pu Radet, 22 respondents in Pu Chhorb and 23 respondents in Pu Trom, mainly selected for the study based on purposive selection within the broader random sample.

3- A historical survey was undertaken in parallel with agrarian systems, employing focus group discussions (FGDs), in-depth interviews with key-informants and randomly selected of sample respondents. The main objective was to discuss on the changes over time underway in Mondulkiri, to make sense of the cultural dynamics, to understand the land tenure situation and the way ‘economic development’ is being implemented in this study area.

4.3 FINDINGS AND DISCUSSION

4.3.1 The Transformations of the Land Use: A Brief History of Agrarian System

The changes overtime in the agrarian system in Mondulkiri province led to identify two main periods namely i) from the pre-colonial period, through the Khmer Rouge regime, up to the liberalization of the Cambodian economy in the early 1990s and ii) from the early 1990s to present time (Figure 4-2).

i) Up to the early 1990s

Historically, the Phnong people appear to have lived in the province for at least 2,000 years, yet there is very little documentation. They lived in groups comprised of 5-10 families, closely attached to the natural forest, which is considered as the main asset for them, practicing shifting cultivation and collecting non-timber forest products (NTFPs). They had several plots of shifting cultivation with a minimum of 10 to 15 years of fallows.

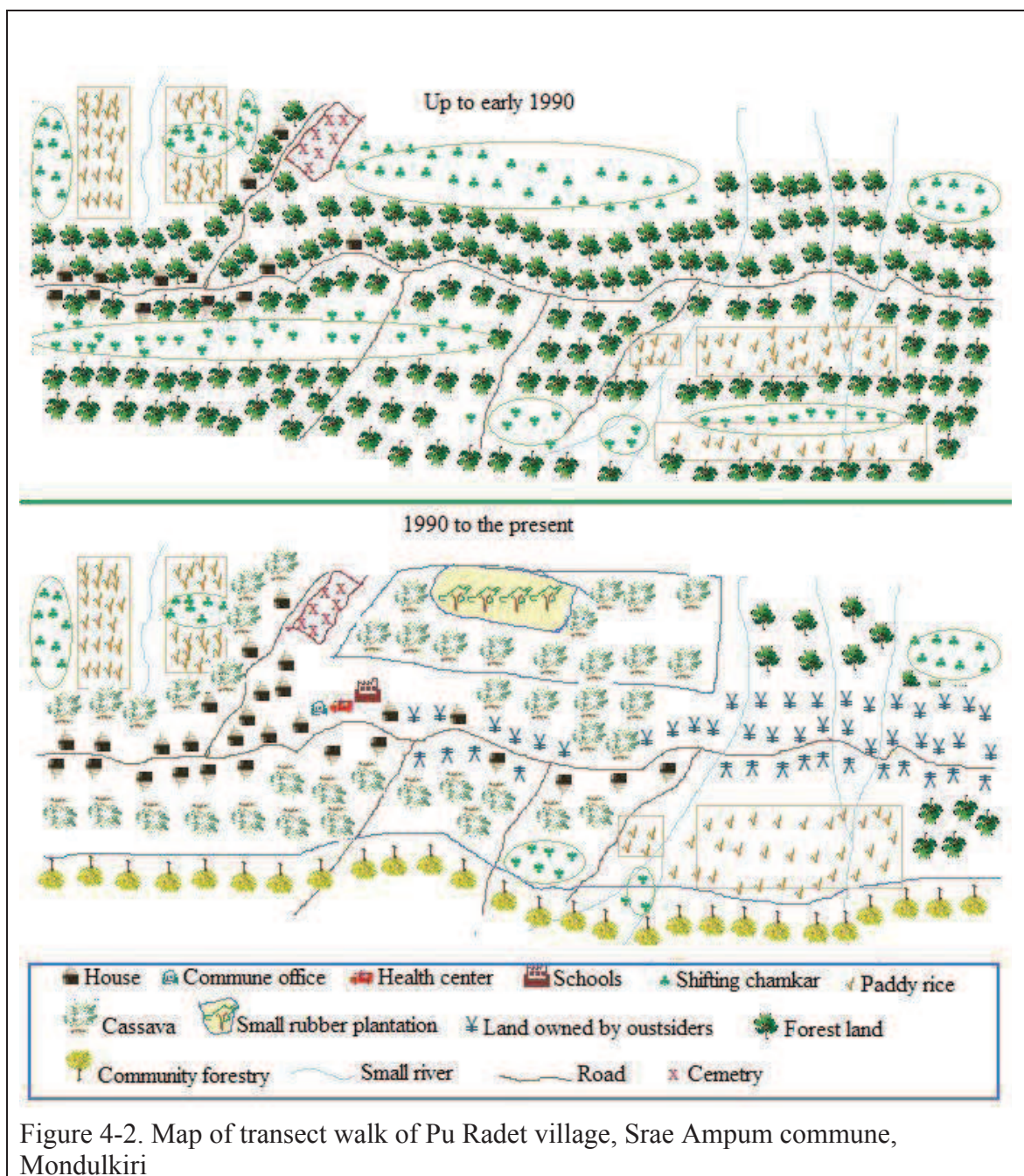
These areas did not show real economic interest for the development of trade at the colonial period and French anthropologists could describe an unchanging system till the second part of the 20th century (Forest, 1980; Matras-Troubetzkoy, 1983; Mouhot, 1999; Garnier, 2009).

During these periods, the farming systems of the indigenous people (IP) of Mondulkiri remained mainly based on subsistence agriculture. The Phnong originally occupied the valleys and the lowest slopes using them to cultivate the traditional shifting systems, called “*chamkars*”³ and, partially on flat areas, inundated paddy rice; the combination of the shifting systems in the upland and a few paddy fields in the lowlands was seen as the best way to secure adequate rice provision for the household consumption. Additionally, the living was also dependent on the collection of NTFPs in the remote parts of the area.

Only the Khmer Rouge, in the 1970, brought a real change. Considering the traditional mode as archaic, they forced the population to move to places where it was possible to grow irrigated rice, the only system acceptable to them. Like other people in the province, the

³ *Chamkar* is actually a generic concept in Cambodia for all the crops but inundated rice. In the shifting systems of the periphery of the country, *Chamkar* corresponds more precisely to the plots resulting from the shifting of the natural vegetation.

Phnong were displaced several years and they were only allowed to return to their traditional homeland in the 1980s, after the collapse of the Khmer Rouge regime.



At that moment, local farmers were still free to reclaim any forest land and could hold the use rights on the fallow land that they cleared. With a province population of 28,960 inhabitants in 1997 and a total forest area of 1,422,000 ha, the total density of population living from this system was two people per km² (Mondulakiri province coverage of 14,682 km²). A standard family of six people could then have a theoretical access to 300 ha, which could easily allow each family to slash and burn one hectare of land every year, cultivate this

hectare during three successive years, then leave as a fallow for a theoretical duration of 300 years. With a theoretical mean yield of 0.7 t/ha, the three hectares per family could produce the two tons of paddy rice that were necessary for the home consumption.

There were few houses along the road (Figure 4-2) but most of indigenous families had their own houses located near their shifting plots; they came to village just when they had meetings or ceremonies. Exchange of labor among local people was common, but selling was inexistent. The land possession was acknowledged by all stakeholders as customary ownership. Globally speaking, thanks to the low population density and to the long fallow period on land largely covered by forest vegetation, the sustainability of agrarian system was not yet an issue.

ii) From the 1990s up to the present time

The situation significantly changed from the early 1990s which correspond to the first important migrations from the central Cambodia. Between 2000 and 2012, the population of Mondulkiri province has been grown from 38,830 to 70,400 inhabitants. Migrations (M) actually arrived in the villages surveyed in two separate periods.

- Firstly, a group of Khmer migrants (M_1) arrived in the village in 1989 as army forces, officially to restore the central power but actually with the purpose of logging the forest and developing trade. Later, they also called their relatives and friends who came and started to buy land. These first immigrants built close relationships with the local Phnong, offering new and interesting opportunities for trading wild animals and timbers. Land access was easily, sometimes freely, allocated to them during that time. They extended some crops for home consumption and they could even accumulate in land to sell some lands when the concessions arrived in the early 2000s (Yoeu *et al.*, 2016). Still now, a fraction of the lands close to the road still belong to Khmer owners who never stayed there. They currently live in town, have not cultivated any crop yet and they probably sell these lands when the price will go up.

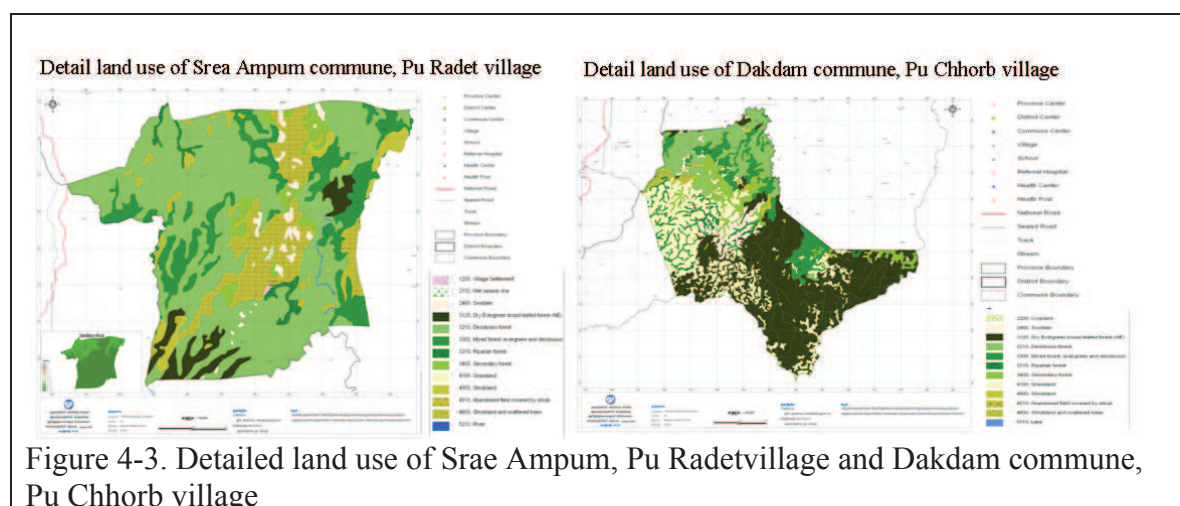
- A second wave of Khmer immigration (M_2) moved into the area from 2000 to 2012 with, this time, a clear purpose of getting land for agriculture. They also brought some capital to invest, which they used to clear the land they purchased and planted the crops for short term return from the market. The extension of cassava markets from 2005 mutually accelerated the migration movement, leading to doubling the population (Yoeu *et al.*, 2016).

These land exchanges strongly reduced the area available for shifting cultivation. As the production needs for the subsistence of the households remained unchanged, or increased when new consumption needs arose, people tried to keep cultivating the same area each year, but they strongly reduced the duration of the fallows, down to 4-6 years in average by 2013. The consequence was also that the access to the forested fallows or to the remaining forest became more difficult, and the collection of NTFPs strongly decreased.

With the land they obtained, migrants mostly planted cassava for the market since the beginning of the process, every year with the same system. The roots are harvested, chopped and dried before being sold to traders who mostly export to Vietnam where the starch is extracted and re-exported. Later, this cassava system was also adopted by the Phnong people as a cash crop, but on limited part of the holdings.

4.3.2 Landscape, Current Land Use and Land Holding

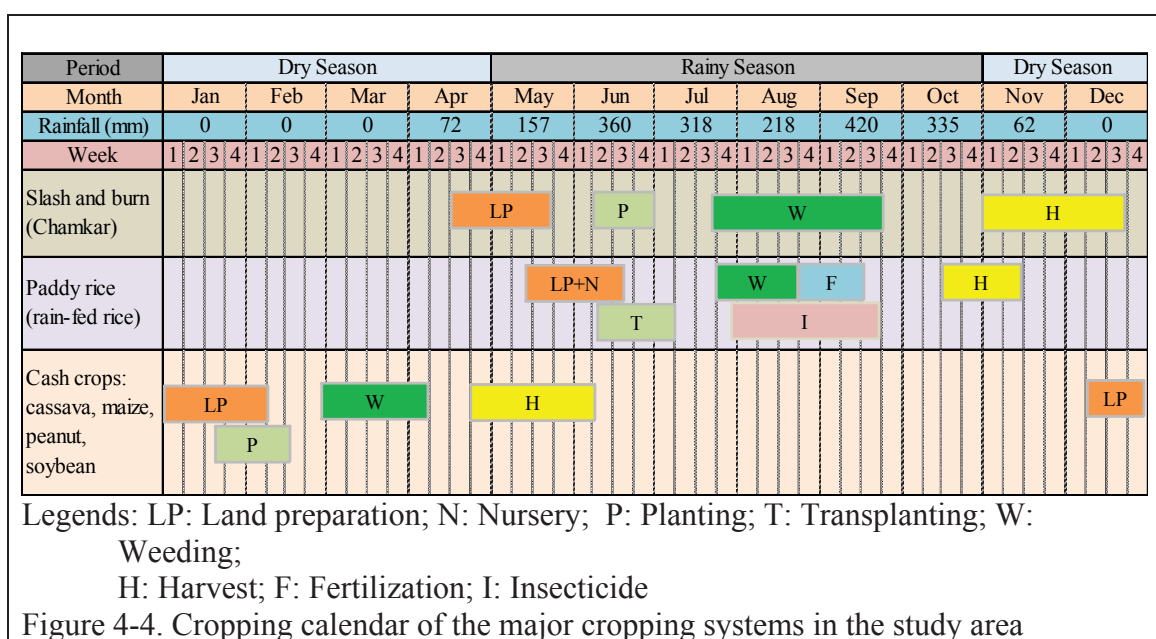
The study areas are mostly covered by dry evergreen broad leafed forest, deciduous forest, mixed forest, riparian forest, secondary forest, grassland, shrubland, abandoned fields covered by shrubs and scattered trees, wet-season rice or paddy rice (for only Srae Ampum), and shiftingplots. Different land use areas can be identified according to the position of the plots (Figure 4-3). The cultivated areas (hills and mountains) are mostly on the slopes. The paddy fields are typically located in the low flat areas, while terraced paddy fields extend in some places as long irregular shapes that follow natural contours of land. The shifting fields are located on the slopes between the lowland and the forest. Each family slashes at least one plot every year, and keeps it under cultivation for 3 to 4 years. Therefore, on the same year, each family manages 3 to 4 plots in different locations before leaving them for fallow, while these locations will change from one year to the others.



4.3.3 Characterization of the Major Cropping Systems in the Study Area

The major cropping systems in study area are shifting cultivation, paddy rice, and cash crops. The technical operations are mostly done by hand, using a limited number of traditional tools working by hands, with the exception of the hand tractor which is used for the land preparation of paddy rice and cassava fields and, more recently a sowing machine for peanut and soybean cultivation.

Before analysing the outputs of the main cropping systems, it is of prime importance to understand their organization and, consequently, identify the main constraints that their implementation meets. The cropping calendar is one way to highlight the succession of works that have to be organized for each system at each particular period or months as shown in The cropping calendars of these systems (Figure 3-4) highlighting the major operations of technical itinerary such as land preparation, nursery preparation (rain-fed rice), transplanting, weeding, fertilization, pest management, and harvesting.



4.3.3.1 Shifting *Chamkar*

Shifting or swiddens have been described as “[a] natural forest... transformed into a harvestable forest (Gibson, 2000).” Pieces of the forest are slashed-and-burned to prepare the land (Gupta and O’Toole, 1986). In the mountainous areas of Southeast Asia, upland rice, associated to a few other annual crops is generally cultivated. The cleared fields are cultivated and harvested for one or more years, and then left to fallow for varying periods to allow

secondary forest regrow (Fox, 2000) before a new cycle of clearing and cultivation can start. In Asia vast areas considered primary or virgin forest can actually correspond to really late secondary forests on land previously cleared for shifting (Fox, 2000).

Indeed, shifting or slash-and-burn systems were particularly common in Cambodia in the province of Monduliri and Ratanakiri up to the 2000s, although they may also have been encountered locally in other provinces surrounding the Mekong central plain. Technically, the system is broadly similar for all the indigenous communities, whereas the length of time the land is left fallow, the number of plots of lands their size and the location of the boundaries in relation to the villages may nevertheless vary (Pillot *et al.*, 2000).

In the archetypical shifting cultivation systems of Monduliri, several associated crops are grown in the same plot at the same time. Often maize, vegetables, legumes, root crops, and other food crops are cultivated along with paddy rice in the shifting field. The cultivation cycle starts by clearing the land during the dry season. The biggest trees are left in place while their branches are cut, then gathered together with the wood products of the clearing. After several weeks of drying, at the end of the dry season, from middle of February up to May (Figure 4-5), these plants are burnt.

Due to the importance of the biomass to clear, slashing and burning on the first year takes much more time than just the clearing on the following years. After the first rains, the plot is sown with upland rice (often a glutinous variety), generally associated to a diversity of vegetables at low density. Would the burning have been sufficient to get rid of the seeds from the wild species present in the soil, there is not much weeding to be done on the first year. By November, the harvest can take place; it takes only one or half day.

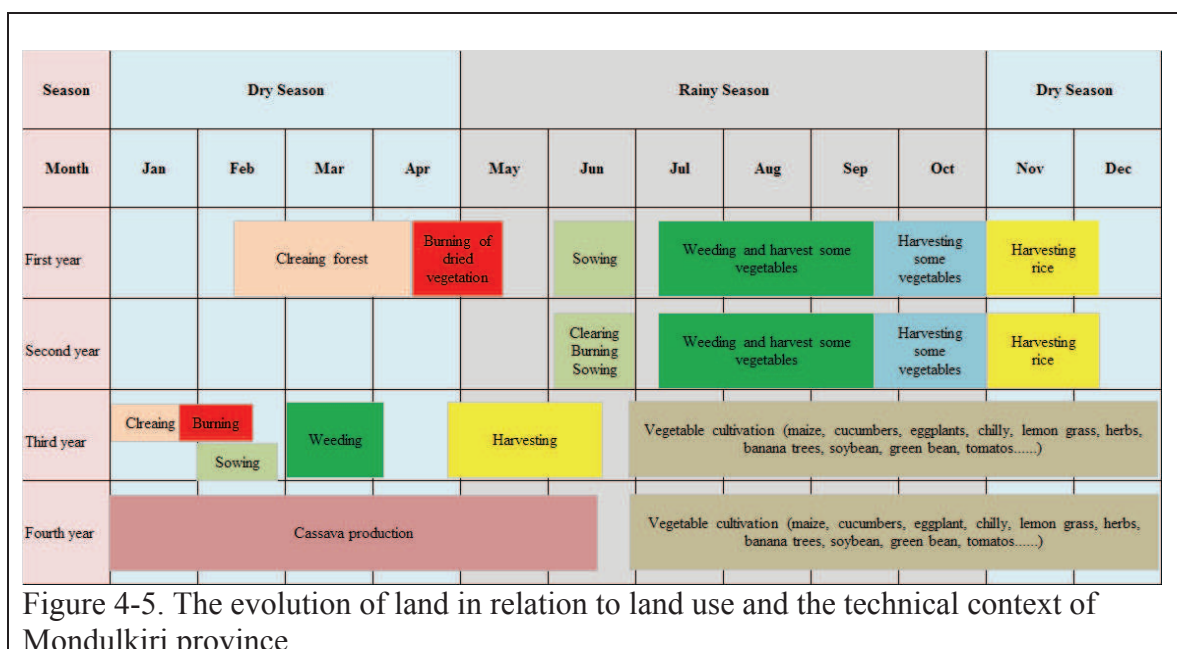
On the second year, farmers still grow upland rice but the burning is too little to get rid of the various weed seeds that were displayed on the plot during the previous year. The weeding time becomes much more important, however, people still mostly use their own family labor for this activity.

On the third year, upland rice is generally not sown any longer. Only vegetables, easier to weed, are cultivated then. After they found the soil fertility was low, they left the field for fallow but they still could collect some vegetables and other NTFPs.

On the fourth year, it is now common that people plant cassava, which is the most adapted crop for low fertility soil and high weed pressure. This fourth year is a recent innovation: it

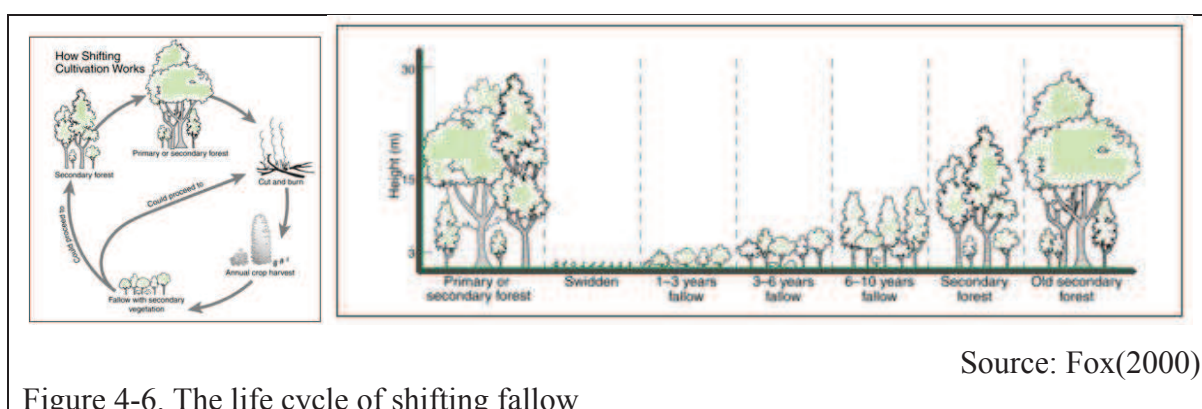
responds to the need of intensification following the reduction of the land available per family, and it includes cash crops in the system.

When farming operations are completed, the plot is left for fallow, although some products (e.g. fruits, bananas, cassava, etc.) may still be harvested from the fallow fields.



Upland rice yields on shifting plots range from 1.6 to 2 tons per hectare on the first year. The yield however drops quickly the following years, until it is left as fallow for regeneration of the soil fertility.

Indigenous farmers manage the system in ways that integrate production from both cultivated fields and secondary forests of diverse ages, including everything from grass and bushes in its early stages, to young open-canopy trees, to mature closed-canopy tree communities (Figure 4-6).



4.3.3.2 Rainfed Lowland Rice-Based Systems (wet-season rice)

Rainfed lowland rice-based cropping systems include the agriculture in practice on alluvial terraces flooded exclusively by rainfall during the wet season. This type of system is found in all the colluvial-alluvial plains of the wide Mekong Valley and the Tonle Sap Great Lake area. Medium-and short-duration rice are generally grown on the lighter textured soils occurring on the medium and upper fields, while the late-duration varieties are more often cultivated in the lower fields (Nesbitt, 1997).

The key activity in these systems centres on monsoon. It starts by land and nursery preparation; when the rain arrives. In middle of May and June, transplantation can start, the lowest places –the first to be permanently flooded- being transplanted first. Weeding is always an important cost in labor. Some farmers also apply fertilizer and insecticide in between August and September. The paddy rice harvests take place in late October until November, before collecting the shifting rice. In Mondulkiri, most of the works are manually done by hands, except land preparation for which hand tractors can be hired. Yields range from 1.5 to 2.5 tons per hectare.

4.3.3.3 Cassava

In Mondulkiri, cassava increasingly replaces crops which require higher soil fertility and more production labor. Cassava is preferentially grown in distant fields, nearby the forest area and the fields that are reserved for shifting cultivation. The season starts by land preparation from December to January, after having completely finished the paddy rice harvests. Weeding is carried out in a whole month of March and early April; its quality has a major impact on the final yield. No fertilisation is applied, neither organic nor chemical. Cassava can be harvested from 9-12 months after planting. The harvest season is splits on several months, due to the need to chop and dry the cassava products manually.

Fallows sometimes break the succession of cassava mono-cropping systems depending on soil fertility, pests and diseases, and also on market and demographic pressure. In fact, the Phnong farmers often maintain some short fallows; in contrast, Khmer migrants plant cassava without any fallow.

Available local varieties attain the maximum yield in the first or the second year. The average cassava yield was from 6 to 15 tons per hectare in the study area, where the soil

are still fertile. However, in the areas where cassava has been grown continuously with little or no fertilizer for many years, crop yields are rather lower.

4.3.4 Economic Performances of Cropping Systems

The economic valuation of a cropping system results in determining value-added by the farmer with this cropping system, and to relate this result to the quantity of production factors (e.g. land, capital and labor) that were mobilised in the production process. Even though this is not the only reason that can govern the decision that one specific stakeholder can take, farmers are often concerned about input costs and returns of cropping systems to decide on the choice of their system. In this analysis, the two main indicators that were mainly used to compare cropping systems have been the land and the labor productivities.

Table 4-2. Economic performances of cropping systems

Item	Shifting <i>chamkar</i>	Cassava	Paddy rice
Total land size (ha)	53.58	161.56	30.68
Total gross output-GO (USD)	19,787	129,470	13,006
Total intermediate cost-IC (USD)	1,155	4,609	4,900
Seed (USD)	1,155	4,609	1,088
Tractor (USD)	-	-	3,811
Fertilizer (USD)	-	-	-
Herbicide (USD)	-	-	-
Insecticide (USD)	-	-	-
Total labor cost-LC (USD)	60,750	131,680	32,100
Land preparation (USD)	26,105	32,845	215
Planting (USD)	7,290	14,500	3,530
Weeding (USD)	14,920	28,540	12,305
Harvest (USD)	12,435	55,795	16,050
Total number of labor (mnd)	12,150	26,336	6,420
GVA(GO-IC)	18,632	124,862	8,107
Land productivity (USD/ha)	348	773	264
Labor productivity (USD/mnd)	1.53	4.74	1.26
Intermediate cost-IC (USD/ha)	21.56	28.53	159.70
Labor cost-LC (USD/ha)	1,133.77	815.06	1,046.28
Required labor (man-day/ha)	227	163	209
Required family labor (man-day/ha)	227	123	209
Cash advance per ha	22	229	160
Net income (USD/ha)	(786.04)	(42.20)	(3.74)

As shown in Table 4-2, cassava monoculture is currently the system that brings the highest value-added per unit of land, and also the highest labor productivity: USD 773/ha and USD

4.74/man-day, respectively. This is also a system that the most requiring in cash advance (USD 229/ha), when we consider together the hired labor and the intermediate costs.

In comparison, the land productivity of the cassava system is twice the one of the shifting system and three times more than the productivity of the paddy fields. This high return explains why Khmer immigrants, when they arrive with financial capacities to provide the cash advance needed by these systems, are so generally cultivating this crop. This said, such an important return is highly fragile for at least two reasons:

- The first one is that there is no reason why the yields of cassava should be sustainable on the long term. Cassava is cultivated on deep and rich soils, for less than ten years, and still without fertilisers. Obviously, it is still benefiting from the high level of residual fertility of the deep ox soils formerly covered by the forests. Such a stock is high, but it is limited: time is probably close to the moment when the cassava yields are going to seriously decrease without fertilizers or which leads to the same economic result when the costs of production will have to increase to cover growing needs of chemical fertilization⁴.
- The second reason is that salaries represent the main share of the costs of production (USD 200/ha on a total of 229). Even though the land productivity is high, the net income corresponding to cassava is low, and it is very sensible to the price of the labor. As this latter has shown in the past ten years, a trend of rapid increase, the scenario of another sharp increase of the labor cost, up to doubling again, may still be possible. In such a case, the profitability of these systems would certainly drop down at a level that would probably mean their collapse, unless mechanisation innovations would allow to strongly reducing the labor required.
- Another way of looking at the same issue is to note that the current labor productivity of the cassava systems is at USD 4.74/day (Figure 4-7), which is actually slightly below the cost of the salaries (USD 5/day). In other words, farmers who use only paid labor to produce cassava lose money, or the crop is only profitable when they accept, for their own family labor, an income that is already below the level of the wages. This is still acceptable for the time being since the opportunity costs of the family labor is much lower than its market price, but this situation will not stand long if the demand for paid

⁴ On similar types of soils in the province of Kampong Cham, which had been deforested for 10 to 15 years, permanent cultivation of cassava leads to a yield decrease of 40 percent after five years (Boulakia *et al.* 2012).

labor further increases. This could happen if the extension of the rubber estates recently planted by a number of companies leads to a major additional call for manpower.

As we mentioned above, for the time being, the economic results of the cassava systems well explain why the Khmer immigrants quasi exclusively cultivate this crop when they have the financial resources to do it. The situation of the Phnong households is quite different since they have more easily access to labor exchanges within their group. Compared to cassava, shifting cultivation requires even more labor per hectare, but these requirements are much simply covered by family labor or by the mobilisation of solidarity links within the social groups.⁵

In such conditions, shifting systems are also interesting since they do not require much cash advances (in the case of Phnong farmers) while they offer a land productivity that is still higher than the paddy permanent cultivation. This, added to the fact that they do not need cash advance, explains why these systems are resisting though their economic output looks much lower than the ones of cassava.

This said, since the labor productivity of the shifting is at USD 1.5/day when the salaries offered in cassava or rubber plantations stand at USD 5/day, the future of these systems is also threatened. Obviously, for the Phnong farmers, the alternative is not so much between shifting cultivation and cassava plantations, but rather between working on their own shifting plots and selling their labor in cassava or rubber plantations. The future of the labor market will make the future of the shifting systems.

Finally, both the labor productivity and the land productivity are the lowest for the paddy rice cultivation. The labor productivity of the lowland paddy is only one fourth of what is the cassava labor productivity. This explains that these systems have historically always been very limited, and why the Khmer immigrants are so reluctant to go for paddy rice cultivation, whereas, coming from the central Cambodia –the rice bowl of the country– they have the know-how and the cultural background that should encourage them to do so. Indeed, maintaining a lowland paddy rice production in these conditions is linked to the cultural value that the Phnong give to producing their own rice, far beyond the market economic value of the commodity.

⁵ All 227 days required for one hectare of shifting cultivation are met with family or exchange labor, while in the case of cassava 25 percent of the 163 days required per hectare are paid labor.

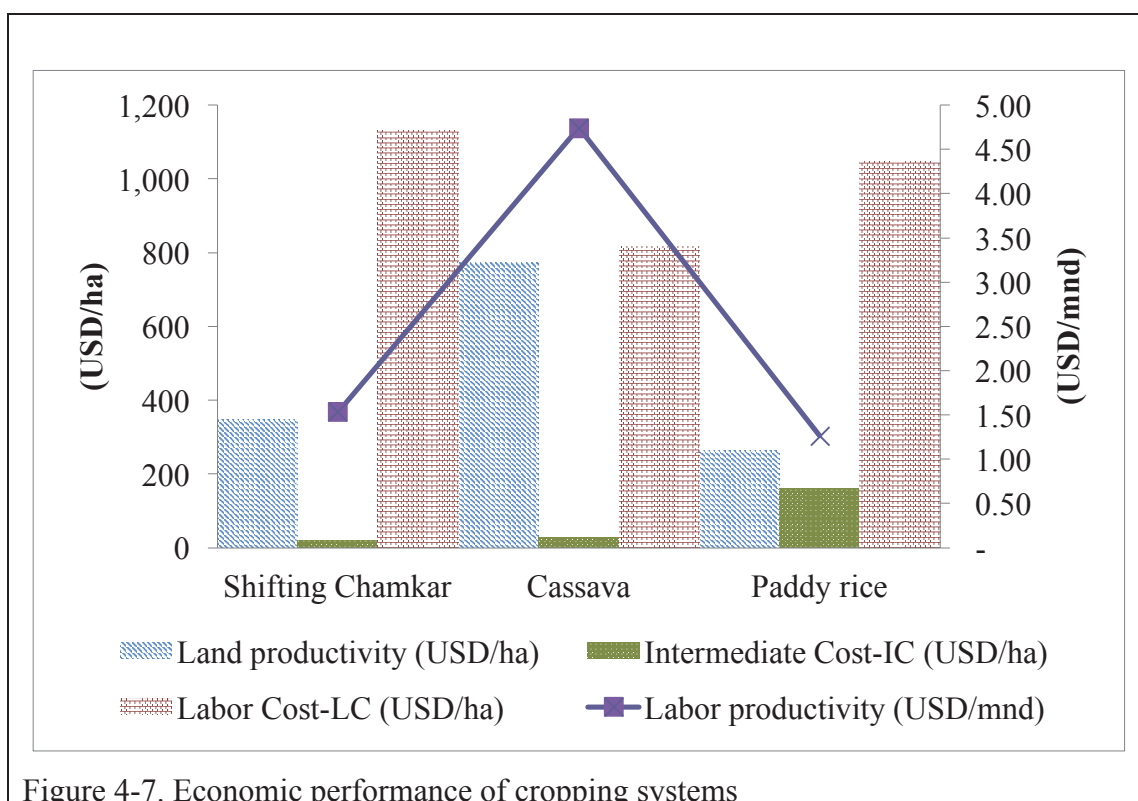


Figure 4-7. Economic performance of cropping systems

4.3.5 Economic Strategies and Their Results: Classification of Farming Systems

Investigating on the economic performances of the cropping systems is often used to model the possible future of agricultural production and land use. When the production is undertaken by family farms, the producers generally combine several of these cropping systems into coherent farming systems. The results of the combination being more than the sum of the parts, the economic results of the cropping systems therefore can only partially explain the choices of the producers. Due to the different accesses to land that the households may have, also due to the historical background of the families and their livelihoods, to the social networks on which they are embedded, local producers may organize different strategies and combinations, each of them having its own economic impact and its individual sensibility to changes in the environment and finally each of them having its own potential for future changes. Looking at this diversity, and classifying it, may lead to identify the strategies in expansion or, on the contrary, those which are regressing.

4.3.5.1 The Current Differentiation in the Land Access

Data from our field surveys revealed a clear distinction in the access that each household can have to land. This access is obviously a result of the history, marked by the traditional control of the Phnong people on land resources, put at stake by the extension of large concessions by the state and by at least two waves of colonisation by immigrants settling down as local

farmers. However, all agricultural lands fundamentally belong to the state, though the possession rights mix private access, which is individual and can be exchanged, and collective access, a legal status developed in the 2000 to pay respect to the traditional rights of the minorities (Yoeu *et al.*, 2016). Nevertheless, even in the cases –still rare- where a collective land titles is awarded, the beneficiaries share the property among themselves, thus recognizing *de facto* to each member of the group an individual access to a part of the collective property. Therefore, including in this case, it is easy to calculate, for each household, as well identified amount of land that this household is cultivating.

There were three types of land use that were defined on the study site: settlement, permanent cultivation and shifting cultivation. Majority of the sample respondents have the land for housing (settlement). Nearly half of sample respondents have the land for permanent cultivation (agricultural land use) whereas 41 percent have land for shifting cultivation, but they are not the same. In the study sample, only one percent of the respondents used to lease out the land, which 11 percent of rent some land. They rent the land from people who are not permanently resident there and keep the land uncultivated.

Two groups have been distinguished among the households interviewed, according to their ethnic origin (Khmer and Phnong), which also corresponds to two opposed positions in the historical development of the access to land. The land access of the two groups for permanent and shifting cultivation is shown in Table 4-3.

The Khmer group cultivates a mean area of 1.24 ha in permanent cultivation, which is twice more than what the Phnongs do (0.58 ha). On the contrary, the average land size for shifting cultivation was 0.22 ha for the Khmer and 1.74 ha for the Phnong group, respectively (Table 3-3). The difference was statistically significant at one percent level. The Phnong group has bigger land size for shifting cultivation than the Khmer. The difference of average land size for farming was significant at five percent level.

Table 4-3. Comparison type of land access of the sample respondents

Land size	Khmer group		Phnong group		Difference (3=1-2)
	Mean (1)	St.dev.	Mean (2)	St.dev.	
Land size of permanent cultivation (ha)	1.24	1.76	0.58	1.17	0.66***
Land size of shifting cultivation (ha)	0.22	0.46	1.74	2.17	-1.52**

Note: *** and ** refer to significance at 1 percent and 5 percent level, respectively, using the F-test

4.3.5.2 Characterization of Farming Systems (farm types)

Based on the surveys and FGDs, there were six types of farms have been identified. Four types correspond to the Phnong households, which is distinct by their cropping strategies while the remaining two types characterised the Khmer immigrants, resulting from two main historical waves of immigration that have occurred since the 90s (Table 4-4).

Table 4-4. Characteristic of farm strategies with specific activities

Ethnic group	Past activities	Current activities	Type	No. of Respondents
Indigenous People (IP)	1. Shifting 2. Paddy rice 3. NTFPs	1. Cassava 2. Shifting 3. Paddy rice 4. Selling labor 5. NTFPs collector	IP ₁	7
	1. Shifting 2. NTFPs	1. Cassava 2. Shifting 3. Selling labor 4. NTFPs collector	IP ₂	33
	1. Shifting 2. Paddy rice 3. NTFPs	1. Cassava 2. Paddy rice 3. Selling labor 4. NTFPs collector	IP ₃	17
	1. Shifting 2. NTFPs	1. Cassava 2. Selling labor 3. NTFPs collector	IP ₄	27
Migrants (M)	1. Traders 2. Loggers 3. Hunters	1. Cassava 2. Selling labor 3. Trader 4. Logger 5. Hunter	M ₁	22

	1. Traders	1. Cassava 2. Selling labor 3. Rubber and pepper 4. Trader 5. Hunter	M ₂	29
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a. Type I: IP₁

IP₁ gathers the Phnong farmers who still practice some shifting cultivation while they start investing on short-term cash crops (e.g. cassava, soybean) and paddy rice. Households of this group have the maximum number of family members (up to 7), who are currently involved in on-farm and off-farm activities. Cassava is highly favorable cash crops that they are planting after seeing the results obtained by their Khmer neighbours. Average farm size of shifting is 1 to 2 ha (usually several plots and 3-4 year fallows) and paddy rice is 0.5 ha, mostly located in Ou Te outside Pu Radet village. Some shifting plots were sold at low price in the early 2000s either to companies or Khmer immigrants (often to invest in a hand-tractor or other materials). Due to practicing the traditional methods and using local seeds, and tools, they consequently received low outputs or returns. They also sell labor to neighbouring farms, especially for planting and collecting cassava when they already have finished with their own farms. Furthermore, another source of incomes is generated from non-timber forest products (NTFPs) collection from inside and outside the community forest (CF).

For this IP₁ group, the farm strategy clearly targets to diversify the activities in order to valorize an abundant manpower: investments in cash crops while maintaining the traditional slash-and-burn, development of labor intensive activities with low opportunity costs for the household manpower: this group has high capability in labor mobilization and sharing labor among the IPs. However, they have little capital to invest on long-term cash crops and they are not able to borrow money from credit systems since their collateral is little.

b. Type II: IP₂

IP₂ farms have almost the same history of land allocation as IP₁, but they do not have land available for paddy rice cultivation. In this condition, the consumption of the six family members cannot be ensured by the one hectare of shifting land. These farms have to put their investments on market oriented short-term crops and selling labor (Figure 4-8). They are capable for medium to high market integration, particularly investment in cassava.

c. Type III: IP₃

Contrary to the two previous groups, IP3 brings together the Phnong families who have lost their access to shifting cultivation. They consequently intensify their lowland paddy rice production, keep collecting NTFPs. Additionally, they allocate some areas for cassava production and work off-farm (selling labor) whenever they have done and completed their own farm tasks. They tend to work more on short-term cash crops, mainly market oriented crops in the future.

d. Type IV: IP₄

IP₄ households have totally sold their shifting fields to immigrants and only kept some lands for cassava production. Some of them even sold all their lands and currently are forced to borrow from relatives or outside immigrants for growing some cassavas. Nevertheless, the NTFPs collection and off-farm-activity are still the major sources of their incomes.

e. Type V: M₁

M₁ is the first group of Khmers, coming from the first wave of migrations. In the beginning, the main household activities of this group were based on logging, trading, and hunting. Agricultural activities were rare, but food products were rather exchanged with the local IPs. Only several families had small vegetable gardens surrounding the houses with little animal rearing.

Since the end of the 1990, these families largely acquired land. At present, they are planting cassava and still potentially doing trading and logging. They are able to hire the labor for this. They invest on short-term cash crops combined with off-farm and non-farm activities (Figure 4-8).

f. Type VI: M₂

M₂ have arrived with the second wave of immigration from central Cambodia and households of this group did not have the same opportunities to diversify their livelihoods as the M₁ could have. They have however invested as much as they could in agriculture. In the first three years after clearing the forest, the cassava and soybean were chiefly planted. Average farm size is now around 3 ha which are currently occupied by cassava, soybean, and, more and more rubber or pepper commodities.

<p>IP₁: Investment on market integrated crops while maintaining minimum security of food crops</p> <ul style="list-style-type: none"> - Shifting: 0.82 ha (2-3plots); paddy: 0.62ha; cassava: 0.58 ha - Large family members: 7 - High capability in labor mobilization and sharing labor among IPs - Mostly diversifying shifting crop with cassava and intensifying the paddy rice for increasing income - Capital accumulation by focusing on NTFPs collection, and off-farm activity - Medium to high market integration and investment in cassava 	<p>IP₂: Investment on market oriented crops while no access to paddy land to complement</p> <ul style="list-style-type: none"> - Shifting: 1 ha (2-3plots); cassava: 1.16 ha - Large family members: 6 - High capability in labor mobilization and sharing labor among IPs - The need to get some land for cassava for ensuring enough income - Mostly diversifying annual shifting crops with cassava plantation to ensure increasing income as capital accumulation together with NTFPs collection, and off-farm activity - Medium to high market integration and investment in cassava
<p>IP₃: Diversification of resources, minimum rely on market for food provision and minimizing of risks</p> <ul style="list-style-type: none"> - Paddy: 0.8 ha; Cassava: 0.94 ha - Large family members: 6 - High capability in labor mobilization and sharing labor among IPs - Intensification of annual paddy rice and diversification of annual shifting crops to ensure necessary income - Capital accumulation by focusing on farms, NTFPs collection, and off-farm activity - The need to get some land for cassava for ensuring enough income - Low investment in cassava - Low market integration and investment in cassava 	<p>IP₄: Reduced access to land and specialization on off-farm activity combined with cassava</p> <ul style="list-style-type: none"> - Cassava: 0.96 ha - Medium family members: 5 - High capability in mobilization selling labor - Mostly intensifying labor in off-farm activity and collecting NTFPs for ensuring income - The need to get some land for cassava for ensuring enough income
<p>M₁: Investment on short-term cash crops combined with off-farm and non-farm activities</p> <ul style="list-style-type: none"> - Cassava: 1.8 ha - Medium family members: 5 - Medium capability in selling labor - Mostly intensifying labor in off-farm activity and non-farm activity (go when it is profitable) - Moderately market integrated 	<p>M₂: Investment on long-term cash crops combined with non-farm activity</p> <ul style="list-style-type: none"> - Cassava: 1.6 ha, extra land: 3 ha - Small family members: 4 - High financial capital - Low capability in selling labor - Capital accumulation by working on non-farm (daily profitable) and less off-farm activity - Medium investment in rubber, pepper and perennial trees in the future

Figure 4-8. Classification of farm strategies and their characteristics

4.3.5.3 Economic Performances of Farms

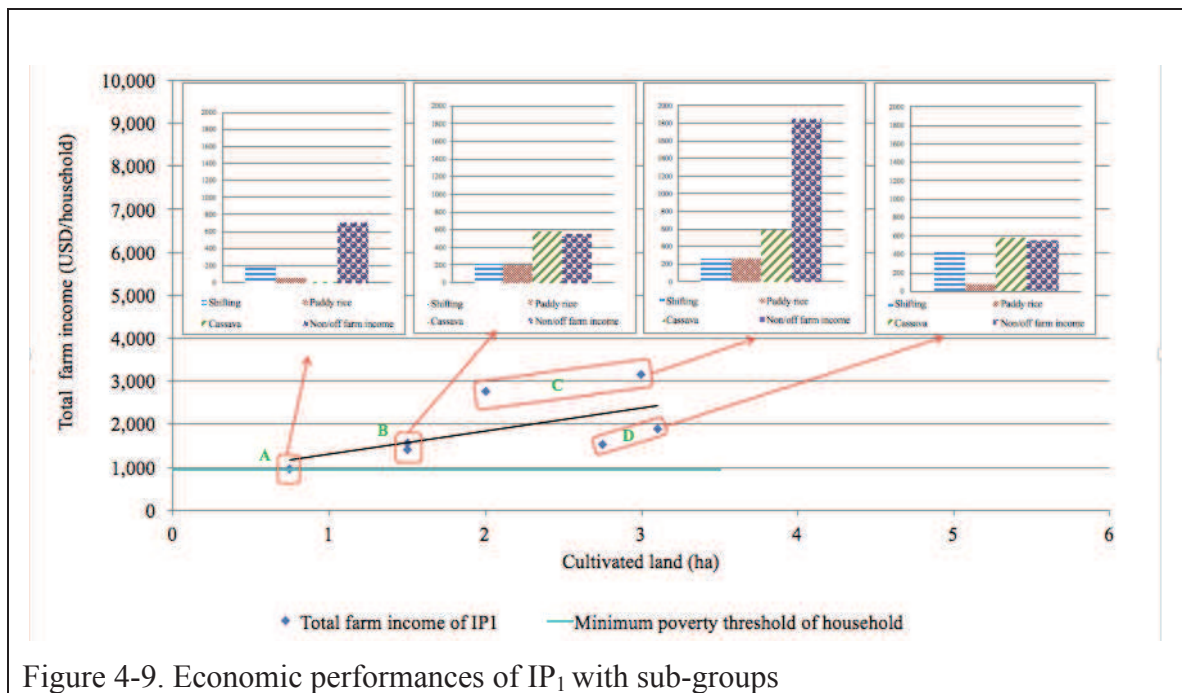
For each of the six types characterised above, we have correlated the total income from the livelihoods (farm, off-farm and non-farm) to the access to land. In a context where the land production factor is now getting rarer and rarer or when land would have to carry other environmental services than the strict provisioning services, this allows to identify who are the types which are now the more sensible to land access. We also compare the total income coming from the livelihoods with a theoretical overall poverty threshold (World Bank, 1997; Gibson, 2000; Kimsun and Bopharath, 2011).⁶ When the families are getting an income which is below this poverty threshold, they are supposed not to cover their basic needs, unless they decapitalize their assets by selling the land or increasing the cultivation cycle, hence not reproducing fertility. In contrast, when they get an income higher than the poverty threshold, they have a surplus for possible capitalization. The minimum poverty threshold was calculated at USD 936/household/year which derives from average size of family members of six multiplying by the cost of consumption per capita of rural people USD 156 /person/year.⁷

a. IP₁: Investment on market integrated crops while maintaining minimum security of food crops (sample of 7 respondents)

Among the seven cases of this type that were investigated, all households obtain a total farm income above the minimum poverty threshold. The total income does increase when more land is available (by USD 539 per each additional hectare). This indicates how much this type has actually diversified its livelihoods and that the solutions brought by each individual farm to combine income generating activities are particularly diverse. Off-farm income contributes in high proportion to the total household income compared to other income sources, especially income from shifting, paddy rice or cassava (Figure 3-9). The result is that this type is not much sensible to land access since it has already performed its diversification.

⁶In 2007, the overall poverty line (food poverty line + non-food allowance) per capita per day was at USD 0.77 in Phnom Penh, USD 0.67 in other urban areas, and USD 0.59 in the rural. The study considers taking overall poverty line per capita per day in 2004 data because it is closely to minimum poverty threshold as current situation of rural people is 1,753Riel/capita/day (USD 0.43).

⁷Therefore, to reach the poverty threshold, the households would need USD 156/person/year for expenditure (USD 0.43/day).

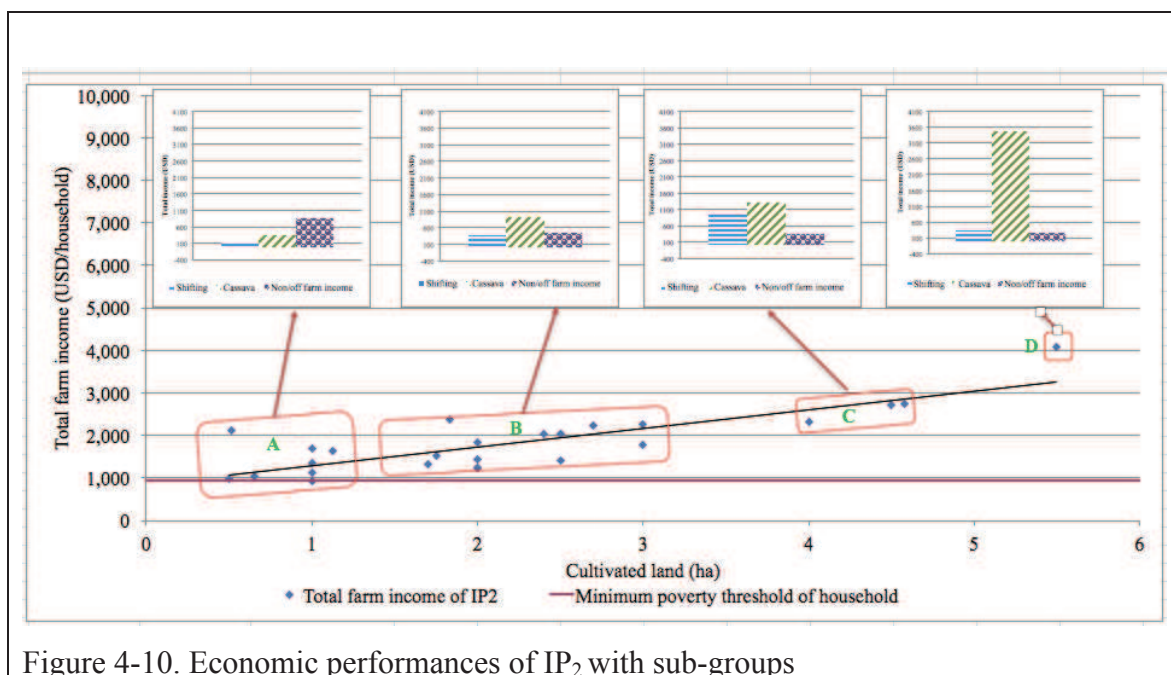


Within IP₁, several subgroups can be identified (Figure 3-9). With less than 1 ha, A is close to the minimum poverty threshold and it can hardly survive since its agricultural capacity is very low, especially the income from cassava. For B, C, and D the share of income from cassava is the same (USD 580 for an average land at 0.75 ha) while the non-agricultural income (off-farm and NTFPs) are the highest for category C (USD 2,170). To conclude, the IP₁ correspond to the type that preserves the most shifting cultivation. However, it is not well represented and, even when the access to land is essential, the income remains low and the capacity to invest in new activities is still limited. The resistance of the shifting cultivation in this group seems mostly due to the lack of financial resources that moving to cassava would require. This said, if the pressure from the market still remains in favor of cassava expansion or if the land market rises even more, it can be highly expected these farmers will not resist very long, will continue to sell a part of their belongings, leading to abandon the shifting cultivation for cassava and moving to type IP₃.

b. IP₂: Investment on market oriented crops while no access to paddy land to complement (sample of 33 respondents)

For this second type, the results are close to those of the IP₁. This group is less diversified towards off-farm and non-farm activities than the previous one; therefore it is more dependent on the land access. When the land access rises –from subgroup A to subgroup B-, the income from cassava increases more than proportionally (Figure 4-10). This confirms that the strategy of investment is here concentrated on market crops, which results are highly linked with the

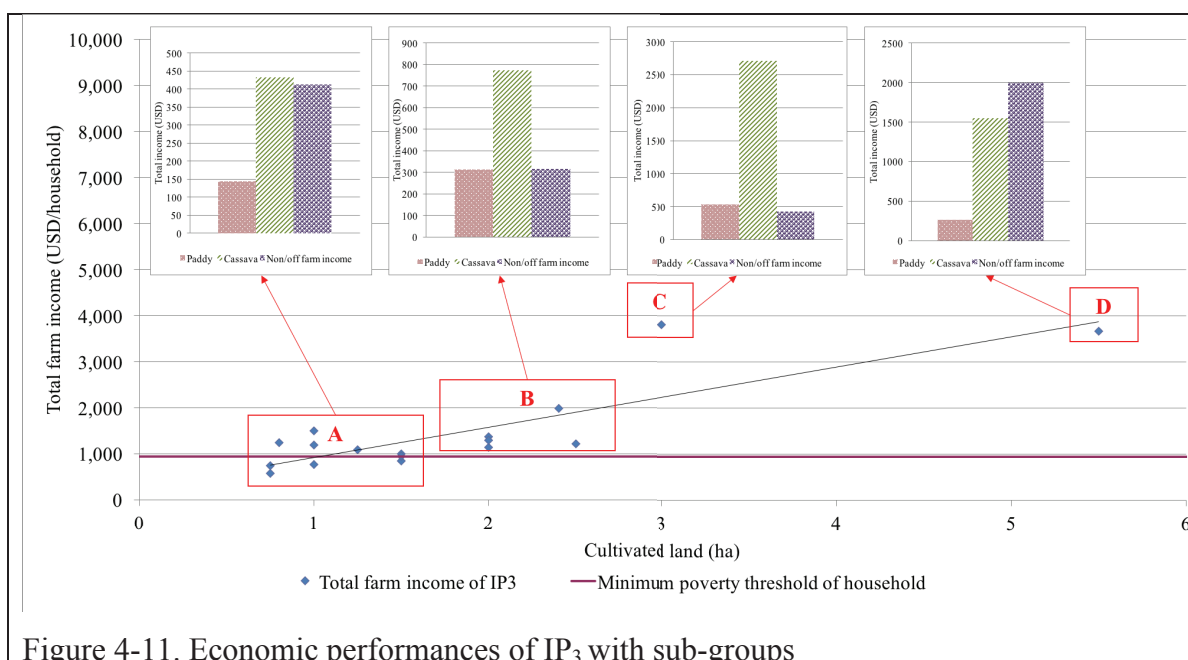
surface cultivated. The highest average farm income is for sub-group D which, with an average land of 5.5 ha, can get a four times of the minimum threshold income (USD 4,076).



Compared to the IP₁, IP₂ farms have a little higher capacity to invest, especially those with more than 4 ha (subgroups C and D). They represent the second group that maintains shifting systems, and since they have enough land, they can keep it for a while. However, they are already quite involved in market oriented systems, and therefore, sensible to the incitation from the market, especially from the cassava value chain.

c. IP₃: Diversification of resources, minimum rely on market for food provision and minimizing of risks (sample of 17 respondents)

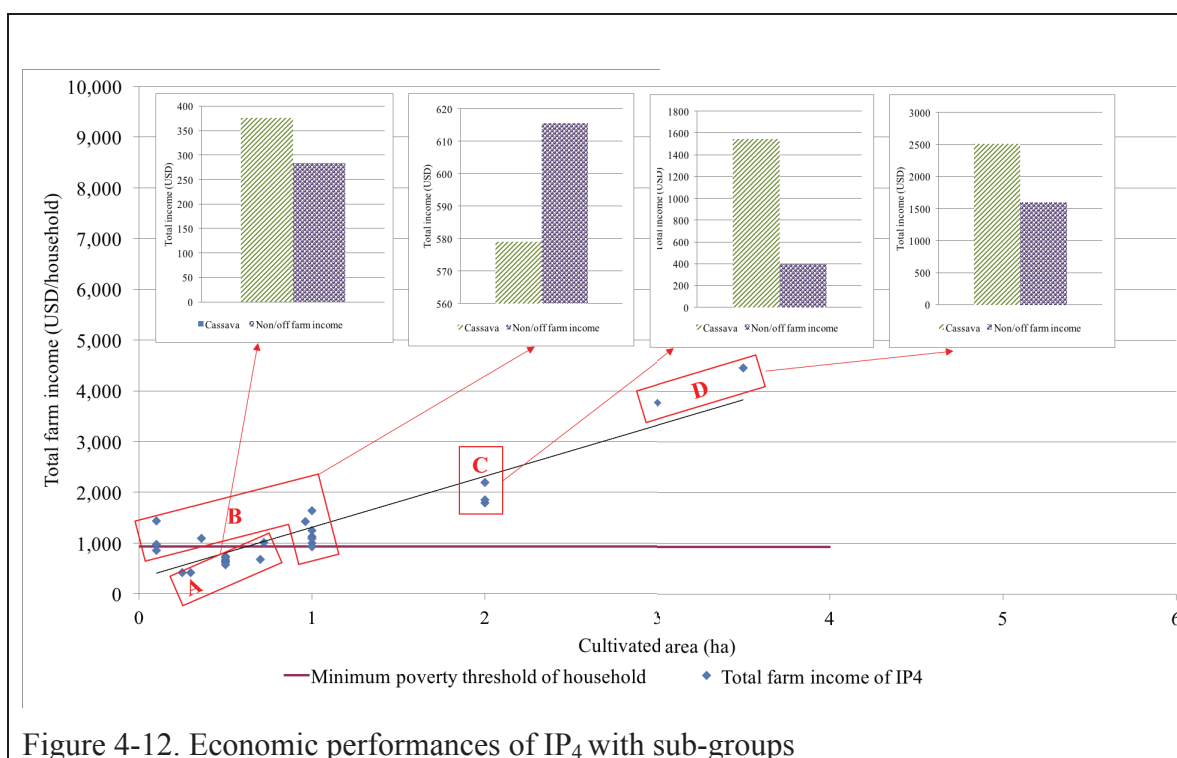
The total farm income of the IP₃ is constituted by three main activities, i.e. paddy rice, cassava and non-farm or off-farm activities. Since there is no income from traditional shifting systems in this group, the cassava income remains the most important share in the total household income (average of USD 1,364), for all farms, whatever important is their access to land. It accounts for 55 percent while non/off-farm activities stand at only 32 percent and paddy rice at 13 percent (Figure 3-11).



In such a system, most households with less than one hectare do not meet the poverty threshold. Specifically, sub-group A, with a land average of 0.56 ha of cassava and 0.55 ha of paddy rice, offers very low farm incomes with USD 143, USD 432, and USD 413, of paddy rice, cassava, and non-farm or off-farm income, respectively. The total farm income of sub-group B is still dependent on cassava at 50 percent, but the other sources (off-farm and paddy rice) are equal.

d. IP₄: Reduced access to land and specialization on off-farm activity combined cassava (sample of 27 respondents)

With a limited access to land, IP₄ farmers beneficieate from an income hardly equal to the poverty threshold (half of the farms of the sample do not meet this level). Its main components are based on cassava and non-farm or off-farm activities. This confirms that when the access to the land is low, the income is narrowly correlated to the land access. In other words, farmers have the capacity to properly develop any additional land (Figure 4-12).



Sub-group A, with less than 0.5 ha of land, is definitely unable to meet the poverty threshold; the average household income is USD 659, comprised of 57 percent of cassava. Sub-group B with an access slightly higher (0.26 ha difference) has higher household income (USD 1,194 including 52 percent from non- or off-farm activities). With more cassava, sub-groups C and D maintain high farm income, USD 1,942 and USD 4,114, respectively, with less need for non-farm or off-farm activities.

e. M₁: Investment on short-term cash crops combined with off-farm and non-farm activities (sample of 22 respondents)

With 1.76 ha on average cultivated in cassava, households of the M₁ type are clearly above the poverty line. The average farm income is at USD 2,662, equally shared between the cassava and of the non- or off-farm activities (Figure 4-13). This illustrates the diversity of economic results that the farms can get from cassava, according to the share of the labor that is contracted to external workers. Also the diversity of the non-farm and off-farm activities of this group contributes to non-linear incomes. However, being moderately invested in agriculture, this group is not the most sensible to the market conditions.

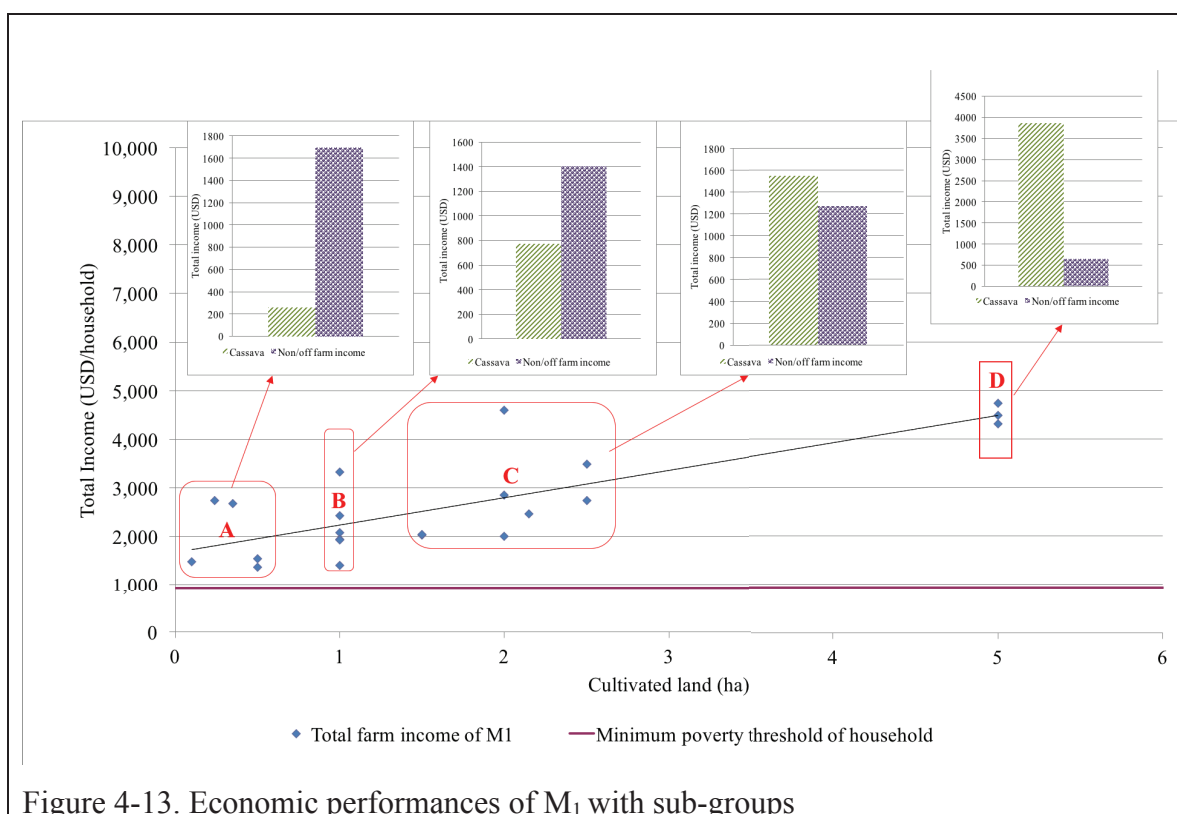


Figure 4-13. Economic performances of M₁ with sub-groups

Comparing the sub-groups, the highest farm income (USD 4,510) returns to sub-group D for which cassava covers 86 percent of the 5 ha cultivated. On its side, sub-group A, with only 0.34 ha of cultivated land, presents a moderate income of USD 1,956 (97 percent of which is non- or off-farm income). The proportion of cassava in the income regularly increases when the land access improves.

**f. M₂: Investment on long-term cash crops combined with non-farm activity
(sample of 29 respondents)**

Although farmers from the M₂ groups arrived more recently, their economy is already diversified, since non-farm activities offer more than 50 percent of the income when the total land is less than 3 ha, and slightly less over 3 ha (Figure 4-14). In this latter case, the type corresponds to farms strongly specialised on cassava, using largely external labor, and thus being major actors to encourage further immigration. They are the agricultural leaders, often the innovators, or the ones ready to test the new equipment that can allow maintaining paid labor and increasing productivity.

With an average farm income at USD 2,635, the sub-groups C and D are also those who can invest in perennial crops, like rubber and pepper, to diversify from the only cassava.

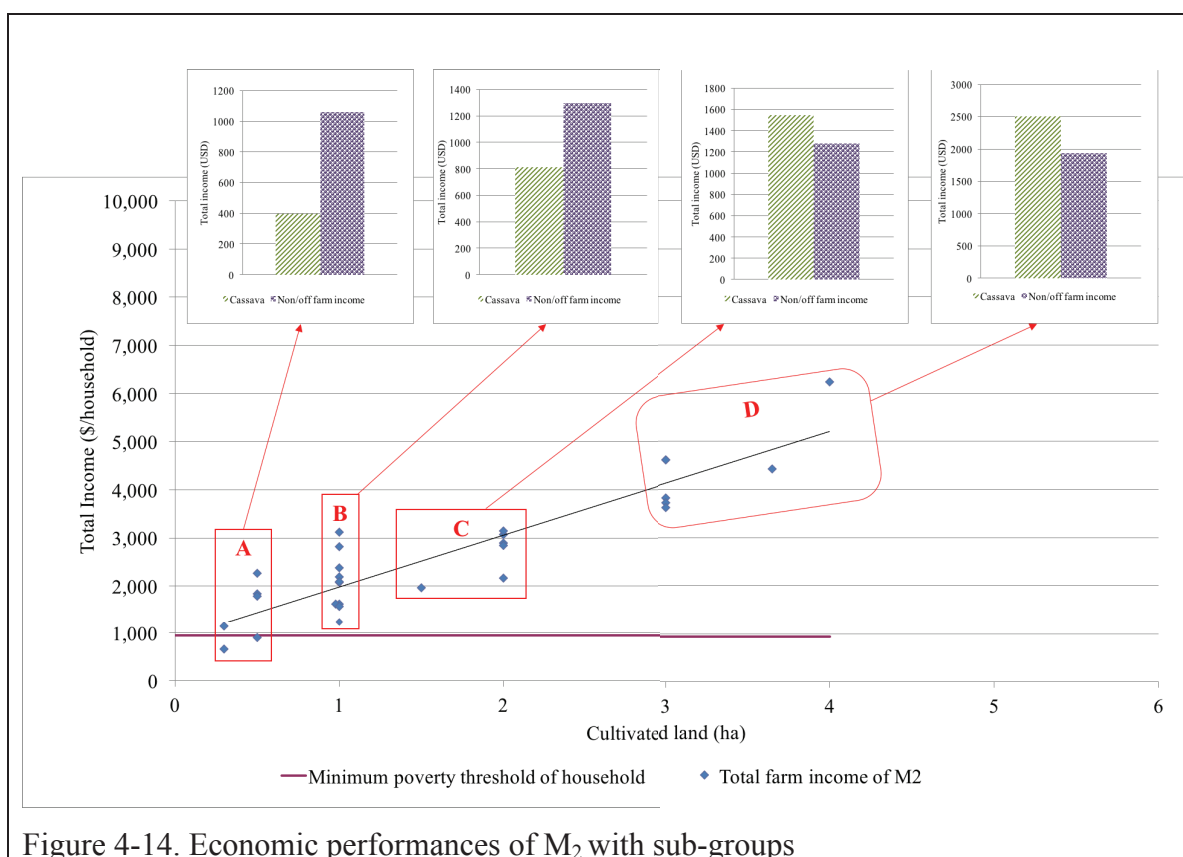


Figure 4-14. Economic performances of M₂ with sub-groups

4.4 CONCLUSION

The dynamics of change in the land use and farming systems of Cambodia's upland eastern border are indeed highly linked with the demographics of the province. The two successive waves of Khmer immigration since the 90s have led to a total reorganization of the agrarian system which was originally based on shifting cultivation. A number of the plots previously cultivated with the shifting system have been sold to the new immigrants, leading to an equivalent reduction of the land cultivated by the local population. In front of this situation, the indigenous households seem to have little extended their lands in the forest itself. They rather diversified their activities, selling more and more labor in the cassava farms developed by the immigrants. Thanks to the high price of the commodity, the agricultural wages on the labor market have raised at three times the opportunity costs -as measured by the labor productivity in the shifting systems.

In the meantime, the sharp decrease of the land available for shifting cultivation has led to an acceleration of the cultivation cycles, then to partial abandon of the traditional system in two of the four types of farming systems currently operated by the IPs.

The extension of permanent farming now displays a contrasted picture. The traditional shifting system is replaced by two different permanent cultivation systems. First, the permanent paddy rice cultivation offers a lower productivity than the former slash-and-burn systems. It can therefore be analyzed as a Malthusian adaptation to meet the needs of intensification, led by the reduction of the access to land, when, at the same moment, the paddy rice production has to increase to feed the growing population. However, it can also be seen as a resistance from the Phnong society that gives to the local production of paddy rice, a value that goes far beyond its market price. On the contrary, the Khmer immigrants, who are not sensible to these values, largely ignore the paddy rice production.

The second alternative to the shifting cultivation, the cassava mono-cropping, presents a much higher land and labor productivities than its predecessor. In this sense, it does not correspond to a Malthusian adaptation but to a real innovation that multiplies the change and generates encouragements to new additional migrations. The innovation looks robust, with a continuous increase of the acreage and of the number of farmers since the mid-2005.

The cassava extension has therefore been the engine that has attracted the Khmer immigration in the province and pulled the indigenous population out of the shifting cultivation, directly (through the land exchanges) and indirectly (by generating a call for manpower). However, a close analysis of the success of the cassava systems showed that they might not be so definitively successful in the long run. The price of the cassava, partly linked with the biofuel industry, can be dropped down. Even more expected is the decrease of the yields, sooner or later, but unavoidable, compromising the labor productivity which is already slightly below the labor market cost. Finally, the cost of the labor itself can still get higher, following the demand in other sectors especially the rubber plantations that are currently coming into production. The productivity of the crop could strongly be declined or even led to zero by any of the three events above, and even more by a combination of the three of them.

In such an uncertain context, looking at the strategy of the rural stakeholders may help to better understand the dynamics and to foresee the possible future trends. The first conclusion at this level is that even without shifting agriculture; farmers have already managed to reorganize a diversity of income which represents a certain protection against the possible events in the economic environment. The second conclusion is that the remaining places left to shifting cultivation are highly at stake. Only two of the six farming system types still include shifting cultivation. Among them only the subgroups of those who have more than 4

ha to cultivate (representing less than 20 percent of these types) appear to be in position to maintain sustainably shifting cultivation.

However, a possible failure of the cassava in the future, either by a fall of the market or by the full consumption of the fertility rent, would certainly lead to a renewed interest for the shifting systems. This may bring about to new land transformations: the lands having previously carried these systems have been sold and would have lost their fertility, thus becoming unable to bring again the same kind of cultivation; there would be then no other way out than accepting a certain level of shifting in the large areas remaining covered by forests still now.

Provided the strict condition that the duration of the fallow is sufficient, the system may be ecologically sustainable. This calls to pay a close attention to the public policies, especially the allocation of land rights which can take into consideration, in the future, both the necessary preservation of forest and a moderate exploitation under strict conditions.

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Annexe of Chapter 4

Table A 4-1. Economic performances of farm strategies of IP₁ (average value)

IP ₁	Shifting <i>chamkar</i>		Paddy rice		Cassava		Non- /off- farm income	Total land	Total income
	Land size (ha)	GVA (USD)	Land size (ha)	GVA (USD)	Land size (ha)	GVA (USD)	(USD)	(ha)	(USD)
A	0.5	174	0.23	60.72	0.016	12.368	702	0.746	949
B	0.5	174	0.5	132	0.5	386.5	1326	1.5	2,019
C	1.375	478.5	0.55	145.2	2.925	2261.02	320	4.85	3,205
D	0.75	261	1	264	2.5	1932.5	1319	4.25	3,777

Table A 4-2. Economic performances of farm strategies of IP₂ (average value)

IP ₂	Shifting <i>chamkar</i>		Cassava		Non- /off- farm income	Total land	Total income
	Land size (ha)	GVA (USD)	Land size (ha)	GVA (USD)	(USD)	(ha)	(USD)
A	0.39	135.39	0.46	861.09	1,351.97	0.85	2,348.46
B	1.07	371.61	1.21	934.78	460.18	2.28	1,766.57
C	2.67	928.00	1.69	1,308.95	358.33	4.36	2,595.28
D	1.00	348.00	4.50	3,478.50	250.00	5.50	4,076.50

Table A 4-3. Economic performances of farm strategies of IP₃ (average value)

IP ₃	Cassava		Paddy rice		Non-/off- farm income	Total land	Total income
	Land size (ha)	GVA (USD)	Land size (ha)	GVA (USD)	(USD)	(ha)	(USD)
A	0.56	432.88	0.55	143.88	413.13	1.11	989.89
B	1.00	773.00	1.18	311.52	315.25	2.18	1,399.77
C	3.50	2,705.50	2.00	528.00	425.00	5.50	3,658.50
D	2.00	1,546.00	1.00	264.00	2,000.00	3.00	3,810.00

Table A 4-4. Economic performances of farm strategies of IP₄ (average value)

IP ₄	Cassava		Non-/off-farm income	Total land	Total income
	Land size (ha)	GVA (USD)	(USD)	(ha)	(USD)
A	0.49	375.96	283.64	0.49	659.60
B	0.75	579.05	615.55	0.75	1,194.59
C	2.00	1,546.00	396.67	2.00	1,942.67
D	3.25	2,512.25	1,602.50	3.25	4,114.75

Table A 4-5. Economic performances of farm strategies of M₁ (average value)

M ₁	Cassava		Non-/off-farm income	Total land	Total income
	Land size (ha)	GVA (USD)	(USD)	(ha)	(USD)
A	0.34	261.27	1,695.00	0.34	1,956.27
B	1.00	773.00	1,406.25	1.00	2,179.25
C	2.00	1,546.00	1,271.07	2.00	2,817.07
D	5.00	3,865.00	645.00	5.00	4,510.00

Table A 4-6. Economic performances of farm strategies of M₂ (average value)

M ₂	Cassava		Non-/off-farm income	Total land	Total income
	Land size (ha)	GVA (USD)	(USD)	(ha)	(USD)
A	0.51	395.33	1,060.71	0.51	1,456.05
B	1.05	811.65	1,295.00	1.05	2,106.65
C	2.00	1,546.00	1,280.00	2.00	2,826.00
D	3.24	2,501.21	1,934.29	3.24	4,435.49

**CHAPTER 5: PROVISION ECOSYSTEM
SERVICES BY LANDSCAPES OF
MONDULKIRI PROVINCE, CAMBODIA**

PROVISION ECOSYSTEM SERVICES BY LANDSCAPES OF MONDULKIRI PROVINCE, CAMBODIA

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ABSTRACT

Natural ecosystems provide a wide range of services to human beings. Provision ecosystem services by landscapes of Mondulkiri province known as less populated with huge natural forest upland Cambodia is attracting attention to emphasize relationships between agriculture and ecosystems, due to rapid land use changes, economic concession policies and economic development. This paper aims at understanding and defining links between ecosystem services (ES) and dis-services EDS) by landscape, and evaluating trade-offs between provisioning services (added-value) and regulating services (carbon sequestration). ES and EDS frameworks combined with agrarian system analysis and diagnosis method were employed to identify ES and EDS provided by crop production systems. Preliminary assessments illustrated that the value of ES to agriculture is enormous and often underappreciated. Agroecosystems also produce a variety of ES, such as regulation of soil and water quality, carbon sequestration, support for biodiversity and cultural services. On the other hand, agriculture can also be the source of DES, including loss of wildlife habitat, nutrient runoff, sedimentation of waterways, greenhouse gas emissions, and pesticide poisoning of humans and non-target species. In terms of farm models, production system that is most efficient economically for farmers and ecological in terms of ES provision, is a system in which farmers combine shifting with cassava. The opportunity cost of conversion from forest to agricultural crops present a particularly high value in rubber and cassava based systems. Current trade-offs between provisioning and regulating ES in the assessed region are not strongly controlled through Cambodian Forest or Land Laws, allowing an active increase of forest conversion for economic land concessions. Furthermore, the changes in policies and different rubber prices have also influenced the relationship between different ES. To maximize the gain from these synergies scenarios, policy and management should aim to promote an agricultural structure that facilitates these synergies in sustainable manners, economic and ecological sounds. The illustration of trade-offs between different ES could be helpful for management schemes for multifunctional landscapes.

Keyword: Ecosystem services, ecosystem dis-services, agroecosystem, trade-offs, farm model

5.1 INTRODUCTION

Trade-off analysis is a significant facet in the assessment studies of ecosystem services (ES)(Carpenter *et al.*, 2009; Mooney *et al.*, 2009), and it is a key issue when integrating ES in landscape planning, management, and decision making (De Groot, Alkemade *et al.* 2010)as well as in the analysis of alternative pathways that lead to future sustainable land use (Rounsevell, Pedrolí *et al.* 2012). Trade-offs between ES emerges in situations in which one service increases at the cost of another ES (Bennett, Peterson *et al.* 2009, Raudsepp-Hearne, Peterson *et al.* 2010). The reverse of trade-offs are synergies, which can be defined as situations in which both services either increase or decrease (Bennett, Peterson *et al.* 2009, Haase, Schwarz *et al.* 2012).

Alternative to Slash-Burn (ASB), researchers summarize the indicators of local, regional and global benefits of a range of land use options in a matrix format, and then analyze the trade-offs and synergies for a range of management options, including different levels of land use intensification (Tomich *et al.*, 1998). Deforestation and establishment of diverse land use systems result in inevitable losses of certain ES of global importance (e.g. biodiversity, carbon stocks, etc.) for local livelihoods and national economic development.

Changes in forest areas in the northern plains of Cambodia from 2002 to 2010 (Rainey, Heng and Evans, 2010) through population growth, logging and deforestation for agricultural purposes have resulted in changes in ES, especially carbon sequestration. Despite the adoption of the new Land Law in 2001, deforestation has increased following the attribution of economic land concessions (ELCs) to private companies for diverse plantations. Therefore, land issues are major threats; a typical of this region like uncertain land ownership and unsecure tenure, or expansion of uncontrolled deforestation of concession areas, followed by environmental degradation and increased erosion of fertile topsoil (Mund, 2011).

However, ES's values have not yet effectively incorporated in actual planning and design processes, although awareness of administrations on these main resources is rising and inventories indicator measuring the performance of ecosystems are emerging (Hayek, Neuenschwander and Grêt-Regamey, 2012). Particularly in the regions where rapid land use changes generate increasingly complex and unsustainable environments, multiple trade-offs have to be made between socio-economic and ecological variables. Therefore, there is therefore a need for new tools supporting better integration of the ES into planning and enabling effective

trade-off decision-making for balancing social, ecological and economic aspects of landscape (De Groot *et al.*, 2010).

Crucially, little is known about trade-offs between ES within various types of land use in Mondulakiri province, especially concerning the consequences of the replacement of forest and long-fallow shifting agricultural systems by permanent agriculture, to provide convincing evidence as to which land cover or land use offers the more valuable services. Given the rapid global trends, land use decisions often affect multiple and competing objectives. Considering uncertainties on carbon stocks and fluxes under potential alternative land uses, it remains unclear how trade-offs among services can be addressed, what are trade-offs in the provision of different ES and are there trade-offs affected by the change in policies, what contexts or policies may help to reduce some of the most undesirable impacts and how possible rational decisions on land use can be made. The challenge on future land use and planning is still a question with regard to change in land use policies (land ownerships) together with power of rubber prices that produce various total ecosystem values of alternative land use types but unclearly defined and estimated. There is also a need for land use projection under proposed scenarios that can be applied for the analysis. This paper aims at analysing the trade-offs in ES of different land uses along several designed scenarios in Mondulakiri province of northeastern Cambodia.

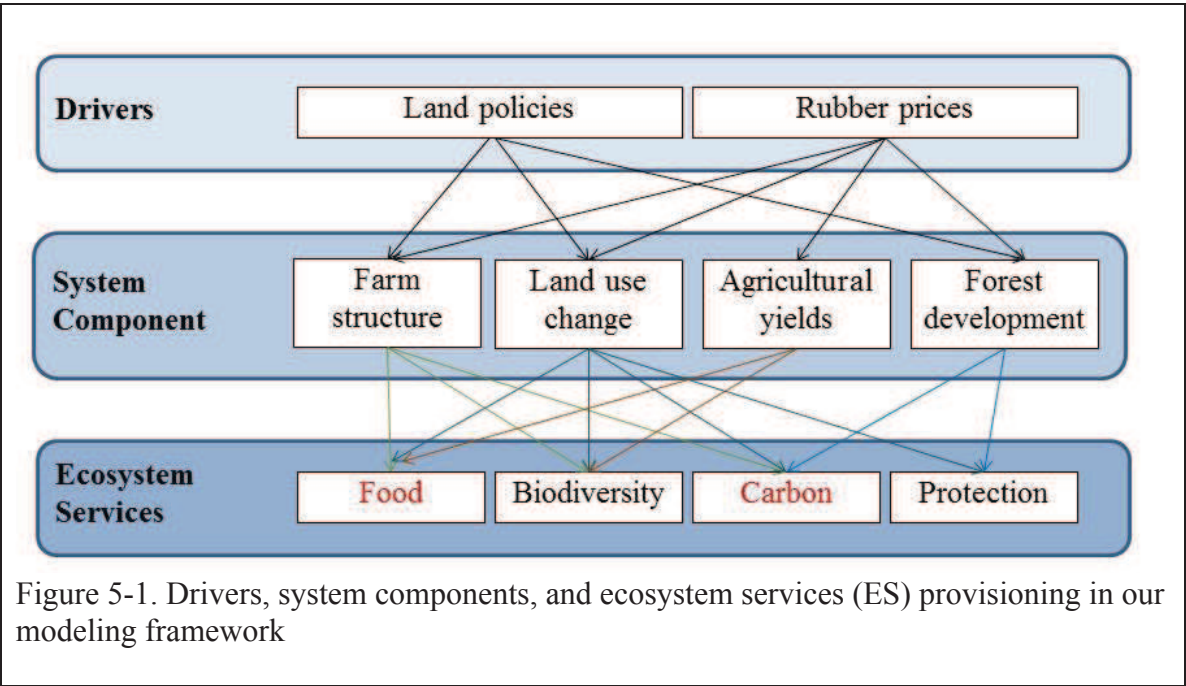
5.2 METHODS

5.2.1 Conceptual Approach

Our conceptual approach is presented in Figure 4-1. We based our analysis on a local change scenario that drives the provision of ES in the upland of Cambodia, Mondulakiri province. The main system components that determine the provision of ES are land use, farm structures, agricultural yields, and forest development. The land policy and the rubber price affect immigration and drive changes in our main system components, which in turn affect ES provision. Economic and biological interdependencies have an indirect effect on the level of ES. Trade-offs, synergies and economic interaction among ES emerge in our modeling framework from changes in common drivers.

The changes in the underlying drivers represented in our scenarios affect the level of the spatially explicit provision of food and trade-offs with biodiversity, carbon sequestration, and protection against natural hazards. Moreover, beyond these singular effects of drivers on trade-offs between ES, there are also interactions among the simulated ES. We used the concept of

ES and benefits to estimate the trade-offs between different ES only in terms of food and carbon provision of landscape (highlighted in red see Figure 5-1) through the calculation of their economic values on a market-based approach.



According to our conceptual framework, the trade-offs are influenced in two ways. First, the land policies and the rubber prices directly drive the four system components in the simulation. Therefore, ES provision also changes during the simulation period, from 2013 to 2033, leading to new trade-offs and synergies at landscape level. Second, economic values may change because of farm structure modifications whereas biological interdependencies between units of ES (per parcel) are fixed in our modeling approach. A sensitivity analysis, i.e., increasing the provisioning of one focal ES in our simulations, reveals the emerging trade-offs and synergies with other ES represented in our modeling framework.

We employed the framework of Zhang *et al.* (2007) in order to define ecosystems and agriculture that are embedded in a complex relationship based on positive and negative interrelations and feedback loops. ES to agriculture affect not only the location and type of farming, but also farmland’s economic value. Ecosystems provide supporting services (e.g. soil structure, soil fertility, nutrient cycling, water provision, etc.), regulating services (e.g. soil retention, pollination, etc.), and dis-services (e.g. pest damage, flood, disaster, etc.). Figure 5-2 illustrates provisioning services and non-marketed services that are the two main outputs of agroecosystems.

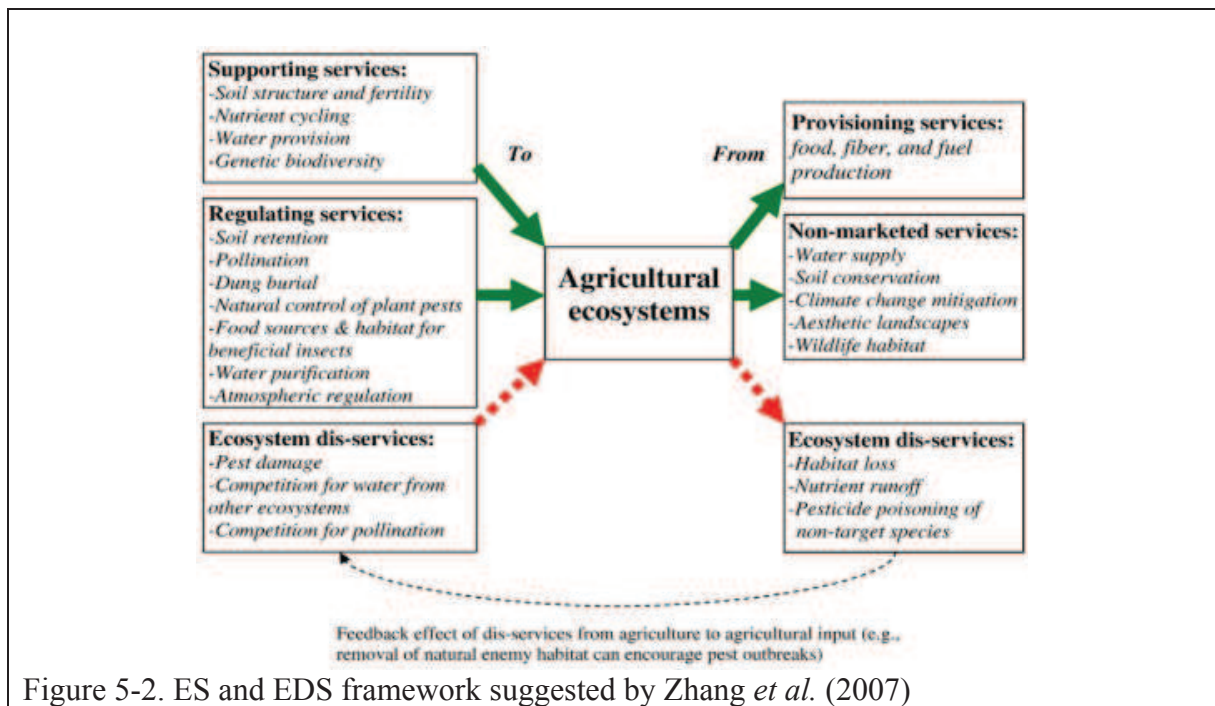


Figure 5-2. ES and EDS framework suggested by Zhang *et al.* (2007)

To define the different flows of ES and EDS, we also adapted field methodology from various studies of agrarian analysis and diagnosis (Cochet and Devienne, 2006; Dufumier, 2006; Cochet, Devienne and Dufumier, 2007; Cochet, 2012). There are three key steps to understand farmers' choices and under socio-econo-political conditions: (i) landscape reading; (ii) historical study; and (iii) production system modeling and performance economic calculation (see Yoeu, Pillot, and Salles 2016).

5.2.2 Modeling Framework

We assessed the components of the total economic value (TEV) of these ES, namely the market value of goods and services, as well as the 'intrinsic' values of biodiversity. In addition, the provision of food (agricultural productions) and carbon sequestration were also calculated to adequately simulate the links between the provisions of different ES. We defined the model with respect to the main drivers of ES change in Table 4-1. Effects of land policies and rubber prices effects on forest development were largely simulated using precise land use change scenarios (Yoeu *et al.* 2016). The economic values of crop productions were calculated as land productivity (added-value).

5.2.2.1 Input Data for Carbon Estimates

This study did not directly conduct any experimental ecological test on the field in Cambodia. All data of carbon stocks for each land use type are taken and adapted from the study of Ziegler *et al.* (2012) that has performed a meta-analysis of over 250 studies reporting above- and below-

ground and soil organic carbon estimates for different land uses. Additionally, Ziegler *et al.* (2012) have particularly provided significant references in terms of total ecosystem carbon (TEC) in various land use in Southeast Asian countries. In the natural forest, the TEC stock is assumed as constant over years when there is no clearance of the forest (Table 5-1).

Table 5-1. Data used for carbon stocks of different land covers with various references

Type of land uses	Adapted from Ziegler <i>et al.</i> , (2012)		Data used for estimation	
	Mean TEC		Mean TEC	Description assumption
	(t C/ha)	(t CO ₂ e/ha)	(t CO ₂ e/ha)	
Forest	428	1,569	1,569	No change from one year to others All forest are supposed to be equally accessible (same NPV)
Rubber	235	860	860	No change from one year to others
Shifting	133	488	488	<5 year fallows and no change from one year to others
Cassava	106	387	387	Only soil organic carbon as permanent field
Paddy rice	106	387	387	Only soil organic carbon as permanent field

Forest: We took mean value of TEC of 1,569 ton CO₂e/ha from Ziegler *et al.* (2012) considering there is no change from one year to others since forest still remains there (no logging in the future). We did not specifically distinguish the forest types since it excessively appears as too complicated, difficult to assess or supported by too limited data. However, the region includes several forest types, ranging from dry lowland dipterocarp forests to moist mountainous forests and wet rainforests, although in many cases, it is hard to know exactly what species encompass the associations due to the lack of standardization of forest nomenclature (Maxwell, 2004; Ziegler *et al.*, 2012).

Rubber: The forest land can be replaced by rubber plantations, which are assumed to keep producing during 25 years. We took the mean value of carbon stock (during the first 20 years), which was 860 tons CO₂e/ha (Ziegler *et al.*, 2012).

Shifting agriculture: The shifting cultivation (with less than 5 years of fallow), which is currently the most common in the study area, is assumed to correspond to “short-fallow swiddening” in the study of Ziegler *et al.* (2012). Since shifting is similar to forest case with fallows, the mean TEC of shifting was taken with 387 ton CO₂e/ha that was also assumed not

to change from shifting field to the end of the fallow. The rotation systems involve moving from plot to plot within the same landscape, with relatively little primary forest affected (Conklin, 1957).

Cassava and paddy rice: These two systems were regarded as “permanent croplands” in Ziegler *et al.* (2012). When forest is converted into permanent agriculture, it is reasonable to assume that biomass carbon stock is zero after clearance of the plots (IPCC, 2006; Pearson *et al.*, 2008). Yet, the soil organic carbon (SOC) is still maintained at around 387 tons CO₂e/ha (Ziegler *et al.*, 2012).

5.2.2.2 Carbon Pricing

Carbon pricing has been chosen to significantly correspond to the levels used by the REDD+ program led by Forestry Administration (FA). This programme has some demonstration projects including the Oddar Meanchey and Seima Protection REDD+ projects. Recently, Cambodia has used the same prices to apply to the Forest Carbon Partnership Facility (FCPF) Carbon Fund, a sub-national scale pilot project in the ‘Northern Plains’ region.

Estimates made of the social cost of carbon change widely, yet have tended to increase in later studies. For example, the UK government, based on a review of the damage costs in the literature, recommended USD 138/ton C within a range of USD 69/ton C to USD 276/ton C as a total estimate of the global damage cost of carbon emissions, rising by USD 1.42/ton C per year in real terms to reflect the increasing marginal cost of emissions over time (DEFRA website). Estimates in the Stern’s review of the economics of climate change (Stern, 2007) are even higher at USD 85/ton CO₂e or USD 311/ton C (at 2,000 prices) for a business as a usual scenario.

The carbon values quantified in the latest report of IPCC (Intergovernmental Panel Climate Change) are considerably higher than those resulting from the current trading frameworks, such as the clean development mechanism (CDM) and the EU emissions trading systems. The average price in the CDM in 2006 was USD 10.5/ton of CO₂ (IPCC, 2006). Prices in the carbon trading frameworks are heavily influenced by regulations. As the scientific knowledge on climate change significantly increased, everyone agreed that much stricter emission reductions will be required. Therefore, prices in carbon trading frameworks are set to increase. It is less clear how avoided deforestation will fit in the future carbon trading frameworks i.e., whether it will be fully incorporated or addressed separately.

In fact, pricing approaches at program scale are fragmented between several REDD+ Result-based Financing (RBF) schemes from different initiatives. For example, Norway's International Climate and Forest Initiative has used a payment level of USD 5/ton CO₂e for both the Brazil's Amazon Fund and the Guyana REDD+ Investment Fund (World Bank, 2014). The average price for forestry offsets fell slightly to USD 7.8/ton CO₂e in 2012 (Peters-Stanley *et al.*, 2013). Prices have been declining due to limited demand and increasing supply. In early 2014, the average bid offer for issue credits was USD 5 to 6/ton CO₂e. Therefore, based on historical and international carbon prices, a value of USD 5/ton CO₂e has been chosen for the calculation. Under these assumptions, the carbon value will increase by four percent each year from 2013 to 2033, this being considered as the "expansion path" due to the production technology, considered homothetic.¹

5.2.2.3 Sensitivity Analysis of Crop Productions

Land productivity (gross value-added) of agricultural crops was calculated using primary data from field surveys as well as secondary data from Ministry of Agriculture, Forestry and Fisheries (MAFF). We assumed that in the next 10 years, the yields of the selected crops will exactly reproduce the level of the past 10 years as shown in dot line of Figure 5-3. For sensitivity analysis, we started the trend in 2013 when our field surveys were done, with and projection up to 20 years in 2033. All the prices of crops are fixed during time estimation: paddy rice of USD 0.25/kg, cassava of USD 0.125/kg, and rubber² of USD 1.8/kg, respectively. Labor and intermediate costs of production are also stable which is based on the cost calculation from field surveys (see Yoeu *et al.* 2016). Equivalent data for rubber were taken from (Hansen and Top, 2006).

¹In projective geometry, a homothetic transformation is similarity transformation (i.e., by 4 percent fixes a given elliptic involution) that leaves the line at infinity pointwise invariant. In this case, the ratio of input usages is always the same regardless of the level of output, and the inputs can be expanded proportionately so as to maintain this optimal ratio as the allowable total cost expands.

² Rubber production whole cycle including cost of production and yield was taken from Hansen, K. K. and N. Top (2006). "Natural Forest Benefits and Economic Analysis of Natural Forest Conversion in Cambodia."

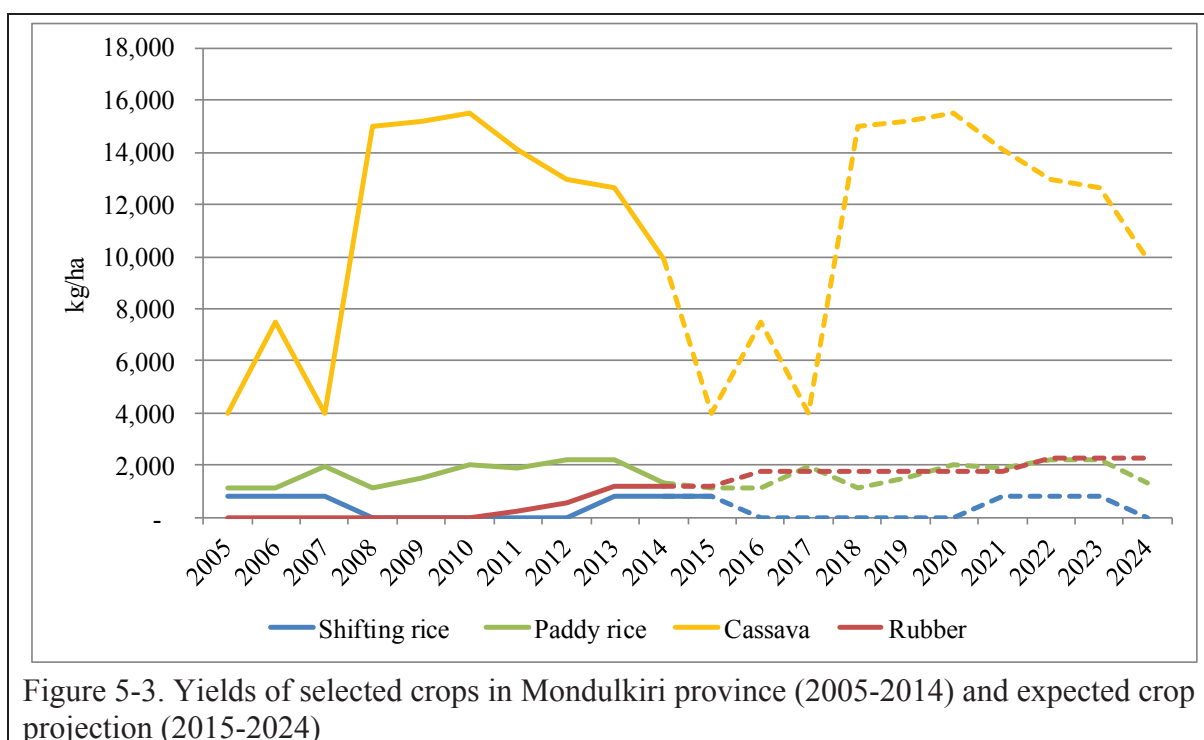


Figure 5-3. Yields of selected crops in Mondulkiri province (2005-2014) and expected crop projection (2015-2024)

The cost-benefit analysis (CBA) was primarily used for estimating the provisioning services of rubber, cassava, paddy rice and non-timber forest products (NTFPs) productions. The net present value (NPV) can be described as the difference between the present or discounted value of benefits and the present or discounted value of costs. The general formula for the NPV is as follows:

$$NPV = \sum_{t=0}^n \frac{Benefits_t - Costs_t}{(1+r)^t} \quad (1)$$

- NPV is calculated to estimate the profitability of land use over 20 years
- Discount rate used is 10 percent for every year³
- NPV of each provisioning service of land use is an average of gross margin per unit of land (total gross output minus total intermediate input divided by total cultivated land)

³ In the analysis, it is assumed that the future costs and prices increase at the same inflation rate. The inflation rate in Cambodia averaged 5.11 percent from 1995 until 2016, reaching an all time high of 35.57 percent in May of 2008 and a record low of -5.69 percent in May 2009 (NIS, 2016). With 5 percent (NIS, 2006), the 10 percent real discount rate equals a nominal interest rate of around 15 percent. Furthermore, a study on "Natural Forest Benefits and Economic Analysis of Natural Forest Conservation in Cambodia" done by CDRI applied 10 percent of discount rate (Hansen and Top, 2006) that it is truly reflected to current interest rate loan from private credits or banks in Cambodia.

- NPV of each regulating service of land use is calculated from the average of carbon stock over time rotation
- Prices of agricultural products are fixed at the level of the baseline

The land productivity of agricultural crops was directly estimated by using data from field surveys. The cost-benefit analysis (CBA) also includes calculation of benefits from an alternative land uses which were selected from some case studies. Baseline values for NTFPs collection, carbon sequestration, biodiversity (followed the adaption from studies in China and Vietnam), timbers, rubbers and cultural values were extracted from past researches already conducted in the study province.

Time frame for the analysis of land cover changes is 20 years, from 2013 to 2033, influenced by agricultural markets, responses from farmers cultivating cash crops, as well as availability of land for agriculture following the possible land policies.

5.2.3 Development Scenarios Future Land Use

The current land use situation in Mondulkiri is conversely changing rapidly. The present situation carries a number of potential sources of land conflicts that the institutional framework, while it has been much developed since the 2000s, may be unable to regulate.

Indeed, all the necessary legal tools do already exist; they are available to support any policy orientation. The economic land concessions (ELCs) legal framework can be used to support a vigorous development of capitalist production based on a little number of companies employing laborers on rubber plantations of several thousands of hectares. On the other end, the collective land titles (CLTs) legal framework is also available to protect the access to land of the local communities. In other words, the institutional framework, by superposing elements that can support any policy orientation on the field, actually leaves the largest freedom to the local powers to determine the policy they wish to support.

In these conditions, enlightening the possible impact in the future of different policies, also depending on the possible economic stimulations from the market, by modeling the results of various scenarios, may influence the balance of powers locally. To illustrate this assumption, we assessed here the possible impact over 20 years of two opposed policy options, each of them being in two different economic contexts. This exercise may not offer specific prediction, but it indicates the outer limits of the meaningful hypothesis on land possession and economic transformation of land use.

5.2.3.1 The Land Ownership Policies

Regarding tenure security, Article 1 of the 2001 Land Law guarantees ownership rights and other relevant rights in accordance with the 1993 Cambodian Constitution. The Sub-Decree on the procedure of land registration of the IP also aims at guaranteeing land tenure security⁴. For compliance with the 2001 Land Law, Sub-Decree on in the 2005 ELCs aims to determine the criteria (Articles 3 and 4⁵), procedures (Article 5), mechanism and institutional arrangements (Articles 10⁶ and 14) for initiating and granting new ELCs.

Taking into account that the current policy on private land ownership (private concessions) and collective land ownership (indigenous land ownership) has yet been unclear and insufficiently justified, our research envisages contrasting scenarios based on two opposed options in the future:

- In *Hypothesis A*: We assume that policies at national and provincial levels would clearly support large estates land ownership and concession rights compared to collective land ownership of the IP and recognition of smallholders' rights. In case of conflicts, local public institutions, based on a favorable interpretation of the ELCs regulations, would support the concession rights rather than the traditional access of the IP.
- *Hypothesis B*: The policy in Hypothesis B would strongly support the rights of the local communities and collective land ownership when opposed to ELCs' ownership, using legal tools such as the Forestry Law Article 37 or Land Law Article 25. The 2001 Land Law promised that the IP could register their collective ownership to protect their traditional shifting cultivation. In 2009, the Sub-Decree on procedure for registration of land of indigenous communities was approved. Indigenous community land includes residential and agricultural land and encompasses land reserved for shifting cultivation. Under these laws, indigenous communities may continue to manage their community land according to their traditional customs.

5.2.3.2 The Economic Context (rubber prices)

In Cambodia, rubber has been, since the 2000 until 2011, the most dynamic investment in long term crops, supported by very encouraging prices on the market. Recently, the government has expressed its strong commitment to promoting ELCs and rubber development. This rubber

⁴ Sub-Decree on the Procedure of Land Registration of Indigenous People, No.83ANK/BK, June 9, 2009, Art. 2.

⁵ Article 4 of the ELCs requires any proposal to meet the conditions before approval

⁶ Article 10: The Technical Secretariat shall widely disseminate the Notice for Solicited Proposals and shall also send the Notice to the Council for the Development of Cambodia.

plantation would be used as tool for generating income for the state, stimulating private enterprises, and creating jobs for rural communities. At present, in addition to existing private industrial plantations, more privately owned plantations are granted under the ELCs scheme, initiated by the government since 1992. Up to 2012, the government has granted ELCs to 118 companies of the total land area of 1,200,000 ha (MAFF, 2015b). Most of these rubber plantations have been converted from forestland.

Rubber plantations being the major commodity envisaged by the concessions in Mondulkiri, we have considered the price of rubber as the major driver that can encourage plantations (when it is high) or slow down the expansion of concessions and immigration (when it is low). Prices of rubber are indeed highly variable. In 2011, the world price of rubber peaked up high around USD 5,100/ton and dropped recently down to USD 2,200/ton (EIU, 2015). Noticeably in Cambodia, at farm gate, ranging price of rubber could range from USD 1,350/ton (in 2014) to USD 5,000/ton.

Starting from the prices in 2015, we have chosen two contrasting assumptions about rubber price trends that characterize the possible economic environment of the local economic stakeholders in Mondulkiri for the next 20 years.

- In *Hypothesis α* , the farm gate prices, after four years of decrease to a low point at USD 1,800/ton in 2013, would increase again linearly up to USD 4,000/ton in 2023, then would remain stable. This corresponds to the maximum that could be obtained in the top of the previous cycle in 2011. This is a realistic option in case of a continuous industrial growth in the world, since natural rubber remains compulsory in a number of industrial goods which markets are in continuous extension, whereas the recent drop of the price has discouraged new plantations to be done.
- On the contrary, in *Hypothesis β* , the prices would remain low, considering that the recent drop is explained by a structural surplus on the international market, following the huge number of new plantations implemented in the 2000s, that cannot easily stop their production whatever the level of prices might be. The low price of natural rubber USD 1,500/ton at farm gate price corresponds to the minimum that was offered in the low part of the cycle in 2014.

By crossing the two policy options with the two levels of rubber prices allow us to elaborate the four following scenarios for modeling the future land use changes in Mondulkiri province up to 2032 (see Table 5-2).

Table 5-2. The scenarios considered for the evolution of land use change changes

Hypothesis	Change in natural rubber price	
	Hypothesis α : High price of natural rubber USD 4,000/ton in 2023 (starting from USD 1,800/ton in 2013)	Hypothesis β : Low price of natural rubber USD 1,500/ton in 2033 (starting from USD 1,800/ton in 2013)
Hypothesis A : Policy favors supporting ELCs compared to collective land ownership and smallholder rights	Scenario Aα	Scenario Aβ
Hypothesis B : Policy favors supporting collective land ownership and smallholders compared to ELCs	Scenario Bα	Scenario Bβ

5.2.3.3 Impact of the Scenarios on the Land Use: The Basic Assumptions

Based on the identification of the strategies of the main stakeholders groups⁷, we have made assumptions on their reaction to the different situations outlined in the scenarios (Table 5-3). Thus, the policy favoring the concession holders (Hypothesis A) in a context of high prices of natural rubber (Hypothesis α) would encourage them to turn a higher proportion of their lands into rubber production. This would also impact the ability of some of the smallholders⁸ to shift part of their land from cassava and paddy rice as well as the concession companies to cultivate all remaining lands from their total concessions into rubber. Shifting cultivation would come to an end in A α ; since the access of the IP to land would be even more reduced than today. On the contrary, shifting would continue at the same level in the opposite Hypothesis B β , or would be slightly reduced in the intermediary scenarios A β or B α).

⁷ See Yoeu, Pillot, and Salles (2016) which details a typology of the local stakeholders.

⁸ The group of those, mostly Khmer immigrants, who are the most sensible to the market and have the financial capacity to invest in plantations. For details on the typology of farmers in Mondulhiri (Yoeu, Pillot, and Salles, 2016)

Table 5-3. Assumption of scenarios on cultivated lands, Mondulkiri province

Type of land use	Baseline in 2013 (ha)	Scenario Aα	Scenario Bα	Scenario Aβ	Scenario Bβ
		(ha)	(ha)	(ha)	(ha)
Area in rubber	83,531	206,341*	93,511	88,109**	83,531
Area in cassava	10,271	31,109	52,085	19,429	57,487
Area in paddy rice	22,893	0	4,579	9,157	9,157
Area in shifting	8,468	0	0	5,080	0
Forest area	1,290,506	1,178,219	1,265,494	1,293,894	1,265,494
Total	1,415,669	1,415,669	1,415,669	1,415,669	1,415,669

* Total granted concessions are 128,341 ha in 2013 and remain 55,799 ha is not cleared for planting yet

** 30 percent (16,740 ha) of unplanted area of concessions are taken off and given back to indigenous people as collective land

The changes in the land use according to the scenarios, particularly the possible extension of the rubber and cassava productions, could lead to an increased demand for labor which, in turn, would boost the wages and would encourage immigration from the inner Cambodia. In turn, the different increases in population would lead to different demands for food. We have calculated the impact of the scenarios on the labor requirements and on the production of wealth by using our data from personal surveys as published in Yoeu *et al.*, (2016) and Yoeu, Pillot and Salles, (2016)⁹, which presents economic outputs of each main cropping system represented in the area. These results are summarized in Table 5-3. For instance, the yields in paddy in the lowland paddy systems and in the shifting systems are on average 1.7 ton/ha and 0.78 ton/ha of paddy rice, respectively.

5.2.4 Selected Study Area

This study was conducted in Mondulkiri province of northeastern Cambodia, which is bordered by Kratie to the west, Stung Treng to the Northwest, Ratanakiri to the north and Vietnam to the east and south. This province was mainly chosen due to the rapid and dynamic changes in the forest conversion and the transformation of traditional shifting systems to agro-forestry plantations as well as permanent cash crops, as a result of fast population growth, land policies and institutions, and agricultural markets citations. We mainly included two specific approaches for data gathering and analysis: field interviews to determine assess the farming systems and

⁹Understanding famers' strategies, innovations and change in upland Cambodia.

measure their outputs, and desk review to synthesise the carbon sequestration in selected land uses related to the study area from various scientific publications and reports.

5.3 RESULTS

At the landscape level, the main challenge is how to decide on the optimal allocation and management of the many different land use options. Landscape functions and services have become an initial concept in policymaking, as decision makers have to deal with an explicit demand for landscape services from a broad range of stakeholders. Trade-offs between different ES are an important aspect in the assessment of future sustainable land use.

5.3.1 Ecosystem Services (ES) and Dis-services (EDS) by Cropping Systems

The interdependence between agriculture and ES is of high relevance as the demand for sustained food production grows. Crop yields certainly rely on the provision of ES, which can be negatively or positively affected by agriculture, depending on the practices applied for managing crop systems and agricultural landscapes. Consequently, farmers can be beneficiaries of ES or coadjutants in their provision.

According to International Center for Tropical Agriculture (CIAT), from the standpoint of agriculture as an ES beneficiary, healthy agroecosystem affects farmer positively by (i) supplying proper soil with sufficient nutrients and moisture conditions, and natural pollinators (supporting services); (ii) providing stable flows throughout seasons, and diversity of useful resources that farmers use for food, fuel, timber, and medicines (provisioning services); (iii) regulating the climate, and pest and diseases as result of biological and physical interactions that enhance biological control and water cycles (regulating services); and (iv) supporting cultural heritage, spirituality, identity, and a sense of place providing a basis for education and recreation (MA, 2003b; Zhang *et al.*, 2007; Quintero *et al.*, 2015). For instance, proper management practices at the crop field and landscape level may turn DES into ES, with agriculture becoming ES provider benefiting to other actors or sectors.

Table 5-4 significantly describes ES and EDS by cropping system in the study area, representing the major crops that are highly grown by the farmers based on market demand and their own needs. In this section, we assessed for ES or EDS as qualitative valuation (+ for positive effect “ES”; - for negative effects “EDS”) based on our expertise in the field interviews with peasants and scientific references. ES and EDS to agriculture influence both where and how people choose to farm. For example, cassava provides high range of food production while

only rubber produces high industrial crop (Table 5-4). In overall, the results therefore demonstrated that forest get obtain high positive ES in all categories such as provisioning, regulating, supporting and cultural services, whereas cassava obtains high EDS followed by rubber, paddy rice, shifting and forest, respectively.

Table 5-4. ES and EDS by cropping systems

Types of land use	Forest	Shifting	Rubber	Paddy rice	Cassava
Ecosystem services (ES)					
Provisioning services					
Food	+	++		++++	+++++
Timber	+++		+		
Firewood	+++	++	+		
Medicinal plant	+	++			
Hunting activities	+++	++		+	
Water	+++	++		+	
Fresh air	+++	+			
Industrial products			+++		
Regulating services					
Water quality	+++	++	+		
Carbon sequestration	++++	++	+++	+	+
Climate regulation	++++	+++	++	+	
Natural hazard mitigation	++++	++	+++	+	+
Supporting services					
Soil formation	+++	++	+		
Nutrient cycling	+++	++		+	
Cultural services					
Landscape beauty and recreation	++++	+++	++	+	
Preserve spiritual practices	+++	++		+	+
Ecosystem dis-services (EDS)					
Malaria	---	--	-		
Soil erosion		-	--		---
Decrease land productivity		-	--	--	---
Water pollution			--	-	---
Loss biodiversity			---	--	---
Pesticide poisoning			--	--	---

Natural forest ecosystems of the mountains will provide constant direct benefit flows, if properly maintained and protected. In 2007, a study of only two protected areas in the Great Mekong Sub-region of Cambodia (Phnom Aural and Phnom Samkos Wildlife Sanctuaries) showed the NPV of over USD 1.89 billion, for an area covering only 585,787 ha, considering only sustainable timber harvesting, agriculture, NTFPs, and carbon storage (Grieg-Gran, 2008). In Monduliri, natural forest area accounts for 90 percent of the surface comprising of evergreen, semi-evergreen and deciduous forests. Forest ES can provide economic benefits, both indirect and indirect values, and non-use value. In contrast, EDS by natural forest causes malaria disease due to this Anopheles mosquito infective disease is widespread in the tropical and sub-tropical regions.

Shifting systems use slash-and-burn techniques to clear the land. The long fallow mobilizes fertility in the biomass and in the soils that is partly made available to the crops through the burning of the vegetation. The system receives from ES as a main source of food for the IP. During the fallow period, shifting farmers use the young trees for fencing the construction, for firewood, thatching, ropes, clothing, tools, carrying devices and medicines. It is common for fruit and nut trees to be planted in the fallow fields to the extent that parts of some fallows are in fact orchards. It is found that soil enhancing shrubs or tree species may be planted or protected from slashing or burning in fallows. Many of these species are essential to fix nitrogen in the soil. Moreover, fallows also commonly contain plants that attract birds and animals, thus important for hunting. It is perhaps most importantly tree fallows protect soil against physical erosion and draw nutrients to the surface from deep in the soil profiles.

Nevertheless, shifting is accused of destroying forest resources, being uneconomical, leading to destruction of watersheds, erosion, desertification, etc. During slashing and burning, leguminous and nitrogen-fixing plants are victims. According to respondents' observations, productivity of land is declining while erosion is increasing every year, especially in lower altitude land where intense rainfall can occur just after clearing, burning and sowing (Upadhyay and Ura, 1995).

Rain-fed lowland rice-based farming systems (paddy rice) are commonly found on almost all soil types. The failure to maintain standing water in the rain-fed lowland paddy fields can result in leaching of nutrients from the system, contributing to a yield decline over time (Bell, Ros and Seng, 2001). The cropping systems use seed selected naturally and locally

by farmers and their ancestors. Majority of farmers often sow the seed directly to the field when there is rain arrives early enough.

Meanwhile, due to irregular rainfall or, more often, drought has adverse effect on rice grain yields. Farmers also encounter many external constraints due to weeds and pests. They now use more and more fertilizers and pesticide for maximizing production. According to Howeler (2012), continuously planting crops without fertilizer resulted in yield decline in all crops, as nutrients are removed from the field in all plant parts.

Cassava-based farming systems are commonly cultivated in different conditions, flat and sloping land; growing between 30⁰N and 30⁰S in areas where annual rainfall is greater than 500 mm and mean temperature is greater than 20 ⁰C. The main ES (with farmers' work) is to provide directly food to the society. Thanks to the forest that regulates and supports good soil after first years of clearance, farmers have never use fertilizer in their cassava production yet in the study areas. Cassava processing produces large amount of waste including solid and liquid which are high in organic matter constituents and cyanide.

On the other hand, there are controversial reports about EDS from the cassava cultivation to environment, particularly on soil structure and its nutrients. Cassava is known to cause serious soil degradation due to excessive uptake of nutrients leading to soil nutrient depletion, or by causing serious soil erosion when grown on slopes (Putthacharoen *et al.*, 1998). Due to lack of nutrient replacement especially in the case where cassava is continuously cultivated in the same area for many years, soil fertility certainly declines and consequently lowers cassava root yield (Men and Sothat, 2015). For example, experiences from two provinces in Cambodia (Kampong Cham and Pailin), the main reasons for yield decline include weed problems, soil fertility decline and soil erosion, damages caused by pests and diseases, the use of poor planting materials and heavy rainfall. In Pailin, where more than 90 percent of production is on sloping land, rain, erosion and declining soil fertility as well as poor planting materials, all these cause yield decline of cassava. Both monoculture of cassava and up-and-down ridging by farmers have been reported to produce a high level of erosion as compared to other cultivation practices in cassava-based cropping systems (MAFF, 2015a). Based on a study by Men and Sothat (2015), it was also suggested that inappropriate practices by farmers in growing cassava on sloping land potentially contribute to soil erosion. Most farmers in the study area are carrying the similar practices that have certainly a very negative impact to the soil as it makes the land very susceptible to soil erosion especially when it is associated with heavy rainfall. Reports

from numerous cassava farmers who have come across with this problem of soil erosion on their cassava plantation have confirmed this situation.

Rubber plantation boosts local economy; meanwhile, it also helps local farmers to reduce poverty and become financially well-off in a very short period of time (Xi, 2009). However, rubber plantations return EDS directly on water resources. For example in rapid expansion of rubber plantations in Xishuangbana of China, water resources are gradually drying up. There are more potential threats from excessive rubber plantation on soil erosion, destruction of biodiversity, water and soil contamination from chemical fertilizers and pesticides, and negative impact on pollination and seed dispersal, etc.

5.3.2 Provision of Ecosystem Services (ES)

5.3.2.1 Ecosystem Services in Natural Forest

We have adapted data from Hansen and Top (2006) by de-actualizing the NPV of different types of forests, in terms of NTFPs and timber. Firstly, the values of NTFPs were around USD 33/ha/year in the case of deciduous forest, USD 21/ha/year for semi-evergreen forest, and USD 11/ha/year for evergreen forest. The mean value of the production of NTFPs for the three forest types was around USD 22/ha/year. This value was taken for our own calculations. Secondly, the values of timber were about USD 23/ha/year for deciduous forest, USD 34/ha/year for semi-evergreen forest and USD 155/ha/year for the evergreen forest (Hansen and Top, 2006). We took the mean value of timber production for the different types of forests, which was approximately USD 55/ha/year. We also followed Guo *et al.* (2001) to estimate the value of watershed services which was roughly USD 70/ha/year. The mean value of soil conservation is calculated at approximately USD 60/ha/year in a study of The (2001) is assumed appropriate. Therefore, the TEV of forest over 20 years adds up to the amounts shown in Table 5-5.

Table 5-5. The estimated values of forest ecosystem services

Forest ecosystem services	Average annual value (USD/ha)	Total NPV @10% (USD/ha) over 20 years
NTFPs	22	206
Timber	55	515
Carbon sequestration	314	6,277
Soil conservation	60	563
Water conservation	70	656
Total	521	8,216

Source: Hansen and Top (2006); Guo *et al.* (2001); and The (2001)

Table 5-5 presents the provision of multiple ES by the natural forest, based on a case study from Seima Protected Area of Mondulkiri province. The result shows that average total annual value of the services provided by the forest is of USD 8,053/ha which is made of NTFPs (USD 22/ha), timber (USD 55/ha), carbon sequestration (USD 314/ha), soil conservation (USD 60/ha), and water conservation (USD 70/ha), respectively. Besides, the total NPV of forest at 10 percent discount rate over 20 years is USD 8,216/ha that is comprised of NTFPs (USD 206/ha), timber (USD 515/ha), carbon sequestration (USD 6,277/ha), soil conservation (USD 563/ha), and water conservation (USD 656/ha). In fact, the values associated with forests are greater than their timber values in the case of sustainable logging. Particularly, both the average annual value and NPV of forest carbon sequestration are by far the highest outcomes. Furthermore, the natural forest ES enable providing direct uses and indirect or functional services, as well as option and existence values for maintaining for future generations.

However, in a valuation study conducted by Cambodia Development Resources Institute (CDRI), the NPV of selected forest types at 10 percent discount rate over 50 years was calculated at USD 1,194/ha (USD 120/ha/year) for deciduous, USD 2,445/ha (USD 247/ha/year) for semi-evergreen, and USD 3,721/ha (USD 375/ha/year) for evergreen forests (Hansen and Top 2006). Another example from sustainable financing of two protected areas at 10 percent discount rate over 25 years was estimated the NPV at USD 1,362/ha of Phnom Aural and USD 1,910/ha Phnom Samkos Wildlife Sanctuaries (Grieg-Gran, 2008).

In conclusion, the study independently did not allow comparing the average annualized NPV of forest between our results with the study made by CDRI (Hansen and Top, 2006) due to different data of carbon sequestration and time estimation.

5.3.2.2 Ecosystem Services in Agricultural Land Use Types

Direct value resulting from of agricultural plantation is its added-value (yield minus the cost of the inputs) and indirect value is the carbon sequestration as well as soil conservation. We assumed that there is no ecosystem benefit in terms of soil and water conservation (zero value) in all agricultural plantations. Based on our farming systems typology and our economic data in the study area (Yoeu *et al.* 2016), we calculated that shifting, paddy rice, cassava and rubber presents the following NPV at 10 percent discount rate over 20 years (Table 5-6). Cassava yields are assumed to reproduce the same cycle as shown in the past 10 years and the prices are supposed to remain constant.

Table 5-6. Provision of ES in agricultural landscapes of study areas

Agricultural crops	Ecosystem services	Average annual value (USD/ha)	Total NPV @10% (USD/ha) over 20 years
Shifting*	Production	130	1,454
	Carbon sequestration	98	1,951
	Total	228	3,405
Paddy rice*	Production	251	2,186
	Carbon sequestration	77	1,547
	Total	2,186	3,733
Cassava*	Production	1,358	11,883
	Carbon sequestration	77	1,547
	Total	1,435	13,430
Rubber** (USD 1.8/kg)	Production	1,695	8,628
	Carbon sequestration	172	3,439
	Total	1,866	12,067
Rubber (USD 1.5/kg)	Production	1,368	6,786
	Carbon sequestration	172	3,439
	Total	1,539	10,225
Rubber (USD 4/kg)	Production	4,093	22,131
	Carbon sequestration	172	3,439
	Total	4,264	25,571

*Field survey (2012-2013) and MAFF (2002-2012)

**Hansen and Top(2006)

The results of this study display the important relationship between regulating ES (carbon sequestration) and provisioning ES (yield) among selected agricultural landscapes. Agroforestry plantations, especially rubber, whatever prices are, provide both the highest average annual value and total NPV compared to shifting and paddy rice, except cassava. Among all the agricultural systems, shifting provides the second highest value for carbon

sequestration (USD 1,951/ha) but the lowest value for production (USD 1,454/ha) at 10 percent discount rate over 20 years estimation.

5.3.2.3 Ecosystem Services in Mondulkiri Landscapes

The comparison of implementation options can be made by comparing ES induced by each land use option, highlighting optimum annualized NPV for each land use system. The total NPV of rubber (at high price of USD 4/kg) at 10 percent discount rate was about USD 25,571/ha over 20 years estimation, is the highest among all options (Figure 5-4). It is notably observed that forest ES provides the highest value of carbon sequestration and its forest system has multiple ES including other indirect values such as soil and water conservations. Here we noticed that, due to high value of production (crop yield) of cassava and rubber, the total ES values were boosted up even though relatively very little value was added by carbon sequestration. High contribution of provisioning services has resulted in low regulating services and vice versa in the study area, except rubber plantation.

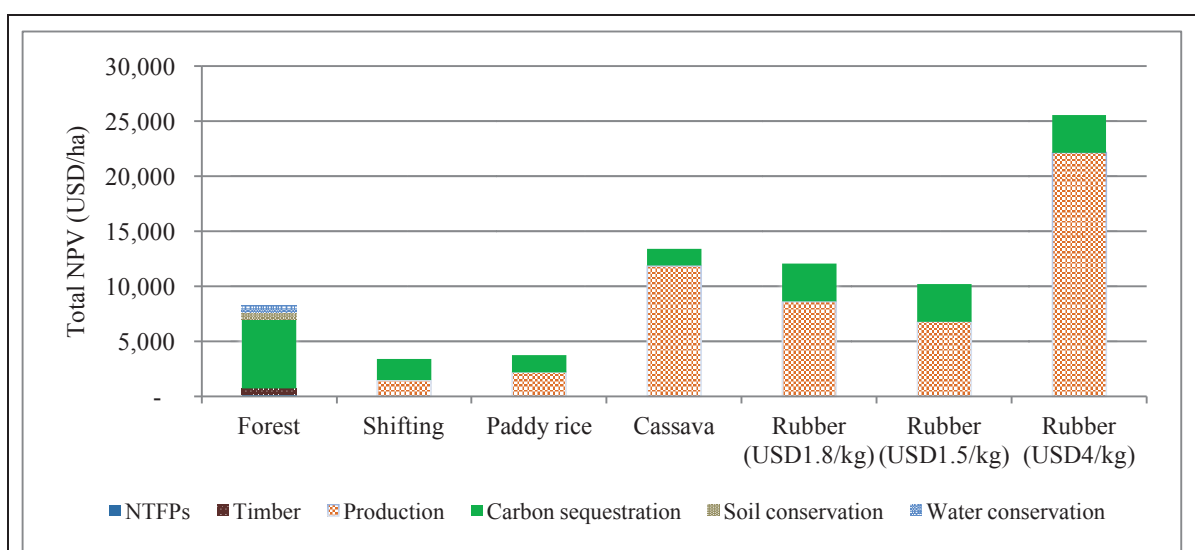


Figure 5-4. Repartition of total NPV per hectare of ES types at 10 percent discount rate over 20 years

Considering different alternative land use options, the long term changes of ES per land use option and category are presented in Figure 5-5. Based on fixed assumptions (NTFPs, timber, carbon stock, soil and water conservations), the average annual provision of ES in forest is the same each year (linear function). In rubber production, the provisioning services begin to be provided from year 7 and whatever prices are, they increase up to year 20. The fluctuation of each system is due to production (change in yield every year), since the regulating services measured by the average carbon stock of the system is constant.

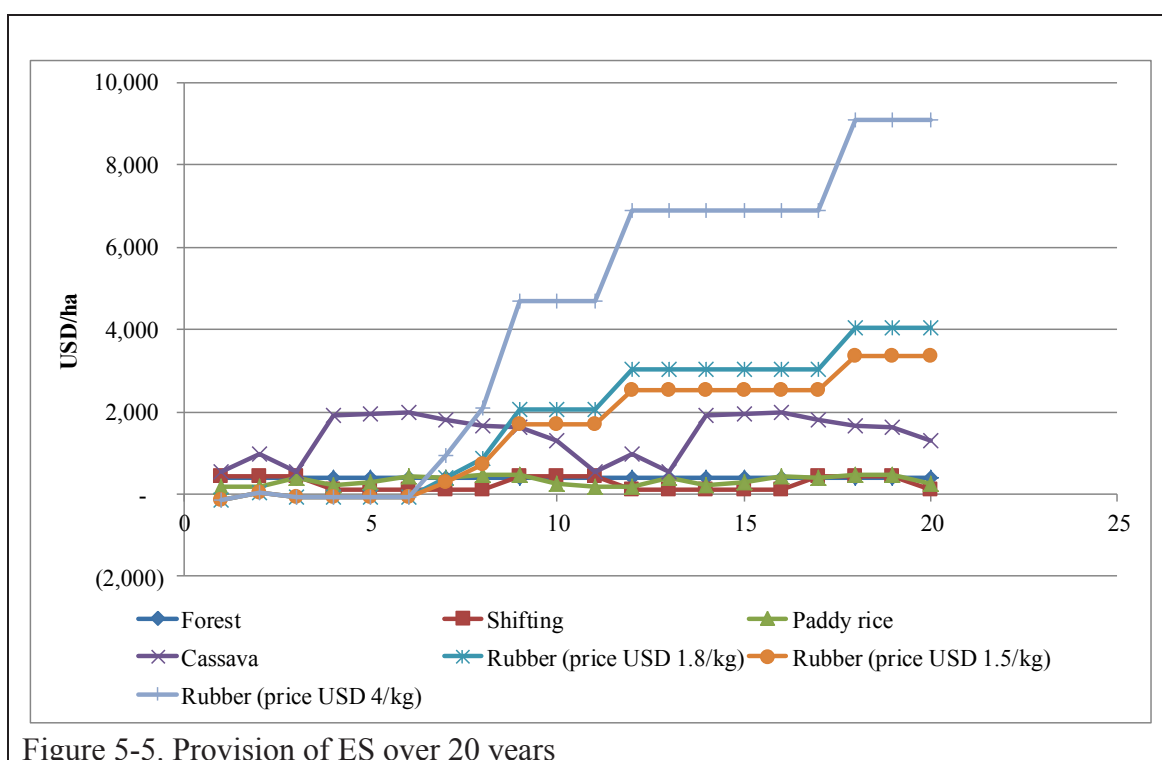


Figure 5-5. Provision of ES over 20 years

5.3.3 Trade-offs between Ecosystem Services and Opportunity Cost

5.3.3.1 Trade-offs between Provisioning and Regulating Services in Each Production System

Trade-offs between food production and the other ES are large for carbon sequestration. We consider agricultural production as an output that benefit both of various ES (e.g. provisioning, regulating) and from the labor of farmers. Incidentally, the farmers' point of views rarely acknowledges about regulating services from their land use systems that also provides carbon sequestration. In fact, trade-offs between provisioning and regulating services in each production system of Mondulkiri landscape are mainly discussed in this section (Table 5-7) based on farmers' strategies and practices. These strategies are combinations of different cropping systems into specific production systems. Referring to specific criteria (e.g. historical milestone of land use, land surface, labor, capital), six production system models have been identified (for the detail on the classification of farm strategies, see Yoeu, Pillot, and Salles, 2016). The calculation of gross value-added (GVA) of agriculture and carbon sequestration of each production system (USD/household-hh) is considered to take the average annual value from Table 4-6 shown previously.

Model IP₁ is a combination of three different types of shifting cultivation (S), paddy rice (P) and cassava (C) systems (S+P+C). In this production system, four main sub-groups (A, B, C and D) have been specifically divided due to land and labor availability. Naturally, due to the low return added-value of shifting cultivation and carbon sequestration, the total added value of the Model IP₁ is also low. In this model, the result shows that the trade-offs between provisioning services (added-value of crops) take values from USD 144 to USD 1,366/hh and regulating services (carbon sequestration) from USD 1,695 to USD 5,213/hh. For instance, sub-group C presents both the highest value-added of USD 1,674/hh and a carbon sequestration of USD 6,350/hh, because this sub-group maintains the largest land surface (almost 3 ha) with high proportion of shifting land surface (1.38 ha). These trade-offs vary and depend on the land surface of combined crops and labor.

Model IP₂ refers to a combination of shifting and cassava by the IP who invest on market-oriented crops while they have no access to paddy land to complement. Majority of farmers is situated in sub-group B (14 households) and total average land surface is 2.28 ha/hh; the provisioning and regulating services are at USD 1,780 and USD 4,942/hh, respectively. In this model, the trade-offs between ES are varied from USD 675-6,234/hh of value-added and from USD 1,800 to 11,150/hh for carbon sequestration.

Model IP₃ represents the IP that look for the highest diversification of resources, minimize their dependence on markets for food provision and also lessen their risks. This model is a combination of paddy rice and cassava systems. This model generates provisioning services from USD 1,000 to 5,250/hh while regulates double value of carbon sequestration from USD 3,000 to 10,640/hh. Majority of farmers are in sub-group A that obtain average land surface of paddy rice (1 ha) and cassava (0.56 ha); however this sub-group receives both the lowest value-added and carbon sequestration due to the small land surface they have.

Model IP₄ illustrates a group of the IP who currently produce only cassava crops with an average land surface from 0.5 to 3.5 ha/hh. This category has a limited access to land and specializes on off-farm activity combined with cassava. The only cassava system has generated trade-offs between provisioning services from USD 660 to 4,400/hh and regulating service from USD 940 to 6,300/hh. Sub-groups A and B have the same number of families (11 households) but different land surface. Most famers in this category obtain limited land surface around 0.5-1 ha, they are inclined to involve in non or off-farm activities rather than agriculture.

Table 5-7. Trade-offs between provisioning and regulating services in Mondulkiri landscapes

No. HH	Type of production system	Surface (ha/hh)				Provisioning services	Regulating service
		S	P	C	Total	Gross value- added (USD/hh)	Carbon sequestration (USD/hh)
7	IP ₁ : Investment on market integrated crops while maintaining minimum security of food crops						
1	IP ₁ A	0.50	0.23	0.02	0.75	144	1,695
2	IP ₁ B	0.50	0.50	0.50	1.50	869	3,153
2	IP ₁ C	1.38	0.55	1.00	2.93	1,674	6,350
2	IP ₁ D	0.75	1.00	0.75	2.50	1,366	5,213
	Average	0.78	0.57	0.57	1.92	1,013	4,103
27	IP ₂ : Investment on market oriented crops while no access to paddy land to complement						
8	IP ₂ A	0.39		0.46	0.85	675	1,838
14	IP ₂ B	1.07		1.21	2.28	1,780	4,942
3	IP ₂ C	2.67		1.69	4.36	2,645	9,776
1	IP ₂ D	1.00		4.50	5.50	6,237	11,141
	Average	1.28		1.97	3.25	2,834	6,924
17	IP ₃ : Diversification of resources, minimum rely on market for food provision and minimizing of risks						
10	IP ₃ A		1.00	0.56	1.56	1,011	3,017
5	IP ₃ B		1.18	1.00	2.18	1,653	4,216
1	IP ₃ C		2.00	3.50	5.50	5,252	10,637
1	IP ₃ D		1.00	2.00	3.00	2,965	5,802
	Average		1.30	1.77	3.07	2,720	5,918
27	IP ₄ : Reduced access to land and specialization on- or off-farm activities combined with cassava						
11	IP ₄ A			0.49	0.49	660	941
11	IP ₄ B			0.75	0.75	1,017	1,449
3	IP ₄ C			2.00	2.00	2,714	3,868
2	IP ₄ D			3.25	3.25	4,410	6,286
	Average			1.62	1.62	2,200	3,136
22	M ₁ : Investment on short-term cash crops combined with off-farm and non-farm activities						
5	M ₁ A			0.34	0.34	459	654
6	M ₁ B			1.00	1.00	1,357	1,934
8	M ₁ C			2.00	2.00	2,714	3,868
3	M ₁ D			5.00	5.00	6,785	9,670
	Average			2.08	2.08	2,829	4,031
29	M ₂ : Investment on long-term cash crops combined with non-farm activity						
7	M ₂ A			0.51	0.51	694	989
10	M ₂ B			1.05	1.05	1,425	2,031
5	M ₂ C			2.00	2.00	2,714	3,868
7	M ₂ D			3.24	3.24	4,391	6,258
	Average			1.70	1.70	2,306	3,286

S: Shifting, P: Paddy rice, C: Cassava, and HH: Household, M: Migrant, IP: Indigenous People, ha/hh: hectare per household, USD/hh: US dollar per household

Model M₁ corresponds to cassava system by migrants who have arrived since the end of the 90s. This group of people invests on short-term cash crops combined with off-farm and non-farm activities. Provision of ES in this system produces a value-added from USD 450 to 6,800/hh and carbon sequestration from USD 980 to 9,700/hh.

Lastly, model M₂ provides an illustration of the situation of recent migrants who would like to invest in long-term cash crops combined with non-farm activity. Similar to M₁, this model carries on cassava production that the trade-offs between provisioning service ranges from USD 690 to 4,310/hh and regulating service is from USD 980 to 6,300/hh.

To sum up, model IP₂ appears as the most efficient model in terms of production (average value-added=USD 2,834/system) and of course carbon sequestration (USD 6,924/system). Based on the analysis of the systems, the result clearly illustrates that increasing of production of provisioning services leads to reduced carbon sequestration and regulating services.

5.3.3.2 Cost-Benefit from Converting Forest to Agricultural Land

Table 5-8 presents the average annual value, total NPV, carbon stock, and CO₂ stock of different landscapes that were selected for cost-benefit analysis from converting forest to agricultural land

Table 5-8. The NPV of production, carbon stock and CO₂ of different land use types

Type of land	Average annual value (USD/ha)	Total NPV @10% over 20 years (USD/ha)	Carbon stock (ton/ha)	CO ₂ stock (ton/ha)
Shifting	130	1,454	133.00	487.67
Paddy rice	251	2,186	105.50	386.83
Cassava	1,358	11,883	105.50	386.83
Rubber (USD 1.8/kg)	1,695	8,628	234.50	859.83
Rubber (USD 1.5/kg)	1,368	6,786	234.50	859.83
Rubber (USD 4/kg)	4,093	22,131	234.50	859.83
Forest	207	1,939	428.00	1,569.33

In terms of carbon stock, forests have the highest carbon stock of 428 tons/ha, followed by rubber (234 tons/ha), shifting (133 tons/ha), paddy rice and cassava (105 tons/ha). Calculation of carbon stock lost from converting forest to agricultural land use is shown in Figure 5-6. Since cassava and paddy rice have the same lowest carbon stock, there was the highest loss (1,182 tons CO₂/ha) converting from forest to cassava and paddy rice.

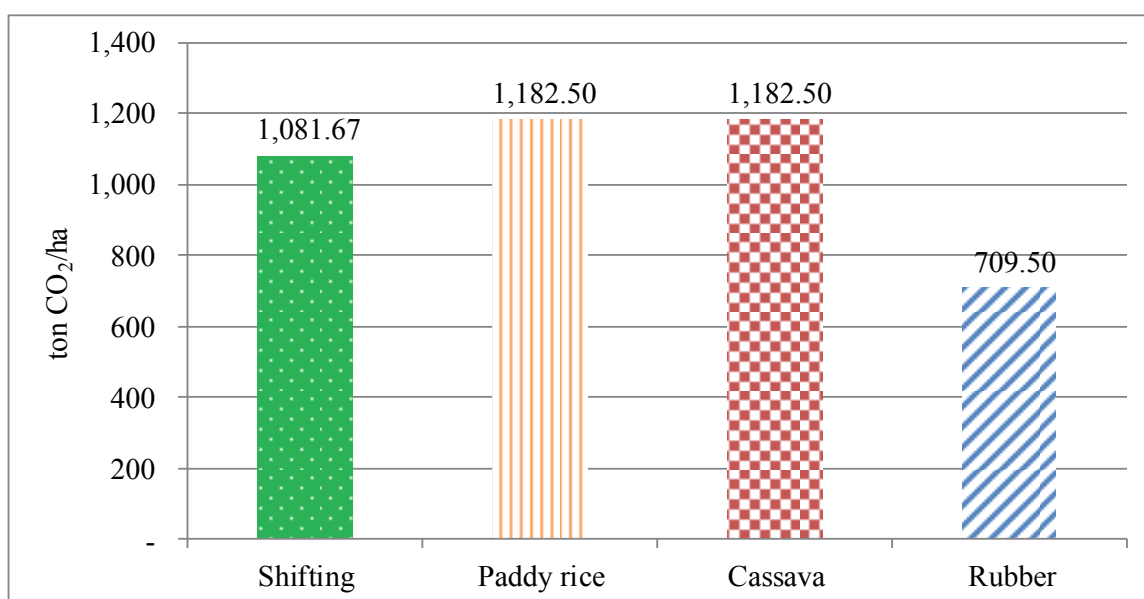


Figure 5-6. Carbon stock losses from converting forest to agricultural land uses

Conversion from forest to rubber plantation in case of high price has the highest profit gain at USD 3,886/ha, followed by changing forest to rubber at price of USD 1.8/kg (USD 1,488/ha), rubber (USD 1,161/ha), cassava (USD 1,151/ha), paddy rice (USD 44/ha), and shifting (USD -77/ha), respectively (Figure 5-7). These analyzes are obviously considered only change in stock values (the stock-based approach), which estimates the difference in carbon stocks in different times. However, these did not rely on the process-based approach or annual values, which estimate the net balance of additions to a subtraction from a carbon stock.

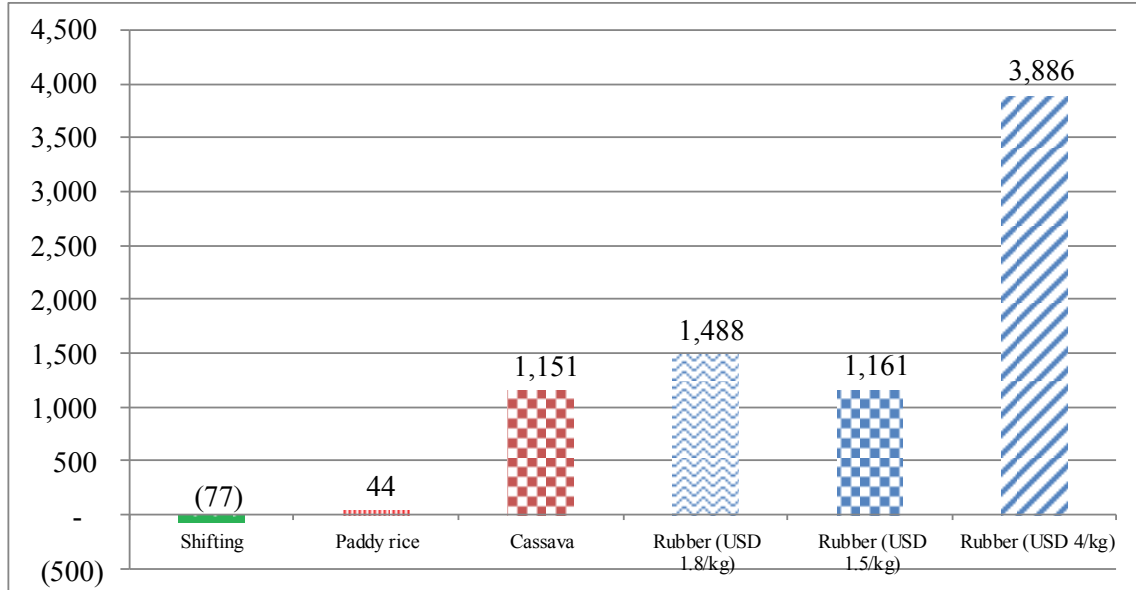


Figure 5-7. Profit gain from converting forest to agricultural land uses

5.3.3.3 Opportunity Cost for Different Land Use Changes

The study assessed the opportunity cost of four types of land use changes: (i) conversion from forest to rubber plantations; (ii) forest to cassava; (iii) forest to paddy rice; and (iv) forest to shifting cultivation (Table 5-9). An initial landscape-level, opportunity cost analysis can be possibly carried out as part of a project's feasibility (or pre-feasibility) study. This is especially important for sites where concession logging or conversion to commercial agriculture is a likely future scenario. This analysis would be a more theoretical and macro-level analysis taking into account that pricing trends and projections from carbon credits, natural resources and agricultural commodities. The results revealed that the conversion from forest to rubber plantation had the highest opportunity cost, in case of high, medium and low prices (USD 136, USD 52 and USD 40/ton CO₂), followed by changing from forest to cassava (USD 24/ton CO₂) and to paddy rice (USD 0.93/ton CO₂). The conversion from forest to shifting system had the lowest opportunity at USD -1.78/ton CO₂.

Table 5-9. Carbon stock losses, profit gain and opportunity cost of different land use change

Agricultural land use	Carbon stock losses		Annual CO ₂ Loss (b= a*4%) (1)	Profit gain (USD/ha) (2)	Opportunity cost (USD/ton CO ₂) (1/2)
	C (ton/ha)	CO ₂ (ton/ha) (a)			
Shifting	295	1,081.67	43.27	(77)	(1.78)
Paddy rice	323	1,182.50	47.30	44	0.93
Cassava	323	1,182.50	47.30	1,151	24.33
Rubber (USD 1.8/kg)	194	709.50	28.38	1,488	52.41
Rubber (USD 1.5/kg)	194	709.50	28.38	1,161	40.89
Rubber (USD 4/kg)	194	709.50	28.38	3,886	136.91

5.3.4 Estimated Change in Provision of ES

Based on the identification of the strategies of the main groups of stakeholders, we have assumed their reactions to the different situations formulated in the scenarios. Thus, the policy favoring the concession holders (Hypothesis A) in a context of high prices of natural rubber (Hypothesis α) would encourage them to turn a higher proportion of their lands into rubber production. This would also impact the ability of some of the smallholders to shift part of their lands from cassava and paddy rice, as well as the concession companies to cultivate all remaining land from total concessions into rubber plantation. Shifting cultivation would come to an end in scenario A α ; since the access of the IP to land would be even more reduced than today. On the contrary, shifting would continue at the same level in the opposite Hypothesis B β , or would be slightly decreased in the intermediary scenarios A β or B α).

5.3.4.1 Estimated Change in Surface Area and CO₂ under Various Scenarios and Baseline

The changes in the land use according to the scenarios, particularly the possible extension of the rubber and cassava productions, could lead to impact on the provision of ES. Table 5-10 presents change in surface area and CO₂ from various policies and rubber prices to baseline. Overall, all scenarios lead to a reduction of the C sequestrated since a major part of the land converted comes from natural forest. In such a process, change in scenario A α and baseline contributes to the highest loss of CO₂ by 100.67 million tons CO₂ while scenario B α loses only 13.54 million tons CO₂.

Table 5-10. Change in surface area and CO₂ under from various scenarios to baseline

Type of land use	Change in scenario A α and baseline		Change in scenario B α and baseline		Change in scenario A β and baseline		Change in scenario B β and baseline	
	Area (ha)	CO ₂ (million tons)	Area (ha)	CO ₂ (million tons)	Area (ha)	CO ₂ (million tons)	Area (ha)	CO ₂ (million tons)
Rubber	122,810	87.13	9,980	7.08	4,578	3.25	-	-
Cassava	20,838	24.64	41,814	49.45	9,158	10.83	47,216	55.83
Paddy rice	(22,893)	(27.07)	(18,314)	(21.66)	(13,736)	(16.24)	(13,736)	(16.24)
Shifting	(8,468)	(9.16)	(8,468)	(9.16)	(3,388)	(3.66)	(8,468)	(9.16)
Forest	(112,287)	(176.22)	(25,012)	(39.25)	3,388	5.32	(25,012)	(39.25)
Total		(100.67)		(13.54)		(0.51)		(8.82)

5.3.4.2 CO₂ Loss from Converting Forest to Agricultural Land Use in Different Scenarios

According to the changes in land use in the different scenarios, we estimated the CO₂ losses from 2013 to 2033 (Table 5-11). In total, the results indicated that scenario A α has the highest CO₂ loss at 183 million tons, followed by scenario B β (138 million tons), and scenario A β (101 million tons). Scenario B α has the lowest CO₂ loss at 71 million tons.

Table 5-11. CO₂ loss from changing forest to agricultural land use in different scenarios (2013-2033)

Type of land use	Baseline in 2013	Scenario A α	Scenario B α	Scenario A β	Scenario B β
	(million tons CO ₂)				
Rubber	59.27	146.40	40.34	62.51	59.27
Cassava	12.15	36.79	30.95	22.97	67.98
Paddy rice	27.07	-	0.50	10.83	10.83
Shifting	9.16	-	-	5.49	-
Total CO ₂ loss	107.64	183.19	71.78	101.81	138.07

5.3.4.3 Profit Gain from Converting Forest to Agricultural Land Use in different Scenarios

According to changes in the land use, the profit gain from converting forest to agricultural land use in different scenarios (2013-2033), according to changes in the land use, is presented in Table 5-12. In fact, scenario A α has the highest profit gain at USD 837 millions, followed by scenario B α (USD 423 million) and scenario B β (USD 163 million). However, scenario A β offers the lowest profit gain (USD 124 million) from converting forest to agricultural land use which possibly due to the lower price of rubber together the small proportion change in area of rubber as well.

Table 5-12. Profit gain from changing forest to agricultural land use in different scenarios (2013-2033)

Type of land use	Baseline in 2013	Scenario A α	Scenario B α	Scenario A β	Scenario B β
	(million USD)				
Rubber	124.25	801.74	363.34	102.25	96.94
Cassava	11.82	35.79	59.93	22.35	66.14
Paddy rice	1.01	-	0.20	0.40	0.40
Shifting	(0.65)	-	-	(0.39)	-
Total profit gain	136.43	837.53	423.47	124.62	163.48

5.3.4.3 Estimated Provision of ES under Various Scenarios

We projected all land-use scenarios considered in the analysis to generate provision of ES (provisioning-gross added-value of agriculture and regulating-carbon stock) (Table 5-13). The results at 10 percent discounted rate over 20 years showed that scenario A α had the highest provision of ES value of USD 15,374 million, followed by scenario B α (USD 13,505 million), scenario B β (USD 12,058 million), and scenario A β USD 11,844 million. Based on the results, rubber prices have a strong impact on land use changes in all the scenarios.

Table 5-13. Estimated ES in different land use of various scenarios at 10 percent discount rate over 20 years

Baseline in 2013	Rubber	Cassava	Paddy rice	Shifting	Forest	Total ES
Area in cultivation (ha)	83,531	10,271	22,893	8,468	1,290,506	
NPV (USD/ha)	12,067	13,430	3,733	3,405	8,216	
Provision of ES (million USD)	1,008	138	85	29	10,603	11,863
Scenario Aα						
Area in cultivation (ha)	206,341	31,109	-	-	1,178,219	
NPV (USD/ha)	25,571	13,430	3,733	3,405	8,216	
Provision of ES (million USD)	5,276	418	-	-	9,680	15,374
Scenario Bα						
Area in cultivation (ha)	93,511	52,085	4,579	-	1,265,494	
NPV (USD/ha)	25,571	13,430	3,733	3,405	8,216	
Provision of ES (million USD)	2,391	699	17	-	10,397	13,505
Scenario Aβ						
Area in cultivation (ha)	88,109	19,429	9,157	5,080	1,293,894	
NPV (USD/ha)	10,225	13,430	3,733	3,405	8,216	
Provision of ES (million USD)	901	261	34	17	10,630	11,844
Scenario Bβ						
Area in cultivation (ha)	83,531	57,487	9,157	-	1,265,494	
NPV (USD/ha)	10,225	13,430	3,733	3,405	8,216	
Provision of ES (million USD)	854	772	34	-	10,397	12,058

In comparison to the baseline at 10 percent discounted rate over 20 years, scenario Aα would produce positive total value of ES of USD 323 million, followed by scenario Bα (USD 158 million), and scenario Aβ (USD 17 million USD). However, only scenario Bβ generates provision of ES lower than baseline by USD 125 million.

5.3.5 Trade-offs ES, Opportunity Cost in Different Scenarios

5.3.5.1 Trade-offs ES of policy A and prices of rubber (A α and A β)

Trade-offs between provisioning service (GVA-gross value-added of agriculture) and regulating service (carbon sequestration) in the case policy A and prices of rubber (2013-2033) is shown in Figure 5-8. Between 2013 and 2033, combination of high rubber prices and a public policy favorable to concession scenario A α achieves triple provisioning services (USD 977 million) but reduced by USD 30 million of the regulating services in terms of carbon sequestration. In the case of low rubber prices, scenario A β decreases provisioning services by USD 12 million, however increases in regulating services by USD 2 million. Therefore, increasing in provisioning service is due to the high level of price than to the positive policy toward concession investments. In addition, high price of rubber is sensibly encouraged the stakeholders to convert a part of their croplands either to rubber plantation or to high return cash crops especially cassava. The conversion from forest to rubber plantation in scenario A α was larger than A β , and there is also a greater loss of regulating services. In overall, an increased in the GVA of agriculture in 2033 initially resulted in a decrease in carbon sequestration which may due to suitable forest parcels are converted to crops.

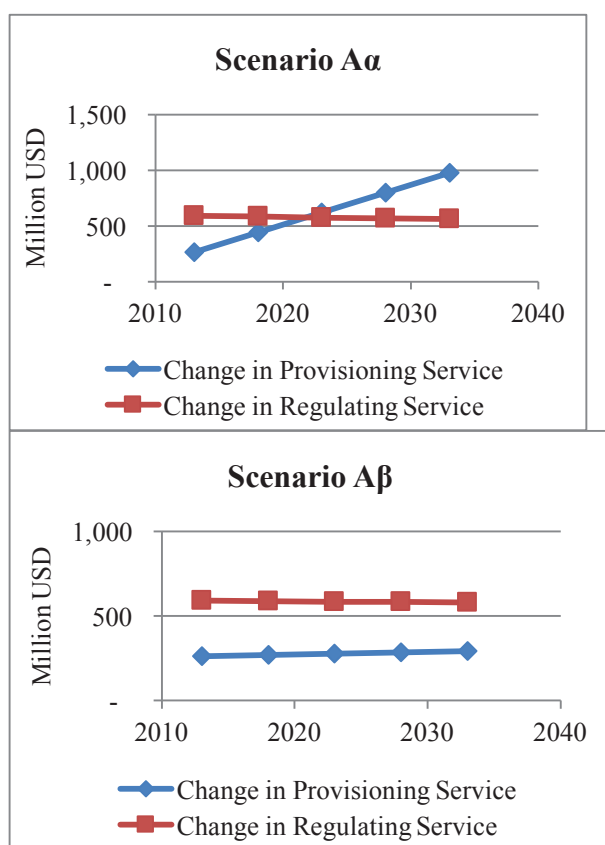
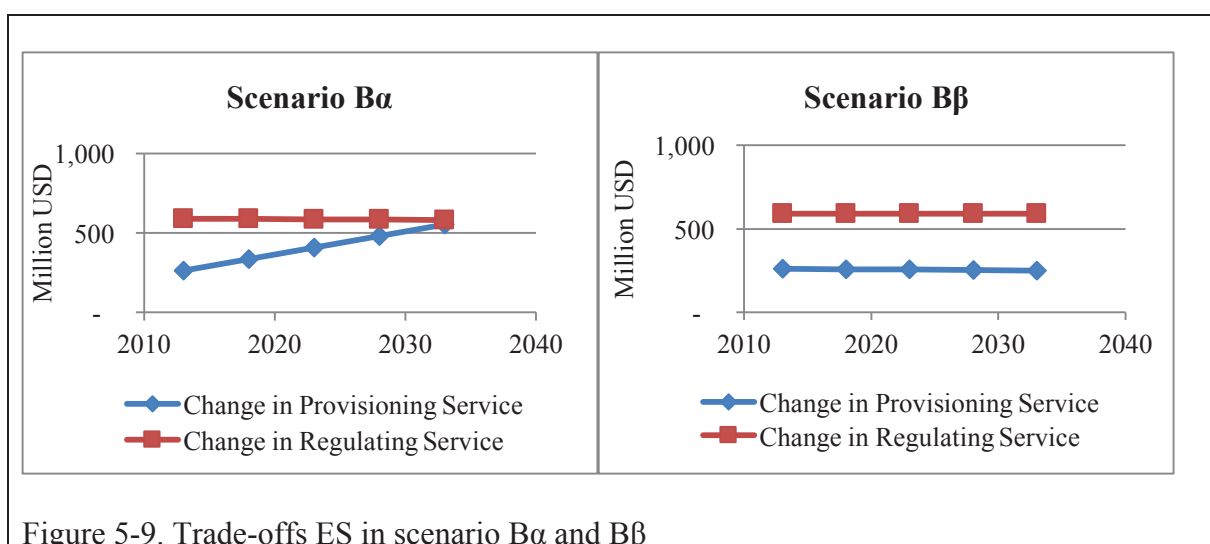


Figure 5-8. Trade-offs ES in scenario A α and A β

5.3.5.2 Trade-offs ES of Policy B and Prices of Rubber (B α and B β)

In the case of a policy is more favorable to smallholders (B), scenario B α generates double provisioning services (USD 552 million), while scenario B β produces only USD 292 million in 2033 (Figure 5-9). The shift from paddy rice to cassava than in rubber, thus high price of rubber have a limited influence on the provisioning services than policy A. It is interesting to highlight that whatever rubber prices are, the policy B creates less carbon sequestration (USD 582 million in B α and USD 581 million in B β) in 2033. Similarly, an increase in provisioning services by investing in agricultural crops leads to a decrease in regulating services when the policy favorable to collective land and in both prices of rubber.



5.4 DISCUSSION AND CONCLUSION

We observed that increasing the provisioning of added-value from agriculture resulted in a decreased regulating services; it is consistent with previous works of Polasky *et al.* (2011) and Briner (2012). In fact, land use changes in the studyarea resulting from agricultural and forestry management decisions expected to have a large impact on ecosystem provisioning. An expansion in agricultural crops leads to a change in land use that is not only unfavorable for the provision of carbon balance but also impacts on biodiversity and other ES, as already described by Nelson *et al.* (2009), Reidsma *et al.* (2006) and Raudsepp-Hearne *et al.* (2010). Increased the GVA of agriculture resulted in a decreased carbon sequestration due to the deforestation.

In most of these model production systems, farmers achieve economic efficiency especially in case of cassava, with this performance being even better if they can adopt the cover crops that could prevent soil loss. Although shifting system provides less provisioning ES, yet it offers the second highest carbon sequestration compared to paddy rice and cassava. This system produces great biodiversity during fallows. Thus, production system that is most efficient economically for farmers and ecological practices in terms of ES provision is a system in which farmers combine shifting with cassava. The opportunity cost of conversion from forest to agricultural crops presents a particularly high value in rubber and cassava based-systems.

Current trade-offs between provisioning and regulating ES in the assessed region are not strongly controlled through Cambodian Forest or Land Laws, allowing an active increase of forest conversion for ELCs. Therefore, market incitation and policies favorable to both private and collective titles are still to be encouraged to extend agricultural land, which potentially generate high provisioning ES but lower regulating ES. To prevent EDS related agricultural practices, this EDS needs to be considered in management schemes since it can strongly influence land use. According to the extreme location conditions of the region, we are strongly concerned with the change in mountains and slopes for rubber and cassava plantations that will be created negative impacts to ecosystems in the future especially soil erosion.

According to Polasky *et al.* (2011), robust ecosystem management schemes must take into consideration projected climatic and economic changes. Climate and socio-economic shifts will affect the ability of ecosystems to provide certain ES, and will influence land users decision making process. Based on the results, the changes in policies and different rubber prices have also influenced the relationship between different ES. For instance, an increase in GVA of agriculture in scenario A α is more than decrease regulation services. On the other hands, this improvement will also be followed by larger reductions of the incomes in the future because the ecosystems are vulnerable to risks caused by the current land uses. To exploit the gain from these synergies scenarios policy and management should seek to promote an agricultural structure that facilitates these synergies in sustainable manners, economic and ecological sounds.

These examples of trade-offs between different ES could be helpful for management schemes for multi-functional landscapes. The areas where synergies between different ES mainly between carbon sequestration and protection occur are large that is good to be maintained by future land use planning and management.

References of Chapter 5

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Annexe of Chapter 5

Table A 5-1. Yields of selected crops in Mondulkiri province (2005-2014) and assumed crop projection (2015-2024)

Year	Shifting rice (kg/ha)	Paddy rice (kg/ha)	Cassava (kg/ha)	Rubber (kg/ha)
2005	783	1100	4000	0
2006	783	1100	7500	0
2007	783	1942	4000	0
2008	0	1150	15000	0
2009	0	1500	15200	0
2010	0	2037	15500	0
2011	0	1859	14136	250
2012	0	2190	13000	550
2013	783	2232	12650	1200
2014	783	1330	9900	1200
2015	783	1100	4000	1200
2016	0	1100	7500	1750
2017	0	1942	4000	1750
2018	0	1150	15000	1750
2019	0	1500	15200	1750
2020	0	2037	15500	1750
2021	783	1859	14136	1750
2022	783	2190	13000	2300
2023	783	2232	12650	2300
2024	0	1330	9900	2300

Table A 5-2. Repartition per hectare of total NPV of ES types at 10 percent discount rate over 20 years

Type of land use	NTFPs	Timber	Production	Carbon sequestration	Soil conservation	Water conservation	Total
Forest	206	515		6,277	562	656	8,216
Shifting			1,600	1,951			3,550
Paddy rice			2,186	1,547			3,733
Cassava			11,883	1,547			13,430
Rubber (USD1.8/kg)			19,226	3,439			22,665
Rubber (USD1.5/kg)			15,400	3,439			18,840
Rubber (USD4/kg)			47,279	3,439			50,718

Table A 5-3. Summary of net present value (NPV) of different forest types

Forest type	Ecosystem services	NPV @8%	NPV @10%	NPV @12%	Annualized NPV @10%
Deciduous	NTFPs	459	365	301	37
	Sustainable timber	-306	-248	-207	-25
	Carbon sequestration	355	336	319	34
	Soil and water protection	932	741	612	75
	Total	1,441	1,194	1,025	120
Semi- evergreen	NTFPs	285	230	192	23
	Sustainable timber	403	367	333	37
	Carbon sequestration	412	401	389	40
	Soil and water protection	1,611	1,300	1,087	131
	Total	2,299	2,445	2,128	247
Evergreen	NTFPs	149	119	100	12
	Sustainable timber	1,931	1,691	1,494	171
	Carbon sequestration	636	610	588	62
	Soil and water protection	2,245	1,300	1,088	131
	Total	4,325	3,721	3,273	375

Source: Hansen & Top (2006)

Table A 5-4. Calculation of NPV of shifting at 10 percent discount rate over 20 years

No. of year	Gross output					Intermediate cost (USD/ha)	NPV (USD/ha)
	Rice yield (kg/ha)	Price (USD/kg)	GO of rice (USD/ha)	Vegetable (USD/ha)	Total GO (USD/ha)		
1	783	0.25	195.75	173	368.75	21.55	315.64
2	783	0.25	195.75	173	368.75	21.55	286.94
3	783	0.25	195.75	173	368.75	21.55	260.86
4	0	0.25	0	0	0	0	-
5	0	0.25	0	0	0	0	-
6	0	0.25	0	0	0	0	-
7	0	0.25	0	0	0	0	-
8	0	0.25	0	0	0	0	-
9	783	0.25	195.75	173	368.75	21.55	147.25
10	783	0.25	195.75	173	368.75	21.55	133.86
11	783	0.25	195.75	173	368.75	21.55	121.69
12	0	0.25	0	0	0	0	-
13	0	0.25	0	0	0	0	-
14	0	0.25	0	0	0	0	-
15	0	0.25	0	0	0	0	-
16	0	0.25	0	0	0	0	-
17	783	0.25	195.75	173	368.75	21.55	68.69
18	783	0.25	195.75	173	368.75	21.55	62.45
19	783	0.25	195.75	173	368.75	21.55	56.77
20	0	0.25	0	0	0	0	-
Total (USD/ha)							1,454.14
Average (USD/ha)							72.71

Table A 5-5. Calculation of NPV of paddy at 10 percent discount rate over 20 years

No. of year	Yield (kg/ha)	Price (USD/kg)	Gross output (USD/ha)	Intermediate cost (USD/ha)	Gross margin (USD/ha)	NPV
1	1100	0.25	275.00	160	115.00	115.00
2	1100	0.25	275.00	160	115.00	104.55
3	1942	0.25	485.50	160	325.50	269.01
4	1150	0.25	287.50	160	127.50	95.79
5	1500	0.25	375.00	160	215.00	146.85
6	2037	0.25	509.25	160	349.25	216.86
7	1859	0.25	464.75	160	304.75	172.02
8	2190	0.25	547.50	160	387.50	198.85
9	2232	0.25	558.00	160	398.00	185.67
10	1330	0.25	332.50	160	172.50	73.16
11	1100	0.25	275.00	160	115.00	44.34
12	1100	0.25	275.00	160	115.00	40.31
13	1942	0.25	485.50	160	325.50	103.71
14	1150	0.25	287.50	160	127.50	36.93
15	1500	0.25	375.00	160	215.00	56.62
16	2037	0.25	509.25	160	349.25	83.61
17	1859	0.25	464.75	160	304.75	66.32
18	2190	0.25	547.50	160	387.50	76.66
19	2232	0.25	558.00	160	398.00	71.58
20	1330	0.25	332.50	160	172.50	28.21
						2186.0
Total (USD/ha)					5,020.00	4
Average (USD/ha)					251.00	109.30

Table A 5-6. Calculation of NPV of cassava at 10 percent discount rate over 20 years

No. of year	Yield (kg/ha)	Price (USD/kg)	Gross output	Intermediate cost (USD/ha)	Gross margin (USD/ha)	NPV
1	4,000.00	0.125	500.00	28.50	471.50	471.50
2	7,500.00	0.125	937.50	28.50	909.00	826.36
3	4,000.00	0.125	500.00	28.50	471.50	389.67
4	15,000.00	0.125	1,875.00	28.50	1,846.50	1,387.30
5	15,200.00	0.125	1,900.00	28.50	1,871.50	1,278.26
6	15,500.00	0.125	1,937.50	28.50	1,909.00	1,185.34
7	14,136.00	0.125	1,767.00	28.50	1,738.50	981.34
8	13,000.00	0.125	1,625.00	28.50	1,596.50	819.26
9	12,650.00	0.125	1,581.25	28.50	1,552.75	724.37
10	9,900.00	0.125	1,237.50	28.50	1,209.00	512.73
11	4,000.00	0.125	500.00	28.50	471.50	181.78
12	7,500.00	0.125	937.50	28.50	909.00	318.60
13	4,000.00	0.125	500.00	28.50	471.50	150.23
14	15,000.00	0.125	1,875.00	28.50	1,846.50	534.87
15	15,200.00	0.125	1,900.00	28.50	1,871.50	492.82
16	15,500.00	0.125	1,937.50	28.50	1,909.00	457.00
17	14,136.00	0.125	1,767.00	28.50	1,738.50	378.35
18	13,000.00	0.125	1,625.00	28.50	1,596.50	315.86

19	12,650.00	0.125	1,581.25	28.50	1,552.75	279.28
20	9,900.00	0.125	1,237.50	28.50	1,209.00	197.68
Total (USD/ha)					27,151.50	11,882.60
Average (USD/ha)					2,585.86	594.13

Table A 5-7. Calculation of NPV of rubber (USD 4/kg) at 10 percent discount rate over 20 years

No. of year	Yield (kg/ha)	Price (USD/kg)	Gross output (USD/ha)	Intermediate cost (USD/ha)	Gross margin (USD/ha)	NPV
1	-	4.00	-	334.00	(334.00)	(334.00)
2	-	4.00	-	148.00	(148.00)	(134.55)
3	-	4.00	-	228.00	(228.00)	(188.43)
4	-	4.00	-	242.00	(242.00)	(181.82)
5	-	4.00	-	235.00	(235.00)	(160.51)
6	-	4.00	-	242.00	(242.00)	(150.26)
7	250.00	4.00	1,000.00	242.00	758.00	427.87
8	550.00	4.00	2,200.00	283.00	1,917.00	983.72
9	1,200.00	4.00	4,800.00	283.00	4,517.00	2,107.21
10	1,200.00	4.00	4,800.00	283.00	4,517.00	1,915.65
11	1,200.00	4.00	4,800.00	283.00	4,517.00	1,741.50
12	1,750.00	4.00	7,000.00	283.00	6,717.00	2,354.27
13	1,750.00	4.00	7,000.00	283.00	6,717.00	2,140.24
14	1,750.00	4.00	7,000.00	283.00	6,717.00	1,945.68
15	1,750.00	4.00	7,000.00	283.00	6,717.00	1,768.80
16	1,750.00	4.00	7,000.00	283.00	6,717.00	1,608.00
17	1,750.00	4.00	7,000.00	283.00	6,717.00	1,461.81
18	2,300.00	4.00	9,200.00	283.00	8,917.00	1,764.18
19	2,300.00	4.00	9,200.00	283.00	8,917.00	1,603.80
20	2,300.00	4.00	9,200.00	283.00	8,917.00	1,458.00
Total (USD/ha)					81,850.00	22,131.17
Average (USD/ha)					7,795.24	1,106.56

Table A 5-8. Calculation of NPV of rubber (USD 1.8/kg) at 10 percent discount rate over 20 years

No. of year	Yield (kg/ha)	Price (USD/kg)	Gross output (USD/ha)	Intermediate Cost (USD/ha)	Gross margin (USD/ha)	NPV
1	(334.00)	1.80	-	334.00	(334.00)	(334.00)
2	(148.00)	1.80	-	148.00	(148.00)	(134.55)
3	(228.00)	1.80	-	228.00	(228.00)	(188.43)
4	(242.00)	1.80	-	242.00	(242.00)	(181.82)
5	(235.00)	1.80	-	235.00	(235.00)	(160.51)
6	(242.00)	1.80	-	242.00	(242.00)	(150.26)
7	208.00	1.80	450.00	242.00	208.00	117.41
8	707.00	1.80	990.00	283.00	707.00	362.80
9	1,877.00	1.80	2,160.00	283.00	1,877.00	875.63
10	1,877.00	1.80	2,160.00	283.00	1,877.00	796.03
11	1,877.00	1.80	2,160.00	283.00	1,877.00	723.66
12	2,867.00	1.80	3,150.00	283.00	2,867.00	1,004.87

13	2,867.00	1.80	3,150.00	283.00	2,867.00	913.51
14	2,867.00	1.80	3,150.00	283.00	2,867.00	830.47
15	2,867.00	1.80	3,150.00	283.00	2,867.00	754.97
16	2,867.00	1.80	3,150.00	283.00	2,867.00	686.34
17	2,867.00	1.80	3,150.00	283.00	2,867.00	623.94
18	3,857.00	1.80	4,140.00	283.00	3,857.00	763.09
19	3,857.00	1.80	4,140.00	283.00	3,857.00	693.72
20	3,857.00	1.80	4,140.00	283.00	3,857.00	630.65
Total (USD/ha)					33,890.00	8627.53
Average (USD/ha)					3,227.62	431.37

Table A 5-9. Calculation of NPV of rubber (USD 1.5/kg) at 10 percent discount rate over 20 years

No. of year	Yield (kg/ha)	Price (USD/kg)	Gross output (USD/ha)	Intermediate Cost (USD/ha)	Gross margin (USD/ha)	NPV
1	-	1.50	-	334.00	(334.00)	(334.00)
2	-	1.50	-	148.00	(148.00)	(134.55)
3	-	1.50	-	228.00	(228.00)	(188.43)
4	-	1.50	-	242.00	(242.00)	(181.82)
5	-	1.50	-	235.00	(235.00)	(160.51)
6	-	1.50	-	242.00	(242.00)	(150.26)
7	250.00	1.50	375.00	242.00	133.00	75.08
8	550.00	1.50	825.00	283.00	542.00	278.13
9	1,200.00	1.50	1,800.00	283.00	1,517.00	707.69
10	1,200.00	1.50	1,800.00	283.00	1,517.00	643.36
11	1,200.00	1.50	1,800.00	283.00	1,517.00	584.87
12	1,750.00	1.50	2,625.00	283.00	2,342.00	820.86
13	1,750.00	1.50	2,625.00	283.00	2,342.00	746.23
14	1,750.00	1.50	2,625.00	283.00	2,342.00	678.39
15	1,750.00	1.50	2,625.00	283.00	2,342.00	616.72
16	1,750.00	1.50	2,625.00	283.00	2,342.00	560.66
17	1,750.00	1.50	2,625.00	283.00	2,342.00	509.69
18	2,300.00	1.50	3,450.00	283.00	3,167.00	626.57
19	2,300.00	1.50	3,450.00	283.00	3,167.00	569.61
20	2,300.00	1.50	3,450.00	283.00	3,167.00	517.83
Total (USD/ha)					27,350.00	8627.53
Average (USD/ha)					2,604.76	431.37

Table A 5-10. Calculation of annual carbon sequestration of all crops and forest

Type of land use	Average TEC (t CO ₂ e/ha)	Price of CO ₂ (USD/ton)	Annual carbon sequestration (USD/ha)
Forest	1,569	5	7,845
Rubber	860	5	4,300
Shifting	488	5	2,440
Cassava	387	5	1,935
Paddy rice	387	5	1,935

Table A 5-11. Calculation of TEV of forest (USD/ha) at 10 percent discount rate over 20 years

No. of year	NPV of NTFPs @10%	NPV of Timber @10%	NPV of Soil conservation @10%	NPV of water conservation @10%	NPV of Carbon sequestration @4%	TEV (USD/ha)
1	22.00	55.00	60.00	70.00	313.87	520.87
2	20.00	50.00	54.55	63.64	313.87	502.05
3	18.18	45.45	49.59	57.85	313.87	484.94
4	16.53	41.32	45.08	52.59	313.87	469.39
5	15.03	37.57	40.98	47.81	313.87	455.25
6	13.66	34.15	37.26	43.46	313.87	442.40
7	12.42	31.05	33.87	39.51	313.87	430.71
8	11.29	28.22	30.79	35.92	313.87	420.09
9	10.26	25.66	27.99	32.66	313.87	410.43
10	9.33	23.33	25.45	29.69	313.87	401.65
11	8.48	21.20	23.13	26.99	313.87	393.67
12	7.71	19.28	21.03	24.53	313.87	386.42
13	7.01	17.52	19.12	22.30	313.87	379.82
14	6.37	15.93	17.38	20.28	313.87	373.83
15	5.79	14.48	15.80	18.43	313.87	368.38
16	5.27	13.17	14.36	16.76	313.87	363.42
17	4.79	11.97	13.06	15.23	313.87	358.92
18	4.35	10.88	11.87	13.85	313.87	354.82
19	3.96	9.89	10.79	12.59	313.87	351.10
20	3.60	8.99	9.81	11.45	313.87	347.71
Total	206.03	515.07	561.90	655.54	6,277.33	8,215.87
Annual	10.30	25.75	28.09	32.78	313.87	410.79

Table A 5-12. Calculation of TEV of shifting at 10 percent discount rate over 20 years

No. of year	NPV of gross margin of production @10% (USD/ha)	NPV of carbon of shifting @4% (USD/ha)	TEV (USD/ha)
1	315.64	97.53	413.17
2	286.94	97.53	384.48
3	260.86	97.53	358.39
4	-	97.53	97.53
5	-	97.53	97.53
6	-	97.53	97.53
7	-	97.53	97.53
8	-	97.53	97.53
9	147.25	97.53	244.78
10	133.86	97.53	231.39
11	121.69	97.53	219.22
12	-	97.53	97.53
13	-	97.53	97.53
14	-	97.53	97.53
15	-	97.53	97.53
16	-	97.53	97.53
17	68.69	97.53	166.23
18	62.45	97.53	159.98

19	56.77	97.53	154.30
20	-	97.53	97.53
Total	1,454.14	1,950.67	3,404.81
Annual	72.71	97.53	170.24

Table A 5-13. Calculation of TEV of paddy rice at 10 percent discount rate over 20 years

No. of year	NPV of gross margin of production @10% (USD/ha)	NPV of carbon of paddy rice @4% (USD/ha)	TEV (USD/ha)
1	115.00	77.37	192.37
2	104.55	77.37	181.91
3	269.01	77.37	346.37
4	95.79	77.37	173.16
5	146.85	77.37	224.21
6	216.86	77.37	294.22
7	172.02	77.37	249.39
8	198.85	77.37	276.22
9	185.67	77.37	263.04
10	73.16	77.37	150.52
11	44.34	77.37	121.70
12	40.31	77.37	117.67
13	103.71	77.37	181.08
14	36.93	77.37	114.30
15	56.62	77.37	133.98
16	83.61	77.37	160.97
17	66.32	77.37	143.69
18	76.66	77.37	154.03
19	71.58	77.37	148.95
20	28.21	77.37	105.57
Total	2,186.04	1,547.33	3,733.37
Annual	109.30	77.37	186.67

Table A 5-14. Calculation of TEV of cassava at 10 percent discount rate over 20 years

No. of year	NPV of gross margin of production @10% (USD/ha)	NPV of carbon of cassava @4% (USD/ha)	TEV (USD/ha)
1	471.50	77.37	548.87
2	826.36	77.37	903.73
3	389.67	77.37	467.04
4	1,387.30	77.37	1,464.67
5	1,278.26	77.37	1,355.63
6	1,185.34	77.37	1,262.71
7	981.34	77.37	1,058.70
8	819.26	77.37	896.62
9	724.37	77.37	801.74
10	512.73	77.37	590.10
11	181.78	77.37	259.15
12	318.60	77.37	395.97
13	150.23	77.37	227.60
14	534.87	77.37	612.23

15	492.82	77.37	570.19
16	457.00	77.37	534.37
17	378.35	77.37	455.71
18	315.86	77.37	393.23
19	279.28	77.37	356.64
20	197.68	77.37	275.05
Total	11,882.60	1,547.33	13,429.94
Annual	594.13	77.37	671.50

Table A 5-15. Calculation of TEV of rubber (USD 4/kg) at 10 percent discount rate over 20 years

No. of year	NPV of gross margin of production @10% (USD/ha)	NPV of carbon of rubber @4% (USD/ha)	TEV (USD/ha)
1	(334.00)	171.97	(162.03)
2	(134.55)	171.97	37.42
3	(188.43)	171.97	(16.46)
4	(181.82)	171.97	(9.85)
5	(160.51)	171.97	11.46
6	(150.26)	171.97	21.70
7	427.87	171.97	599.84
8	983.72	171.97	1,155.69
9	2,107.21	171.97	2,279.18
10	1,915.65	171.97	2,087.62
11	1,741.50	171.97	1,913.47
12	2,354.27	171.97	2,526.23
13	2,140.24	171.97	2,312.21
14	1,945.68	171.97	2,117.64
15	1,768.80	171.97	1,940.76
16	1,608.00	171.97	1,779.96
17	1,461.81	171.97	1,633.78
18	1,764.18	171.97	1,936.15
19	1,603.80	171.97	1,775.77
20	1,458.00	171.97	1,629.97
Total	22,131.17	3,439.33	25,570.50
Annual	1,106.56	171.97	1,278.53

Table A 5-16. Calculation of TEV of rubber (USD1.8/kg) at 10 percent discount rate over 20 years

No. of year	NPV of gross margin of production @10% (USD/ha)	NPV of carbon of rubber @4% (USD/ha)	TEV (USD/ha)
1	(334.00)	171.97	(162.03)
2	(134.55)	171.97	37.42
3	(188.43)	171.97	(16.46)
4	(181.82)	171.97	(9.85)
5	(160.51)	171.97	11.46
6	(150.26)	171.97	21.70
7	117.41	171.97	289.38
8	362.80	171.97	534.77

9	875.63	171.97	1,047.60
10	796.03	171.97	968.00
11	723.66	171.97	895.63
12	1,004.87	171.97	1,176.83
13	913.51	171.97	1,085.48
14	830.47	171.97	1,002.43
15	754.97	171.97	926.94
16	686.34	171.97	858.30
17	623.94	171.97	795.91
18	763.09	171.97	935.05
19	693.72	171.97	865.68
20	630.65	171.97	802.62
Total	8,627.53	3,439.33	12,066.86
Annual	431.38	171.97	603.34

Table A 5-17. Calculation of TEV of rubber (USD1.5/kg) at 10 percent discount rate over 20 years

No. of year	NPV of gross margin of production @10% (USD/ha)	NPV of carbon of rubber @4% (USD/ha)	TEV (USD/ha)
1	(334.00)	171.97	(162.03)
2	(134.55)	171.97	37.42
3	(188.43)	171.97	(16.46)
4	(181.82)	171.97	(9.85)
5	(160.51)	171.97	11.46
6	(150.26)	171.97	21.70
7	75.08	171.97	247.04
8	278.13	171.97	450.10
9	707.69	171.97	879.66
10	643.36	171.97	815.32
11	584.87	171.97	756.84
12	820.86	171.97	992.82
13	746.23	171.97	918.20
14	678.39	171.97	850.36
15	616.72	171.97	788.69
16	560.66	171.97	732.62
17	509.69	171.97	681.65
18	626.57	171.97	798.54
19	569.61	171.97	741.58
20	517.83	171.97	689.80
Total	6,786.13	3,439.33	10,225.46
Annual	339.31	171.97	511.27

Table A 5-18. Trade-offs ES of policies and prices of rubber

Description item	Baseline 2013					Total
	Rubber	Cassava	Paddy rice	Shifting	Forest	
Area in cultivation (ha)	83,531	10,271	22,893	8,468	1,290,506	
Provisioning service (million USD)	141.54	13.94	5.75	1.10	99.37	261.70
Regulation service (million USD)	14.36	0.79	1.77	0.83	572.81	590.57
Total (million USD)	155.91	14.74	7.52	1.93	672.18	852.27
Scenario A α						
Area in cultivation (ha)	206,341	31,109	0	0	1,178,219	
Provisioning service (million USD)	844.45	42.23	-	-	90.72	977.41
Regulation service (million USD)	35.48	2.41	-	-	522.97	560.86
Total (million USD)	879.93	44.64	-	-	613.70	1,538.27
Scenario A β						
Area in cultivation (ha)	88,109	19,429	9,157	5,080	1,293,894	
Provisioning service (million USD)	120.49	26.38	2.30	0.66	99.63	249.46
Regulation service (million USD)	15.15	1.50	0.71	0.50	574.32	592.18
Total (million USD)	135.64	27.88	3.01	1.16	673.95	841.63
Scenario B α						
Area in cultivation (ha)	93,511	52,085	4,579	0	1,265,494	
Provisioning service (million USD)	382.69	70.71	1.15	-	97.44	552.00
Regulation service (million USD)	16.08	4.03	0.35	-	561.71	582.18
Total (million USD)	398.77	74.74	1.50	-	659.15	1,134.17
Scenario B β						
Area in cultivation (ha)	83,531	57,487	9,157	0	1,265,494	
Provisioning service (million USD)	114.23	78.04	2.30	-	97.44	292.01
Regulation service (million USD)	14.36	4.45	0.71	-	561.71	581.23
Total (million USD)	128.59	82.49	3.01	-	659.15	873.24

CHAPTER 6: GENERAL CONCLUSION
CHAPITRE 6 : CONCLUSION GENERALE

CHAPTER 6: GENERAL CONCLUSION

Mirroring global trends, the upland Cambodia is facing unprecedented pressures on its land base for commercial forest conversion, agricultural plantations, immigration, and infrastructure demand, while concurrently there are raising concerns related to forest degradation, food security, climate change mitigation and adaptation, and other factors integral to the well-being of the country. Recognizing these challenges, communities, policy makers, relevant stakeholders and leaders are pursuing new strategies to incorporate the values of natural capital into land use planning and policy decisions. This dissertation proposes the modeling of the integration of ecosystem services (ES) into agricultural land use planning and strategies that may preserve natural resources, while enhancing food security in the upland areas of Cambodia.

Specifically, this dissertation is seeking to answer the following research questions: What are the determining factors for change in land use and the provision of ES? What are the trade-offs in the provision of different ES and are there trade-offs affected by the change in policies? On farm level, what are the possible strategies which contribute to mitigate trade-offs in the provision of ES?

For responding to these questions, we have constructed a specific approach based on the methodology of agrarian system analysis and diagnosis by Cochet (2004) and Mazoyer and Roudart (2006). This was combined with the development of scenarios based on expert opinions (Pillot et al., 2000), identifying the most expected reactions of the various stakeholders to different policies implemented by the local administrations, and on calculations of ES and EDS values by using the framework of Zhang et al. (2007).

Three main manuscripts structure this dissertation and detail the results. The first manuscript starts with understanding the drivers of the land use changes in the study area, and the relative impact of the public land policies with regard to the impact of market incitations. The transformation of farming systems concerning the land use changes are then precisely determined in manuscript 2. Understanding the transformation of agricultural techniques allows identifying ecosystem services (ES) and dis-services (EDS) flows to agriculture. Last manuscript is highly focused on the calculation of the economic efficiency of the different possible land uses. The approach of farming system analysis is combined with ES and EDS framework, linking agro-ecosystem and agricultural practices, then calculating the opportunity cost of conversion of the forest to assure ES provision and trade-offs.

6.1 DETERMINATION OF THE MAJOR LAND USE CHANGES AND ELABORATION OF SCENARIOS FOR THE FUTURE

Southeast Asia has experienced major changes in land use and land cover (LULC) in the last two decades. In Cambodia, most areas of forest losses are in the hilly zones and along the mountain ranges where evergreen and semi-evergreen forests are located. Forest change hotspots are frequently situated in the areas bordering to Lao PDR, Vietnam and Thailand. Forests have been increasingly at risk, particularly during the past decades, because of expanding demand for agricultural land and timber in combination with infrastructure development, illegal logging, fuelwood consumption and poverty.

A number of competing schools of thoughts have significantly discussed the causes of LULC, particularly in relation to forests. These views continue to provoke debate within academia, government and civil society. Hirsch (1999) and Lambin et al. (2001) reminded us that within the academia there has often been a popular association between deforestation, poverty incidence and high population. Additionally, the LULC research community has developed a wide range of spatially explicit land use change models over the past decade.

To the best of our knowledge, very little studies published in the literature address scenarios of future change in political and socio-economic conditions at a resolution level that is suitable to incorporate the strategies of the economic stakeholders, namely the local farmers.

In rural Cambodia more particularly, the dual population and land situation is likely to generate important migrations from the inland to the margins of the country, with a key impact on the deforestation and land use in general. However, this situation is also seen as the result of institutional reforms promoted since the early 2000's, including the publication of the Land Law, the Forestry Law, as well as the decrees and regulations following them.

Land use change produces both desirable and undesirable impacts. The assessment of land use changes determines the driver factors and measures its impacts or consequences. Based on our field surveys between 2011 and 2013 conducted in Mondulkiri province, we therefore have analyzed the major changes in the land use as resulting from the successive public policies. Considering the diverse strategies of local stakeholders previously identified in the chosen province, the research also elaborates four scenarios of further transformations foreseen in the next ten years, mainly based on experts' opinions. Several key questions can be asked: why and how the current situation has been historically generated; what were the consequences of the successive policies on the land rights of the stakeholders, consequently on the migrations and

the population growth, and finally how one can use this knowledge to assess the potential political choices by looking forward to their possible impacts. The modelling of the land use changes and their impacts under each of the scenarios is assessed by various criteria that correspond to different policy objectives: the economic production, measured by the Gross Value-Added (GVA), the level of employment (number of workers), paddy rice consumption, paddy rice production and the growth of population through the migrations.

The findings show that, in Cambodia, most areas of forest losses are located in the hilly zones and along the mountain ranges. The history of land use in Mondulhiri relates forestland conversion to the increase of land concessions and to the arrival of migrants from the more populated provinces of central Cambodia. Land use is rapidly changing in the studied villages. However, immigration, while having doubled the population in the last ten years, has not led yet to acute problems of integration. The same villages host the two populations of migrants and indigenous people (IP). The growing market integration of the farming systems has stimulated land exchanges and accelerated land alienation. Moreover, while their livelihoods are undoubtedly different, the two populations have somehow mutually benefited from each other: the Phnong have sold a part of their already deforested land to the arriving Khmers, while they moved to more permanent cultivation or accelerated cycles of shifting systems. The Khmer found there an easily accessible resource (land already deforested), ready for cassava cultivation, under the condition they could master the weeds thanks with the use of herbicides. By doing so, they benefited from most of the remaining fertility rent after the deforestation.

As land is highly considered as a marketable commodity, particularly if planted with valuable crops like pepper or rubber, economic incentives are created to develop forest land for income or for sale. In parallel with these movements, the high prices of rubber, which have been the engine of the interest of concession companies, have decreased since 2011, so that the concessions were allocated in a period of high prices, but investments in plantations should occur now that the prices have fallen by half.

However, land as a market commodity conflicts with indigenous land management concepts, which regard land and forests as collective resource to be kept intact for future generations. So, the future of the territory is therefore at a crossroad. Very different scenarios look possible, going from a large development of the plantations in the concessions up to a partial retrocession of the concession lands to the local communities, and a land use more oriented on cassava and rice crops. Four of these scenarios have been assessed; based on the most expected reactions of the various stakeholders to the different policies implemented by

the local administrations and to different economic market conditions. The results suggest that, in some cases, the value-added of crops may be high enough to generate a positive income, but the compensation for environmental losses and opportunity costs are still undefined and uncertain. This seems to be particularly the case of rubber compared to other alternative land uses including forest or shifting cultivation. The future of shifting systems, squeezed between the expansion of concessions and the development of permanent cultivation of paddy rice and cassava, raises also questions, since the reduction of the surfaces or of the duration of the fallows may have a major impact on the total land use. In all these cases, the scenarios may serve as a transparent framework to ensure that decisions are based on assessments that take into consideration ecosystem trade-offs in the future.

This results of this article thus partly confirm *the hypothesis 1* according to which “policy on ELCs may have had positive impacts on economic outputs rather than on environment while policy on collective titles produced high ES”, whereas the prices of rubber generate high impacts.

6.2 UNDERSTANDING FARMERS’ STRATEGIES, INNOVATIONS AND CHANGES IN UPLAND CAMBODIA

In a Malthusian perspective, primarily focused on the population growth and its relationship with a limited availability of resources; in a closed environment and without major innovation breakthrough, population tends to increase at a faster rate than its food supply (van de Walle, Malthus and Appleman, 1977). Whereas among another important body of the literature, Boserup (1965) is more optimistic, claiming that population pressure is the impetus which drives smallholder farmers to innovate and to intensify their agricultural production to meet growing subsistence needs (Ruthenberg, 1980; Barlett, 1982; Netting, Stone and Stone, 1989; Stone, Netting and Stone, 1990; Netting, 1993). Understanding the relation among population, technology, and resources embedded in the interpretation of such agricultural intensification remains a fundamental problem confronting the human sciences. These relationships are critical to the question of agricultural change in Mondulkiri province of Cambodia. What are the factors of the changes? What are the natures of changes? Are those changes the same for everyone? What are the impacts and will the changes be sustainable? This paper explores the agrarian changes, the strategies of the stakeholders and their consequences, and finally the future of agriculture of these areas. The concept of agrarian system (Barral *et al.*, 2012) is used to link the technical and social transformation in the rural society study with change in social, economic and political context at study area. Then, a production function-based valuation

approach is also used to specify the feasible output of goods and services that could be produced in each cropping system, with a given set of inputs (labour, machinery, natural resources, etc.).

The first finding on the farming systems of Cambodia's upland eastern border are highly linked with the demographics of the province. The two successive waves of Khmer immigration since the 90s have led to a total reorganisation of the agrarian system which was originally based on shifting cultivation. A number of the plots previously cultivated with the shifting system have been sold to the new immigrants, leading to an equivalent reduction of the land cultivated by the local population. In front of this situation, indigenous households seem to have little extended their lands in the forest itself. They rather diversified their activities, selling more and more labour in the cassava farms developed by the immigrants. Thanks to the high price of the commodity, the agricultural wages on the labour market have raised at three times the opportunity costs -as measured by the labour productivity in the shifting systems.

The extension of permanent farming now displays a contrasted picture. The traditional shifting system is replaced by two different permanent cultivation systems. First, the permanent paddy rice cultivation offers a lower productivity than the former slash-and-burn systems. It can therefore be analysed as a Malthusian adaptation to meet the needs of intensification, led by the reduction of the access to land, when, at the same moment, the paddy rice production has to increase to feed the growing population. However, it can also be seen as a resistance from the Phnong society that gives to the local production of paddy rice, a value that goes far beyond its market price. On the contrary, the Khmer immigrants, who are not sensible to these values, largely ignore the paddy rice production.

The alternative to the shifting cultivation, the cassava mono-cropping, presents a much higher land and labour productivities than its predecessor. In this sense, it does not correspond to a Malthusian adaptation but to a real innovation that multiplies the change and generates encouragements to new additional migrations. The innovation looks robust, with a continuous increase of the acreage and of the number of farmers since the mid-2005.

The cassava extension has therefore been the engine that has attracted Khmer immigration in the province and pulled the indigenous population out of the shifting cultivation, directly through the land exchanges and indirectly by generating a call for manpower. However, a closed analysis of the success of the cassava systems shows that they might not be so definitively successful in the long run. The price of the cassava, partly linked with the biofuel industry, should drop down. Even more expected is the decline of the yields, sooner or later,

but unavoidable, compromising the labour productivity which is already slightly below the labour market cost. Finally, the cost of the labour itself can still go up, following the demand in other sectors especially the rubber plantations that are currently coming into production. The productivity of the crop could strongly be decreased or even led to zero by any of the three events above, and even more by a combination of the three of them.

However, a possible failure of the cassava in the future, either by a fall of the market or by the full consumption of the fertility rent, would of course lead to a renewed interest for the shifting systems. This may bring about new land transformations: the lands having previously carried these systems have been sold and would have lost their fertility, thus becoming unable to carry again the same kind of cultivation; there would be then no other way out than accepting a certain level of shifting in the large areas remaining covered by forests still now.

Provided the strict condition that the duration of the fallow is sufficient, the system may be ecologically sustainable. This calls to pay a close attention to the public policies in the future, especially the allocation of land rights, which can take into consideration, both the necessary preservation of the forest and a moderate exploitation of the slopes, under strict conditions. These results would respond to *the hypothesis 2* “at the heart of problem, transformation is needed from a primarily subsistence-oriented agriculture, characterized by low use of inputs and low returns to land, to a more intensive agriculture, probably more commercially oriented whereas respectful of the key ecosystem services”.

6.3 SYNERGIES AND TRADE-OFFS BETWEEN ECOSYSTEM SERVICES

Trade-off analysis is an important facet in the assessment studies of ecosystem services (ES) (Carpenter *et al.*, 2009; Mooney *et al.*, 2009), and it is a key issue when integrating ES in landscape planning, management, and decision making (De Groot, Alkemade *et al.* 2010) as well as in the analysis of alternative pathways that lead to future sustainable land use (Rounsevell, Pedroli *et al.* 2012). However, little is known about trade-offs between ES within various types of land use in Mondulkiri province, especially about the consequences of the replacement of forests and long-fallow shifting agricultural systems by permanent agriculture, to provide convincing evidence as to which land cover or land use offers the more valuable services. Considering uncertainties about carbon stocks and fluxes linked with changes in land use, it remains unclear how trade-offs among services can be addressed, what contexts or policies may help to reduce some of the most undesirable impacts; and how possible rational

decisions on land use can be made. We aimed at analyzing the trade-offs in ES of different land uses along several designed scenarios in Mondulkiri.

The framework of Zhang *et al.* (2007) is employed in order to define ecosystems and agriculture that are embedded in a complex relationship based on positive and negative interrelations and feedback loops. To define the different flows of ES and EDS, we also adapted field methodology from various studies of agrarian analysis and diagnosis (Cochet and Devienne, 2006; Dufumier, 2006; Cochet, Devienne and Dufumier, 2007; Cochet, 2012). There are three key steps to understand farmers' choices and under socio-economic and political conditions: (i) landscape reading; (ii) historical study; and (iii) production system modeling and performance economic calculation. We assessed the components of the total economic value (TEV) of these ES, namely the market value of goods and services, as well as the 'intrinsic' values of biodiversity. The cost-benefit analysis (CBA) was primarily used for estimating the provisioning services of rubber, cassava, paddy rice and non-timber forest products (NTFPs) productions. The net present value (NPV) can be described as the difference between the present or discounted value of benefits and the present or discounted value of costs.

Increasing the provisioning of added-value from agriculture resulted in a decrease of the regulating services; this is consistent with the previous works of Polasky *et al.* (2011) and of Briner (2012). In fact, land use changes in the study region not only impact on the carbon balance, but also negatively on biodiversity and other ES.

In most of these production systems models, farmers achieve economic efficiency as perceived on the short term, especially in the case of cassava. On its side, the opportunity cost of conversion of the forest into crops present a particularly high value in the case of rubber and cassava-based systems.

On their side, shifting systems provide less provisioning ES, compared to paddy rice and cassava, whereas they offer the second highest carbon sequestration after permanent forest. This system maintains a high level of biodiversity during the fallows. Consequently, production systems that are the most efficient economically for farmers and with acceptable consequences in term of provision of ES, could be systems in which farmers combine shifting cultivation on the slopes with cassava on the hill foots.

Current trade-offs between provisioning and regulating ES in the assessed region are not strongly controlled through Cambodian Forest or Land Laws, allowing a dynamic increase of forest conversion by the ELCs. For this reason, market incitation and policies favorable to both

private and collective titles are still encouraging the extension of agricultural land, which potentially generate high provisioning ES but lower regulating ES. To avoid EDS related to agricultural practices, this EDS needs to be taken into account in management schemes that can strongly influence land use. According to the conditions of the region, we are strongly concerned with the changes in mountains and slopes, dominated by the extension of rubber and cassava plantations that will create negative impacts, especially soil erosion to ecosystems in the future.

In accordance with what Polasky et al. (2011) promote, robust production and ecosystem management schemes must take into consideration the expected climatic and economic changes. Climate and socio-economic shifts will affect the ability of ecosystems to provide certain ES, and will influence land users' decision making process. Based on these results, the changes in policies at different rubber prices have also influenced the relationship between the various ES. For instance, increased GVA of agriculture in scenario A α is more than the decrease of regulation services. On the other hand, larger reductions of the income in the future will also follow this improvement; since the ecosystems are vulnerable to risks caused by the current land uses. To maximize the gain from these synergies scenarios, policy and management should seek to promote an agricultural structure that facilitates these synergies in a sustainable manner, economic and ecological sound.

These examples of trade-offs between different ES could be helpful for the management schemes for multifunctional landscapes. These also answered the questions raised *in hypothesis 3* regarding “the consequences of the replacement of forest and long-fallow shifting agricultural systems by permanent agriculture, to provide convincing evidence as to which land cover or land use offers the more valuable services.” The areas are large where synergies occur between different ES, mainly between carbon sequestration and biodiversity protection, that should be maintained in the future land use planning and management.



The current land use changes in the uplands of Cambodia have raised critical concerns on food security, economic development, and future of ecosystem services. In front of these, understanding the production strategies of the agricultural stakeholders and their impact on the production of ecosystem services clarifies the debate.

Firstly, a succession of significant institutional developments has been achieved in Cambodia in the 2000s, following the Land Law in 2002, the Forest Law in 2003 and the subsequent decrees based on them. Far from being a desert of institutions, the Far East is on the contrary rather rich in legal regulations, at least on the paper. However, the successive layers of institutions have created a legal framework that can still be used in any direction, either to reinforce the position of the concessions or, on the contrary, to protect, or sometimes to restore, the access rights of the local communities.

The recent failure of the directive 001BB, that intended to clarify the access rights of the various stakeholders in Mondulhiri, particularly when collective properties were involved, has confirmed that the unstable land tenure situation was not secured by the recent progresses of the legal framework. Especially, the collective land titling could not be achieved; the overall land registration process, while very free of charge, is still convoluted, time-consuming and finally not encouraging landholders to participate in the land registration. Without strong support from NGOs agencies on collective registration, communities cannot claim for collective duly recognized land titles.

For long term investments in sustainable forest management by foreign investors or local communities, clear and secure land titles as well as user rights are fundamental to be taken into consideration and implementation. Therefore, the focus should be on completing the collective titling process underway before new decisions on forest conversion through the ELCs will be made. Once local people's rights are secured including forest conversion, ELCs can be allocated. This should be a high priority centrally to avoid future conflicts in forest management and forest conversion decisions.

Secondly, in such an uncertain context, looking at the strategy of the rural stakeholders may help to better understand the dynamics and to foresee the possible future trends. The first conclusion at this level is that even without shifting agriculture, farmers have already managed to re organise a diversity of income that represents a certain protection against the possible events in the economic environment. Shifting farming and collection of NTFPs should be considered as sustainable practices under conditions of undertaking.

However, the remaining area left to shifting cultivation is highly at stake. Only two of the six farming system types still include shifting cultivation. Among them, only the subgroups of those who have more than 4 ha to cultivate (representing less than 20 percent of these types) appear to be in position to maintain sustainably shifting cultivation.

Yet these systems are increasingly vulnerable in front of the expansion of cassava and rubber plantations into fallows and secondary forests. This transition is also precipitated by government's policy, whose rationale is to integrate marginal land into the global market and to lead to the end of shifting farming, a practice considered as backward, unproductive and environmentally destructive. The loss of shifting paddy rice fields and their transformation into commercial crop plantations also increases the risks of local food insecurity since the production of rice declines when population grows.

Third, in front of the low efficiency of public land policies, market incitation becomes the only one that really affects the orientations taken by the stakeholders for their land use. The rubber market price is still more effective than the superposition of the land law and the forest law to orientate the local land uses. The case of Mundolkiri confirms that the emergence of public institutional regulation frameworks, whatever important this might be to build a capacity of arbitration between the provisioning and the regulation services, is not enough to generate strong orientations. There are challenges to strengthen coherence in the policy framework, to improve the capacity of local public bodies to address land use issues, investing in research and data acquisition in the process, and to adopt a more proactive approach.

The scenarios we elaborated indicate that the policy favouring large-scale concessions may result in several positive effects, while only when the rubber prices are high. The findings of this foresight show that the economic returns from annual crop productions would be lower than from rubber when the market is favourable, but would be higher when the prices are low. The most important benefits from a rubber plantation extension will go to concession companies rather than to individual smallholders. On the contrary, policy more favourable to the rights of indigenous communities and of individual immigrants leads to higher employment creation and better-balanced food security.

Lastly, the trade-off analysis between different land uses in the study area provides good evidence for calculating the opportunity costs of maintaining ES in the Province. Agrarian systems analysis and diagnosis appears useful to structure the framework of the economic calculations. The cost of conversion of forests into alternative land uses has demonstrated the needs for improving the regulating and provisioning services. Efficient production systems have been considered.

The limitation of the calculation should however be clearly enlightened. The calculation of carbon sequestration, soil erosion and water conservation into monetary values remains

difficult. The estimation of total economic value is worth improving due to the number of data that are randomly selected from various case studies.

Understanding how to respond to an undersupply of specific services requires multi-scale thinking, considering trade-offs and synergies between services. From the brief insight into some of the more detailed land use and ES interactions provided in this research, there is clearly a need to think more strategically about how rural land is used. This will help policy makers and land managers to optimize the use of rural land to meet growing demands and ensure greater synergies between different ecosystem services.



Based on the results, we are able to conclude on theoretical approaches which have been essentially used as following:

Agrarian System Analysis and Diagnostic shows very clearly what strategies farmers use to extract ecosystem services from resources with regard to the availability of capital, labour, and land. This approach provides complete information related to input application and quantity of labour for various productions. The fundamental approach helps to discover the historical basis of the current situation and strategies of local people with regard to different regimes. It also facilitates measuring the impacts of agricultural practices on ES while the measurement itself will require complementary frameworks, data and information

However, the limitations of this approach are: The changes in the ecosystem are impacted by strategies of the local stakeholders but far beyond only the farmers and the agricultural productions whereas ASA is concentrating on farmers mainly. When it can explain the individual strategies of farmers, the changes in the ecosystem result from interactions between the individual strategies, and this level is not totally addressed by ASA. It can measure the opportunity costs of specific land uses but not the cost of regulating services.

The ES framework precisely complements these weaknesses by providing opportunity to give value to environmental goods not commonly considered by ASA. From our experiences in this dissertation, we did not meet any contradiction while combining the two theoretical frameworks which usefully complement each other. This being said we only considered a limited number of ES, and provision and regulating services but not the cultural services. It is

still possible that contradiction may exist between the two frameworks when considering those.

The further research should precise the regulating services and cultural services especially for biodiversity, soil erosion, water, and so on. Test the consideration to the option and non-use values, including conversion of cultural and spiritual value into monetary terms.

CHAPITRE 6 : CONCLUSION GENERALE

Reproduisant une tendance générale dans la région, les hautes-terres du Cambodge doivent faire face à des pressions foncières sans précédent, que ce soit par et pour l'exploitation de la forêt, par les plantations agricoles, par l'immigration ou par les besoins d'infrastructures. Au même moment, au nom du bien-être général, les préoccupations relatives à la dégradation de la forêt, à la sécurité alimentaire, à l'adaptation et à l'atténuation du changement climatique se font de plus en plus pressantes.

Prenant conscience de ces défis, les communautés locales, les acteurs des politiques et autres leaders poursuivent de nouvelles stratégies pour inclure les valeurs correspondant au capital naturel dans la planification de l'utilisation des sols et dans la préparation des décisions politiques. Cette thèse propose une modélisation de l'intégration des services écosystémiques dans la planification de l'utilisation agricole du sol et des stratégies qui puissent conserver les ressources naturelles tout en renforçant la sécurité alimentaire des hautes terres du Cambodge.

Plus précisément, nous avons cherché à répondre aux questions de recherche suivantes: Quels sont les facteurs déterminants du changement dans l'utilisation des terres et la fourniture de services écosystémiques ? Quels sont les compromis dans la fourniture des différents services écosystémiques et dans quelle mesure ces compromis se trouvent modifiés par le changement dans les politiques publiques ? Au niveau des exploitations agricoles, quelles sont les stratégies possibles qui contribuent à améliorer les compromis dans la fourniture de services écosystémiques ?

Pour répondre à ces questions, nous avons construit une approche spécifique utilisant en premier lieu des outils tirés de l'analyse des systèmes agraires et du diagnostic par Cochet (2004) et Mazoyer et Roudart (2006). Ces outils sont combinés au développement de scénarios sur avis d'experts (Pillot et al., 2000), appuyés sur l'identification des réactions attendues des acteurs locaux face à différentes politiques possibles mises en œuvre par les administrations locales et face aux différentes conditions du marché économique. Enfin, l'approche intègre l'utilisation du cadre de Zhang et al. (2007) pour le calcul de la valeur de la forêt et des ES et EDS dans l'agriculture.

Trois principaux articles structurent cette thèse. Le premier article commence par analyser les changements dans l'utilisation des terres dans la zone d'étude et l'impact des politiques publiques foncières au regard de celui lié aux incitations des marchés. La transformation des systèmes agricoles sont pour leur part précisément abordés dans le second article. Comprendre

la transformation des techniques agricoles permet d'identifier les services écosystémiques (ES) et dis-services (EDS) relatifs à l'agriculture. Le dernier article est principalement axé sur le calcul de l'efficacité économique des utilisations des terres. Une analyse des systèmes de production agricoles est combinée avec l'estimation de la valeur des ES et EDS, reliant ainsi l'agro-écosystème et les pratiques agricoles, puis calculant les coûts d'opportunité de la conversion de la forêt dans différents systèmes d'utilisation du sol qui sont comparés.

6.1 DETERMINATION DES TRANSFORMATIONS MAJEURES DANS L'UTILISATION DES TERRES ET ELABORATION DE SCENARIOS POUR LE FUTUR

Au cours des deux dernières décennies, l'Asie du Sud-Est a connu des changements majeurs dans l'utilisation des terres. Au Cambodge, la plupart des pertes de forêts sont situées le long des collines et chaînes de montagnes des zones limitrophes du Laos, du Vietnam et de la Thaïlande. Les forêts sont soumises à une pression croissante en raison de la demande de terres agricoles et de bois, combinée au développement des infrastructures, à l'exploitation forestière illégale, à la consommation de bois de feu et à la pauvreté en général.

Différente écoles de pensée ont discuté des causes de ces changements dans l'utilisation des terres, en particulier en ce qui concerne les forêts. Ces points de vue continuent de susciter des débats au sein du milieu universitaire, du gouvernement et de la société civile. Hirsch (1999) et Lambin et al. (2001) nous ont rappelé que, dans le milieu universitaire, l'association est souvent faite entre la déforestation, l'incidence de la pauvreté et l'importance de la population. En outre, cette communauté de recherche a développé toute une gamme de modèles spatialisés pour rendre compte de la transformation d'utilisation des terres sur les pas-de-temps récents. A notre connaissance cependant, très peu d'études élaborent des scénarios prospectifs de transformation des conditions politiques et socio-économiques de ces paysages, avec un niveau de résolution suffisant pour rendre compte des différentes stratégies des acteurs économiques, en particulier des agriculteurs.

Au Cambodge par ailleurs, le caractère dual de la répartition de la population et de la terre disponible est susceptible de générer d'importants mouvements de migration intérieure vers les marges du pays, avec un impact important sur la déforestation des zones d'accueil et l'utilisation des terres en général. Au même moment, l'utilisation des terres est souvent considérée comme le résultat des réformes institutionnelles et politiques promues depuis le début des années 2000, avec la publication de la loi foncière, de la loi sur la forêt, ainsi que les décrets et règlements qui en découlent.

Les transformations de l'utilisation des terres produisent des impacts qui doivent être mesurés de façon complète pour orienter les politiques possibles. L'évaluation de cette utilisation identifie les facteurs de changement, détermine ses conséquences et mesure ses impacts. Sur la base de nos enquêtes de terrain menées dans la province de Mondul Kiri entre 2011 et 2013, nous avons analysé les changements majeurs dans l'utilisation des terres à la suite des politiques publiques successives. En nous appuyant sur la compréhension des diverses stratégies des acteurs locaux précédemment identifiés dans la province de travail, nous identifions ensuite quatre scénarios prospectifs concernant de nouvelles transformations possibles dans les dix prochaines années, et reposant principalement sur des avis d'experts.

Dès lors, plusieurs questions clés peuvent être posées: pourquoi et comment la situation actuelle a été générée historiquement; quelles ont été les conséquences des politiques successives sur les droits fonciers des différents acteurs locaux et, par conséquent, sur les migrations et la croissance de la population, et enfin comment on peut utiliser ces connaissances pour évaluer les choix politiques possibles et leurs impacts respectifs ? L'impact des différents scénarios est évalué par plusieurs critères correspondant à des objectifs possibles des politiques : la production de valeur, estimée par le calcul de la valeur ajoutée brute (VAB) créée, l'emploi (nombre d'actifs supportés dans chaque scénario), la sécurité alimentaire (évaluée par la production de riz paddy), et la démographie résultant des nouvelles migrations.

Les résultats montrent que, au Cambodge, la plupart des zones de régression forestière sont situées dans les collines et le long des chaînes de montagnes périphériques du pays. L'histoire de l'utilisation des terres à Mondul Kiri lie la conversion des forêts d'une part à l'augmentation des concessions foncières accordées par le Gouvernement à des sociétés susceptibles d'investir dans des plantations, et d'autre part à l'arrivée de migrants en provenance des provinces les plus peuplées du Centre du Cambodge. De ce fait, l'utilisation des terres est en transformation rapide dans les villages étudiés. L'immigration est considérable, ayant doublé la population au cours des dix dernières années, sans pour autant donner lieu, à ce stade en tous cas, à d'importants problèmes d'intégration. Les mêmes villages accueillent à la fois la population de migrants et la population autochtone. L'intégration croissante des systèmes d'exploitation agricole au marché a stimulé les échanges fonciers et l'aliénation des terres des populations d'origine indigène s'est accélérée. Alors que leurs moyens d'existence sont sans aucun doute très différents, les deux populations ont en quelque sorte mutuellement bénéficié l'une de l'autre : les Phnongs ont vendu une partie de leurs terres déjà déboisées aux Khmers qui arrivaient, accélérant leurs cycles de culture dans la partie qu'ils n'avaient pas vendue. Pour leur part, les Khmers ont trouvé là une ressource facilement accessible (des terres bon marché et

surtout déjà déboisées) qui se prêtait bien à la culture du manioc, sous la condition qu'ils puissent maîtriser les mauvaises herbes grâce à l'utilisation d'herbicides. Ce faisant, ils ont bénéficié de la majeure partie de la rente de fertilité restant disponible après la déforestation.

Comme la terre est de plus en plus considérée comme un produit marchand, en particulier lorsqu'elle est plantée de cultures pérennes comme les poivriers ou l'hévéa, les incitations économiques sont puissantes pour couper la forêt et vendre.

Parallèlement à ces mouvements, les prix du caoutchouc ont augmenté jusqu'en 2011, alimentant l'intérêt des sociétés concessionnaires. Ils ont depuis largement reflué, de sorte que les concessions ont été attribuées dans une période de prix élevés (forte incitation), mais que les investissements dans les plantations devraient avoir lieu maintenant que les prix ont baissé de moitié (incitation faible voire négative).

Cependant, cette vision de la terre-marchandise entre en contradiction avec certaines valeurs des populations autochtones, qui considèrent également la terre et les forêts comme une ressource collective à conserver pour les générations futures. L'avenir du territoire se trouve donc à la croisée des chemins, et des scénarios opposés semblent possibles, allant d'un grand développement des plantations industrielles jusqu'à une rétrocession partielle des terres de concession aux communautés locales, et une utilisation des terres plus orientée sur le manioc et de riz.

Quatre de ces scénarios ont été évalués, sur la base des réactions les plus attendues des différents acteurs aux politiques mises en œuvre par les administrations locales et aux conditions du marché. Les résultats montrent que, dans certains cas au moins, la production agricole génère un revenu élevé, mais la compensation pour les pertes environnementales et les coûts d'opportunité restent incertains. Cela semble être particulièrement le cas pour les plantations d'hévéa par rapport aux autres utilisations possibles des terres, y compris la forêt ou la défriche-brûlis. L'avenir des systèmes de défriche-brûlis, pressés entre l'expansion des concessions et le développement de la culture permanente de paddy et de manioc, soulève également des questions, et la réduction des surfaces ou de la durée des jachères peut avoir un impact majeur sur la superficie totale dans ce mode d'utilisation de la terre. Dans tous ces cas, les scénarios peuvent offrir un cadre transparent pour assurer que les décisions politiques soient fondées sur des évaluations qui tiennent compte de l'écosystème et forge des compromis dans l'avenir.

Ces résultats confirment donc, au moins en partie, notre hypothèse n°1 selon laquelle «la politique de distributions de concessions peut avoir des effets positifs sur les résultats économiques mais pas sur l'environnement, alors qu'une politique de promotion des droits fonciers collectifs produit plutôt des services environnementaux». Ceci étant, ce sont les prix du caoutchouc, davantage que les politiques foncières, qui induisent les impacts les plus élevés.

6.2 COMPRENDRE LES STRATÉGIES, INNOVATIONS ET UTILISATION DES TERRES DES AGRICULTEURS

Dans une perspective malthusienne, les transformations de l'utilisation des terres seraient avant tout gouvernées par la croissance de la population en relation avec une disponibilité limitée des ressources. Dans un environnement fermé et sans percée majeure de l'innovation, la population tend à augmenter à un rythme plus rapide que son approvisionnement alimentaire (van de Walle et Appleman, 1977). Boserup (1965) est plus optimiste, affirmant que la pression de la population est l'élan qui pousse les petits agriculteurs à innover et à intensifier leur production agricole pour répondre à leurs besoins croissants de subsistance (Ruthenberg, 1980; Barlett, 1982; Netting, Stone et Stone, 1989; Stone, Netting et Stone, 1990; Netting, 1993).

Comprendre la relation entre la population et les ressources exploitées au travers de systèmes techniques particuliers plus ou moins intensifs demeure un problème fondamental pour les sciences humaines. Ces relations sont essentielles à la question du changement agricole dans la province de Mondul'kiri. Quels sont les facteurs de ces changements ? Quelles en sont les natures ? Ces changements sont-ils les mêmes pour tous les acteurs ? Quels en sont les impacts et les changements seront-ils durables ? Notre second article explore les transformations agraires, les stratégies des acteurs et de leurs conséquences, et enfin l'avenir de l'agriculture de ces zones. Le concept de système agraire (Barral et al., 2012) est utilisé pour lier la transformation technique à la transformation économique et sociale dans la société rurale. Ensuite, une méthode d'évaluation basée sur la fonction de production est également utilisée pour spécifier la sortie possible de biens et de services qui pourraient être produits dans chaque système de culture, avec un ensemble donné d'intrants (main-d'œuvre, des machines, des ressources naturelles, etc.).

La première constatation sur les systèmes d'exploitation agricole de la frontière orientale des hautes terres du Cambodge sont fortement liés à la démographie de la province. Les deux vagues successives d'immigration Khmère depuis les années 90 ont conduit à une réorganisation totale du système agraire, qui était initialement basé sur la culture de défriche-brûlis. Un

certain nombre de parcelles précédemment cultivées en défriche-brûlis ont été vendues aux nouveaux immigrants, conduisant à une réduction équivalente des terres cultivées par la population locale. Devant cette situation, les ménages autochtones semblent avoir peu étendu leurs terres dans la forêt elle-même. Ils ont plutôt diversifié leurs activités, vendant de plus en plus de travail dans les champs de manioc mis en place par les immigrants. Grâce au prix élevé de la marchandise, les salaires agricoles sur le marché du travail ont été tirés vers le haut, jusqu'à atteindre trois fois les couts d'opportunité -mesurés par la productivité du travail dans les systèmes de défriche-brûlis.

L'agriculture permanente, en pleine progression, affiche désormais une image contrastée. Le système de défriche-brûlis traditionnel est remplacé par deux systèmes de culture permanents différents.

D'abord, le paddy en culture continue présente une productivité du travail plus faible que celle précédemment obtenue sur les anciens systèmes d'abattis-brûlis. Il peut donc être analysé comme une adaptation malthusienne pour répondre aux besoins de l'intensification, rendue nécessaire par la réduction de l'accès à la terre, quand, au même moment, la production de riz paddy doit augmenter pour nourrir la population croissante. Cependant, il peut également être considéré comme une résistance de la société Phnong qui donne à la production locale de riz paddy, une valeur qui va bien au-delà de son prix de marché. Au contraire, les immigrants khmers, qui ne sont pas sensibles à ces valeurs, ignorent largement la production de riz paddy, trop peu rémunératrice.

La seconde alternative à la culture de défriche-brûlis, la monoculture de manioc, présente des productivités de la terre et du travail beaucoup plus élevées que le système qu'elle remplace. En ce sens, elle ne correspond pas à une adaptation malthusienne, mais à une véritable innovation « bosserupienne » qui multiplie le changement et génère des encouragements à de nouvelles migrations supplémentaires. L'innovation semble robuste, avec une augmentation continue de la superficie et du nombre d'agriculteurs la pratiquant depuis 2005.

L'extension du manioc a donc été le moteur qui a attiré l'immigration Khmère dans la province et a tiré la population indigène de la culture de défriche-brûlis, directement à travers les échanges de terres et indirectement en générant un appel à la main-d'œuvre. Cependant, une analyse plus fine du succès des systèmes de manioc montre qu'ils pourraient ne pas être durables à long terme. Le prix du manioc, en partie lié à l'industrie des biocarburants, devrait tomber. Encore plus attendue est la baisse des rendements, tôt ou tard, mais inévitable,

compromettant la productivité du travail alors que celle-ci est déjà légèrement inférieure au coût du marché du travail. Enfin, le coût du travail lui-même peut encore monter, suite à la demande dans d'autres secteurs, en particulier dans les plantations de caoutchouc qui devraient arriver en production dans les toutes prochaines années. La productivité de la récolte pourrait être fortement diminuée ou même réduite à zéro, par l'un des trois événements ci-dessus, et plus encore par une combinaison des trois.

Cependant, une éventuelle défaillance du manioc dans l'avenir, que ce soit par une chute du marché ou par la consommation totale de la rente de la fertilité, pourrait conduire à un intérêt renouvelé pour les systèmes de défriche-brûlis. Cela peut entraîner de nouvelles transformations foncières : les terres ayant déjà porté ces systèmes ont été vendues et auraient perdu leur fertilité, devenant ainsi incapable de porter à nouveau le même genre de cultures ; il n'y aurait alors pas d'autre issue que d'accepter un certain niveau de décalage dans les grandes zones restant encore couvertes par les forêts aujourd'hui.

A la stricte condition que la durée de la jachère soit suffisante, le système qui se mettrait alors en place peut être écologiquement durable. Cela appelle à accorder à l'avenir une attention particulière aux politiques publiques, en particulier l'attribution des droits fonciers, qui peut prendre en considération, à la fois la préservation nécessaire de la forêt et d'une exploitation modérée des pentes, sous strictes conditions. Ces résultats répondent à notre seconde hypothèse 2, selon laquelle "au cœur des choix à faire, se situe la transformation nécessaire d'une agriculture de subsistance, caractérisée par une faible utilisation d'intrants et de faibles rendements de la terre, à une agriculture plus intensive, probablement davantage orientée vers le marché, mais respectueuse des services écosystémiques essentiels.

6.3 SYNERGIES ET COMPROMIS ENTRE LES SERVICES ÉCOSYSTÉMIQUES

L'analyse des compromis représente une facette importante de l'évaluation des services écosystémiques (ES) (Carpenter et al, 2009; Mooney et al., 2009), et cela devient une question-clé lorsque l'on cherche à intégrer les services écosystémiques dans la planification du paysage, la gestion et la prise de décision sur les politiques publiques (de Groot, Alkemade et al., 2010) ainsi que dans l'analyse des voies alternatives d'utilisation durable des terres (Rounsevell, Pedrolí et al. 2012).

Cependant, les compromis entre ES au sein de différents types d'utilisation des terres dans la province de Mondul'kiri demeurent peu documentés, en particulier quant aux conséquences du remplacement des forêts et de la jachère longue par de l'agriculture permanente. Compte

tenu des incertitudes sur les stocks et les flux de carbone liés aux changements dans l'utilisation des terres, on perçoit difficilement comment les compromis entre services peuvent être abordés, et encore moins comment les politiques peuvent aider à réduire certains des effets les plus indésirables.

Nous avons cherché à analyser les arbitrages dans services écosystémiques des différentes utilisations des terres à Mondulkiri en fonction des quatre scénarios précédemment évoqués. Le cadre de Zhang et al. (2007) a été utilisé pour définir les écosystèmes et l'agriculture, qui sont ensuite intégrés dans une relation complexe faite d'interrelations -positives ou négatives- et de boucles de rétroaction.

Pour définir les différents flux ES et EDS, nous avons également adapté la méthodologie de terrain de diverses études d'analyse et de diagnostic agricole (Cochet et Devienne 2006; Dufumier, 2006; Cochet, Devienne et Dufumier, 2007; Cochet, 2012). Celle-ci inclue trois étapes-clés pour comprendre les choix des agriculteurs dans des conditions socio-économiques et politiques données : (i) lecture du paysage, (ii) étude historique, et (iii) modélisation du système de production et calcul économique de la performance. Nous avons évalué les composantes de la valeur économique totale (VET) de ces ES, à savoir la valeur marchande des biens et services, ainsi que les valeurs «intrinsèques» de la biodiversité et de la séquestration du carbone. L'analyse coûts-avantages (ACA) a été principalement utilisée pour l'estimation des services d'approvisionnement en caoutchouc, manioc, riz paddy et produits non ligneux forestiers. La valeur actualisée nette (VAN) correspond à la différence entre la valeur actuelle ou actualisée des avantages et la valeur actuelle ou actualisée des coûts.

Les résultats obtenus montrent sans ambiguïté que l'augmentation de la valeur ajoutée agricole entraîne systématiquement une diminution de la valeur des services de régulation ; ce résultat n'est en soi pas étonnant et confirme les travaux précédents de Polasky et al. (2011) ou de Briner (2012). Les changements dans l'utilisation des terres sont non seulement défavorables au bilan carbone, mais ils génèrent en plus des impacts négatifs sur la biodiversité et les autres ES.

Les résultats montrent aussi que, dans la plupart des systèmes de production, en particulier ceux qui s'appuient largement sur la culture du manioc, les agriculteurs cherchent à optimiser l'efficacité économique perçue à court terme. Le coût d'opportunité de la conversion de la forêt à l'agriculture cultures présente une valeur particulièrement élevée dans le cas des systèmes à

base d'hévéa ou de manioc, alors que ceux-ci sont justement les plus productifs économiquement.

Les systèmes de défriche-brûlis, de leur côté, fournissent certes moins de services d'approvisionnement que le riz paddy ou le manioc, mais ils se situent au deuxième rang derrière la forêt permanente pour la séquestration du carbone. La défriche-brûlis maintient également un haut niveau de biodiversité au cours des jachères. Par conséquent, les systèmes de production qui sont les plus efficaces sur le plan économique pour les agriculteurs tout en présentant des conséquences acceptables en terme de fourniture d'ES, sont les systèmes dans lesquels les agriculteurs combinent la culture défriche-brûlis sur les pentes avec du manioc sur les pieds de collines.

En réalité, les compromis entre services d'approvisionnement par les cultures et services de régulation par la forêt cambodgienne ne sont pas encadrés par la puissance publique, ce qui ouvre le champ à une forte dynamique de conversion des forêts. Au contraire, les incitations du marché ajoutées aux politiques foncières de reconnaissance des droits privés et collectifs pour les rendre plus facilement échangeables, encouragent encore davantage l'extension des terres agricoles, donc plus de services d'approvisionnement et moins de services de régulation.

Pour éviter les impacts négatifs de certaines pratiques agricoles, il importe que les EDS correspondants soient pris en compte dans les systèmes de gestion des terres. Nous sommes fortement préoccupés par les transformations dans les montagnes et les plus fortes pentes, dominées par l'extension des plantations d'hévéas et de manioc qui entraînent des effets négatifs pour les écosystèmes du futur, en particulier au travers de l'érosion des sols.

Comme l'argumentent Polasky et al. (2011), la détermination de systèmes de production équilibrés et robustes doit prendre en considération les changements climatiques et économiques qui sont attendus dans l'avenir. Ceux-ci auront bien évidemment une incidence sur la capacité des écosystèmes à fournir certains ES, et ils influenceront sur les prises de décision des utilisateurs des terres.

Nous avons donc modélisé comment différentes politiques foncières, à différents niveaux de prix du caoutchouc, influent sur la relation entre les différents ES. Par exemple, dans le scénario A α , l'augmentation de la VAB agricole est plus importante que la diminution de services de régulation. Pour autant, des réductions plus importantes du revenu à l'avenir peuvent survenir, étant donné que les écosystèmes sont vulnérables aux risques causés par l'utilisation actuelle des terres. L'optimisation de ces synergies passe par des politiques qui encouragent

une structure agricole correspondant à des systèmes durables, économiquement et écologiquement.

Ces exemples de compromis entre différents ES éclairent notre l'hypothèse 3 selon laquelle «les conséquences du remplacement de la forêt et de la jachère longue par une agriculture permanente mérite d'être évaluée, afin d'identifier l'occupation du sol et l'utilisation des terres qui offre les services les plus précieux." Les marges de synergie entre ES sont importantes, principalement entre la séquestration du carbone et la protection de la biodiversité, ce qui mérite d'être préservé à l'avenir.



Les changements qui affectent actuellement l'utilisation des terres à Mondulkiri soulèvent donc des questions critiques sur la sécurité alimentaire, le développement économique, social et de l'environnement dans les paysages des Hautes Terres. Face à ces questions, la compréhension des stratégies des producteurs agricoles et de leur impact clarifie le débat.

Premièrement, nous pouvons constater qu'une série de développements institutionnels a été réalisée au Cambodge dans les années 2000, à la suite de la Loi foncière de 2002, de la Loi sur la forêt de 2003 et des décrets d'application qui les ont suivies. Loin d'être un désert de droit, comme il est parfois présenté, le « Far East » cambodgien est au contraire plutôt riche en institutions, au moins sur le papier. Cependant, si les différentes couches institutionnelles successives ont forgé un cadre légal plutôt riche, celui-ci est susceptible d'être mobilisé dans toutes les directions, depuis le soutien aux grandes concessions foncières jusqu'à la protection des droits d'accès des communautés autochtones. Il ne contribue donc pas à une orientation politique claire.

Ainsi, le récent échec de la directive 001BB, qui devait clarifier les droits d'accès des acteurs locaux dans la Province, en particulier en matière d'accès collectifs, a confirmé que la sécurité de tenure de ces acteurs sur leurs terres n'était pas renforcée par les progrès institutionnels récents. Plus particulièrement, l'attribution de titres formels établissant les droits collectifs n'a pas pu être réalisée. Le mécanisme entier qui devait conduire à l'émission de titres de propriété, bien que totalement gratuit, reste trop obscur, trop consommateur de temps et finalement il n'encourage pas les ayant-droits à participer au système d'enregistrement. Sans le

soutien appuyé des ONGs, les communautés ne sont pas en mesure de réclamer leurs droits collectifs.

En ce qui concerne les investissements à long terme par des investisseurs étrangers ou même par des communautés locales, des titres d'accès clairs et sécurisés aussi bien que la reconnaissance de droits d'usage sont fondamentaux à prendre en compte. Un effort particulier devrait être engagé pour compléter le processus en cours de régularisation des droits fonciers collectifs avant toute nouvelle décision d'attribution de concession. Ce n'est qu'une fois que cette sécurisation des droits indigènes serait assurée que des ELC pourraient être allouées sur un espace donné. Ceci devrait représenter une haute priorité pour l'Etat, de sorte à éviter des conflits futurs dans la gestion des forêts et des décisions de conversion.

Deuxièmement, dans un tel contexte foncier incertain, analyser la stratégie des acteurs ruraux aide à mieux comprendre la dynamique de l'espace et à prévoir ses évolutions futures. Même au-delà de l'agriculture de défriche-brûlis, les agriculteurs ont réussi organiser une diversité de revenus qui représente une certaine protection contre les événements possibles dans leur environnement économique, et assure leur résilience.

L'agriculture de défriche-brûlis et la chasse-cueillette traditionnelle dans la forêt devraient être considérées comme des pratiques durables, sous certaines conditions de réalisation, en particulier de durée de la jachère forestière.

Cependant, l'avenir des systèmes de défriche-brûlis eux-mêmes est en question. Seulement deux des six types de systèmes de production identifiés par notre recherche incluent encore de la défriche-brûlis. Parmi eux, seuls ceux qui ont plus de 4 ha à cultiver (représentant moins de 20 pour cent des exploitations de ces types) semblent être en mesure de maintenir durablement la culture itinérante.

Ces systèmes sont donc de plus en plus vulnérables devant l'extension des superficies en manioc et en hévéa dans les jachères forestières et les forêts secondaires. Cette transition est d'ailleurs accélérée par les interventions publiques, dont l'inspiration est avant tout d'intégrer ces superficies marginales au marché foncier, signant par là-même la fin de la défriche brûlis, une pratique considérée comme rétrograde, improductive et destructive de l'environnement.

La disparition de la production de riz de montagne et la transformation des parcelles correspondantes en champs de manioc et d'hévéa accroît aussi les risques d'insécurité alimentaire locale dès lors que la production décroît alors que la population, elle, augmente.

Troisièmement, devant l'incapacité des politiques publiques à orienter l'utilisation des terres, les incitations du marché dominant les directions qui sont prises. En d'autres termes, le prix du caoutchouc se révèle beaucoup plus efficient que l'action publique pour orienter les systèmes d'utilisation du sol... Le cas de Mondulkiri confirme que l'émergence d'un cadre institutionnel public, aussi important soit-il pour bâtir une capacité d'arbitrage entre acteurs et de régulation entre services écosystémiques, n'est pas suffisant pour engendrer des orientations fortes. Le défi est de renforcer la cohérence du cadre politique, d'améliorer la capacité des acteurs publics à prendre en compte les aspects fonciers, d'investir dans la recherche et l'acquisition de données et enfin d'adopter une approche proactive.

Les résultats de la prospective indiquent en outre que la politique en faveur de grandes concessions peut entraîner plusieurs effets positifs, mais seulement lorsque les prix du caoutchouc sont élevés. Les retombées économiques des cultures annuelles seraient inférieures à celles du caoutchouc lorsque le marché est favorable à ce dernier, mais seraient supérieures lorsque les prix sont bas. Les avantages les plus importants d'une extension des plantations d'hévéa iraient aux entreprises de concessionnaires plutôt qu'aux exploitants familiaux qui s'engagent peu sur des plantations nécessitant sept années sans production avant de commencer à toucher les dividendes de l'investissement. Au contraire, la politique plus favorable aux droits des communautés autochtones et des immigrants individuels conduit à davantage d'emplois et assure mieux la sécurité alimentaire.

Enfin, l'analyse des compromis entre plusieurs utilisations du sol permet de mesurer les coûts d'opportunité du maintien de services écosystémiques dans la Province. L'analyse du système agraire offre un cadre pertinent aux calculs économiques qui sont ensuite menés. Les coûts d'opportunité élevés de la conversion des forêts en cultures illustrent bien les besoins de régulation des services d'approvisionnement.

Les limites des calculs effectués doivent cependant être clairement affichées. Le calcul des valeurs de la séquestration du carbone, de la protection contre l'érosion des sols ou la conservation de l'eau reste délicat. L'estimation de la valeur économique totale des services écosystémiques tient aussi, au moins pour une part, à des données extraites d'études de cas choisies au hasard.

Comprendre comment répondre à la sous-fourniture de services écosystémiques suppose de raisonner de façon intégrée et simultanément à plusieurs échelles, considérant tout particulièrement les compromis et les synergies entre services. Les brefs éléments abordés dans

ce travail à propos de l'utilisation des sols montrent la nécessité de repenser stratégiquement l'utilisation de l'espace rural et la fourniture de services écosystémiques à l'échelle de la Province. Ceci aidera les responsables politiques et de l'aménagement à répondre à la demande croissante de régulation et à assurer davantage de synergies entre les différents services.

References of Chapter 6

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General Annexe

A. Questionnaire for Agrarian Research Field Survey

A.1. Guidelines for qualitative data in agrarian system diagnosis and analysis Guidelines for historical study

1. Production systems before the changes/events or years
2. Landscape description before changes
3. Socio-political changes or impact
4. Impacts on people life

A.2. Guidelines for a first understanding of the study area

1. History of the farm

When did you start? How many plots and what were the sizes of surfaces? What kind of crop? What/when/how/why are the changes?

2. Farm income

What are different farm activities – which activities provide the biggest income? – other activities apart from farming?

3. Household

How many members? – age, education and activities – workforce for the farm – do the children plan to stay in the farm?

4. Social network

Are you a member of community forest? Who does he/she ask help with his/her farm when he/she needs? – how does he/she interfere with his/her neighbors?

5. Cropping systems

What kind of cropping systems – evolution during farm history – surface – chemicals use – material used/material own – do they have loan? Information about loan access – why did he/she choose this cropping system – what would he/she like to do if it was possible?

6. Changes in agriculture

How does he/she perceive the changes in agriculture? – does he/she feel confident about the future? Does he/she feel he/she can impact on the changes or does he/she feel this is the way it is? How does he/she think agriculture in the region/in Cambodia will evolve?

A.3. Guidance questionnaires for key-informant

1. How can you access the land?
2. When did you start to own your land?

3. What types of land use are you currently practicing on?
4. Have you ever planned to change your land use?
5. If yes, how can you change?
6. Are there any obstacles to change land use?
7. If yes, what are the problems?
8. Do you know how to use your land in sustainable way?
9. If yes, how can you know?
10. Are there any programs to support for sustainable land use?
11. If yes, what are the programs that you know?
12. Have you ever heard about the word “Ecosystem Services”?
13. If yes, can you give me any examples?
14. What are the benefits of ecosystem services?
15. How can you take the ecosystem services?
16. Are you practicing the organic farming or not?
17. If yes, why do you choose this program?
18. Do you receive any supports for selling the organic products?
19. What are the programs engaging in the organic programs?
20. Where do you sell your organic products?
21. Who are the target customers buying your organic products?
22. Are you practicing the non-organic farming or not?
23. If yes, why do you choose this program?
24. Are you doing shifting cultivation?
25. Do you know about the impact of chemical fertilizers/pesticides/herbicides?
26. What are the impacts of applying the chemical fertilizers/pesticides/herbicides?

B. Questionnaire for In-depth Interview

B.1. Personal Information

Target area	Date	Farmer's information
District:..... Commune:..... Village:.....		Farmer's name:.....
Code:.....		Tel:

Farmer's status

Gender	<input type="checkbox"/> Male <input type="checkbox"/> Female
Age years
Marital status	<input type="checkbox"/> Married <input type="checkbox"/> Single <input type="checkbox"/> Widower <input type="checkbox"/> Widow <input type="checkbox"/> Separate <input type="checkbox"/> Divorce <input type="checkbox"/> Others (Please specify)____
Education level	<input type="checkbox"/> No formal schooling (0) <input type="checkbox"/> Elementary school=1, 2, 3, 4, 5, 6 <input type="checkbox"/> Junior high school=7, 8, 9 <input type="checkbox"/> Senior high school=10, 11, 12 <input type="checkbox"/> College or university <input type="checkbox"/> Others (Please specify).....
Number of members in family	Total.....
Range of age of family members	- <18 years old..... People - 18 to 30 years old..... People - 31 to 45 years old..... People - > 45 years old..... People
Major income source	<input type="checkbox"/> Farm <input type="checkbox"/> Off-farm <input type="checkbox"/> Non-farm <input type="checkbox"/> Business <input type="checkbox"/> Official worker <input type="checkbox"/> Others. Please specify.....

B.2.Land Use

- Do you own, rent, or manage land in this area?
 - Yes
 - No

If YES, how can you access the land?

If NOT, why?

- When did you start to own, rent, or manage land?

years
- If you own land, what is the ownership structure of that land? (Check ONE)
 - Private individual
 - Corporation
 - Partnership
 - Others. Please specify.....

4. What types of land use are you currently practicing on?

- Settlement
- Farming
- Shifting cultivation
- Others. Please specify

5. Have you ever planned to change your land use?

- Yes
- No
- Do not know

6. If YES, what are the reasons and how do you change?

.....
.....

7. If NO, what are the reasons?

.....
.....

8. Do you own land? • Yes • No

Please circle the following type of land use in which you own land:

	Settlement	Permanent farming	Shifting cultivation	Others
How many acres?				

9. Do you lease out land to others? • Yes • No

Please circle the following type of land use in which you lease out land to others:

	Settlement	Permanent farming	Shifting cultivation	Others
How many acres?				

10. Do you rent land from others? • Yes • No

Please circle the following type of land use in which you rent land from others:

	Settlement	Permanent farming	Shifting cultivation	Others
How many acres?				

11.

12. What is the primary use of your owned/rented land? (Check ONE)

- Agriculture
- Timber
- Recreation
- Others. Please specify

13. Which commodities produced on your land?

- Rice
- Corn
- Cassava
- Beans
- Timber
- Others. Please specify

14. If you lease out your land for hunting, approximately how much money do you earn each year from hunting leases?

Please specify the amount

(USD) per year

15. Do you think the natural forest provides the benefits for you?

- Yes
- No

If YES, what are the benefits?

If NO, what are the reasons?

16. Can you access to use these kinds of lands?

- State forest
- Privately held easement
- Recreation
- National wildlife sanctuary
- Land managed by a conservation organization
- Others. Please specify.....

17. Does the government have the rights to tell you that you can do with your my land?

- Yes
- No
- Do not know

18. What are your property rights to use the land?

- to sell
- to lease
- to grant a mortgage
- to subdivide
- to pass on to an heir
- to grant an easement
- Other. Please specify.....

19. Does land use change require prior approval, and are there limits to dividing land rights?

- Yes
- No
- Do not know

If YES, what are the requirements and limits?

If No, what are the reasons?

B.3. Agricultural Practices

1. Cash crops

1. Cost-return from the farm

i. Income

a. Farming

No	Items	Yield (Kg)	Price (Riel/kg)	Total (Riel)
1	Rice			
2	Cassava			
3	Pepper			
4	Beans			
5	Vegetable			
6				
7				

b. Expenditure

a. Farming

No	Items	Unit	Unit price	Total (Riel)
Labor (Man days)				
1	Land preparation			

2	Seed sowing and planting			
3	Fertilizer and pesticide application			
4	Weeding			
5	Irrigation			
6	Harvesting			
Materials and Equipments				
1	Seeds			
2	Suckers			
3	Fertilizers			
4	Pesticides			
5	Herbicides			
Others				

2. Shifting Cultivation (Slash-Burn Cultivation)

- Do you practice shifting cultivation?
 - Yes
 - No
- How many hectares shifting cultivation do you have?..... ha
- How many separate fields?
 - Field 1:.....ha
 - Field 2:.....ha
 - Field 3:.....ha
- Where are your shifting cultivation fields?
 - Village
 - Inside the forest
 - Public land
 - Others. Please specify.....
- Why do you practice the slash-burn cultivation?

.....

.....
- Why “not” do you practice the slash-burn cultivation?

.....

.....
- How long have you been doing this cultivation?..... years (number of years)
- What kind of crop do you grow?
 - Rice
 - Cassava
 - Mungbean
 - Pumpkin
 - Maize
 - Sweet potato
 - Yam
 - Groundnut
 - Others. Please specify.....
- How do you plan these crops?
 - Mixed stand
 - 6-month change
 - 1-year change

- 2-year change
- Others. Please specify.....

10. How long do you allow a field to lie fallow?

- 1-2 years cropping
- 3-4 years cropping
- 5-6 years cropping
- 7-8 years cropping
- 9-10 years cropping
- Others. Please specify.....

11. Crop yield per hectare:

- | | | | |
|-----------------|-------|---------------------|-------|
| - Rice..... | Kg/ha | - Cassava..... | Kg/ha |
| - Mungbean..... | Kg/ha | - Pumpkin..... | Kg/ha |
| - Maize..... | Kg/ha | - Sweet potato..... | Kg/ha |
| - Yam..... | Kg/ha | - Groundnut..... | Kg/ha |
| - Others..... | Kg/ha | | |

12. Cost-return from shifting cultivation

i. Income

No	Items	Yield (Kg)	Price (Riel/kg)	Total (Riel)
1	Rice			
2	Cassava			
3	Corn			
4	Beans			
5	Vegetable			
6	Others			
7				

ii. Expenditure

a. Farming

No	Items	Unit	Unit price	Total (Riel)
Labor (Man days)				
1	Land preparation			
2	Seed sowing and planting			
3	Fertilizer and pesticide application			
4	Weeding			
5	Irrigation			
6	Harvesting			
Materials and Equipments				
1	Seeds			
2	Suckers			
3	Fertilizers			
4	Pesticides			
5	Herbicides			
Others				

3. Natural Forest

1. Ecosystem services from protected forest

No	Description	Agree	Disagree	Do not know
1	Supply timber and wood fiber			
2	Regulate climate by absorbing carbon dioxide			
3	Provide and regulate water resources			
4	Provide genetic resources for medicines			
5	Attract people for recreation and tourism			
6	Support nutrient recycling and soil formation			

2. Forest products

Food products	Forest animal	Use products
<ul style="list-style-type: none"> • Bamboo shoot • Mushroom • Leave • Fruit • Fern • Green mustard • Calamus • Rattan shoot • Wild spinach • Wild cassava • Edible flower • Fiddle-head • Water cress • Wild root • Wild coconut • • • • • 	<ul style="list-style-type: none"> • Birds • Frogs • Mice/rats • Squirrels • Grasshoppers • Lizards • Wild pigs • Wild cats • Wild chickens • Hedgehogs • Snails • Fishes • Shell fishes • Crabs • Shrimps • • • • • 	<ul style="list-style-type: none"> • Fuelwood • Grass • Bamboo wood • Bamboo for wearing • Flower for selling • Rattan • • • • •

3. The benefits of the forest

Heading columns have these meanings: SD=strongly disagree; D=disagree; NS=not sure; A=agree; and SA=strongly agree

No	Statements	SD	D	NS	A	SA
1	Reduce flooding and low flow events by intercepting runoff and encouraging infiltration					
2	Improve water quality by slowing the rate at which rainfall runoff flows to rivers and streams and trapping					
3	Provide fallen leaves to feed soil and aquatic organisms					
4	Improve groundwater quality by increasing and amount of the rainfall					

5	Improve air quality					
6	Help counteract the greenhouse effect and global climate change					
7	Reduce erosion and help the soil recuperate where trees are planted					
8	Increase crop and livestock productivities and soil sustainability by sheltering fields with windbreaks					
9	Diversify the rural economy by providing income (or savings) from harvesting forest products					
10	Provide homes for human, fish, and wildlife					
11	Link natural areas together with plantings to provide travelways for wildlife					
12	Increase the beauty of the environment in our community					
13	Reduce glare and filter out harmful ultraviolet rays					
14	Provide a calming environment by absorbing noise					
15	Provide an opportunity for healthy community action and involvement					
16	Increase property values					
17	Flooded forest area is high potential for development of ecotourism					

4. What are the functions of the forest?

Heading columns have these meanings: SD=strongly disagree; D=disagree; NS=not sure; A=agree; and SA=strongly agree

No	Statements	SD	D	NS	A	SA
1	To protect and form other natural resources					
2	To renew the oxygen stock in the atmosphere by fixing atmospheric carbon dioxide and moderating the so-called greenhouse effect					
3	To allow for the existence of many species of plants and animals, thus protecting diversity of nature and its gene stock					
4	To clean the environment by muffling noises, lowering the wind strength as well as stopping dust and gases					
5	To create conditions for relaxation, recreation and improvement of health					

5. What are the factors threatened on natural resources in this area?

Heading columns have these meanings: SD=strongly disagree; D=disagree; NS=not sure; A=agree; and SA=strongly agree

No	Statements	SD	D	NS	A	SA
1	Rapid population growth in the past 20 years had led to increased demand for fish and fishery-related resources					
2	Increasing price of land, rural people's poverty and extending agricultural land buffer zone of the TSBR					
3	Variety of illegal and destructive practices					
4	Increasing water allocation conflicts between rice growers and fishers					