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The Transition of Farming Systems Causing Forest Degradation in Ratanakiri Province, Cambodia

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Summary

Swidden cultivation is considered to be a cause of forest degradation in many countries around the world, including Cambodia. This agricultural practice has affected forest covers in the northeastern region, as Ratanakiri Province is home to indigenous people who have practiced swidden cultivation since time immemorial. Reportedly, swidden cultivation did not affect forest and tree covers, but the Cambodian trade liberalization policy drove forest degradation in the province. In order to discuss the sustainability and adequacy of this new development, it is important to clarify the traditional practice of swidden cultivation. Thus, this study aims to explore the traditional practice of swidden cultivation and identify the dynamics of forest degradation.

Traditional swidden cultivation comprises three essential elements: a) traditional beliefs, b) multiple cropping, and c) an absence of land alienation. A change in any of these elements may influence land resources, including forest cover.

This study utilized two research methods to achieve its objectives: remote sensing and qualitative research methods. Remote sensing methods employed four satellite images: 2007 ALOS AVNIR2, 2011 ALOS AVNIR2, 2011 ALOS PRISM, and 2012 Worldview-1 (100 km^2). Supervised classification using a maximum likelihood classifier was applied to analyze 2007 ALOS AVNIR2 and 2011 ALOS AVNIR2. 2011 ALOS PRISM was applied to perform direct image georeferencing. Visual image analysis was applied to the 2012 Worldview-1 image to understand exact land-use patterns. Raster and vector data were re-projected to the Universal Transverse Mercator coordinate system (UTM WGS1984 zone 48N meters).

The field survey and data collection took place on four occasions over 145 days. This study selected Phi village as the leading example due to its remoteness and traditional practices. Thirty families were randomly selected from Phi village, seven from Pa Tang, and ten from Pa Dal, for individual interviews. These samples did not

include key informants. Semi-structured questionnaires combined with other qualitative techniques were applied to collect qualitative information. In addition to the interviews, 273 training samples were collected and categorized into 11 land-use classes. An accuracy assessment was applied to 102 randomized training samples, and signature development was applied to 171 training samples.

The key findings of this study are documented in Chapter 4 and Chapter 5. In Chapter 4 it is revealed that Djarai swidden cultivation is a multiple cropping system that interweaves traditional beliefs with land tenure practice. Recently, this farming system has transformed into a monocropping system, whereby Djarai villagers integrate cashew trees and rice crops. Thus, they must expand their farmlands every year. Djarai villagers have intervened in land alienation that results in a flow of migrants into this area.

In Chapter 5, it is shown that the introduction of cash crop production and commercial plantations have affected agricultural practices and caused drastic changes in the forest landscape. First, monocropping requires indigenous farmers to expand farmland by clearing forests for rice production year after year, regardless of the agricultural market. Second, there is a high demand among migrant farmers for access to agricultural lands converted from forests that are without land administration. Third, the government re-enacted a land law that allows for the development of plantations through agricultural development cooperation, resulting in a rapid acceleration of deforestation.

This study concluded that the dynamic force behind forest degradation is the transition of farming systems from Djarai swidden cultivation to cash crop production. Simultaneously, a) traditional beliefs, b) multiple cropping, and c) an absence of land alienation have transformed into a) new or no beliefs, b) monocropping, and c) land alienation. Monocropping and land alienation are two considerable features that affect forest cover.

Contents

List of Figures

List of Tables

List of Abbreviations

ADCs	Agricultural Development Companies
ALOS	Advanced Land Observing Satellite
ASTER GDEM	Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Map (GDEM)
AVNIR2	Advanced Visible and Near Infrared Radiometer type 2
DTM	Digital Terrain Models
ELC	Economic Land Concession
EML	Environmental Management Leader
FAO	Food and Agriculture Organization of the United Nations
GCPs	Ground Control Points
GDP	Gross Domestic Product
GPS	Global Positioning System
JSPS	Japan Society for the Promotion of Science
LRP	Laboratory of Regional Planning
LULC	Land Use and Land Cover
MAFF	Ministry of Agriculture Forestry and Fisheries
MEXT	Ministry of Education, Culture, Sports, Science and Technology
NCDD	National Committee for Sub-National Democratic Development
NGOs	Non-Governmental Organizations
NIS	National Institute of Statistics
NTFP	Non Timber Forest Production
PRISM	Panchromatic Remote-sensing Instrument for Stereo Mapping
QM	Qualitative Methods
RGC	Royal Government of Cambodia
RS	Remote Sensing
SCW	Save Cambodia's Wildlife
UTM	Universal Transverse Mercator
WGS	World Geodetic System

Chapter 1: Introduction

1.1. Changing land use in Cambodia

The agricultural sector dominates Cambodia's economy, where agricultural land use is diversified. According to the Cambodian Ministry of Agriculture (MAFF), in 2004, the total cultivated land was 2.47 million hectares, 90% of which was used for rice production. An important staple for Cambodian people, rice is cultivated across the country. Other than rice, upland crops including sesame, mung, soy, peanuts, and cassava account for 10% of cultivated land. Fruit trees such as banana, cashew, coconut, Jackfruit, mango, and orange account for 111,633 ha (Save Cambodia's Wildlife [SCW], 2006).

The agricultural sector makes important contributions to Cambodia's GDP. The GDP increased annually by 9.8% alongside the agricultural sector, which grew by 5.6% per year between 2000 and 2008 (Yu and Diao, 2011). Growth in the agricultural sector, which slowed to 3% in 2011, reverted to about 4.5% in 2012, and it now continues to contribute toward GDP growth (Seiha et al., 2013). However, while the area of agricultural land has increased, the forested land area has not.

No exception, Cambodia reported large forest losses over the last decade (Food and Agriculture Organization of the United Nations [FAO], 2012, 2010a). The proportion of forest cover in Cambodia ranged from 73–74% of the country landmass between 1969 and 1990 (Savet and Sokhun, 2003), decreasing to 57% between 1990 and 2010. In contrast, the agricultural land area expanded from 26% to 31% between 1997 and 2007 (Broadhead and Izquierdo, 2010), and to 32% in 2011 (FAO, 2014).

Deforestation could negatively impact environmental health or indigenous livelihood. The government aims to ensure environmental sustainability by supporting national social and economic development through sustainable management and use of forest resources (Royal Government of Cambodia [RGC], 2013). Forest cover has decreased below the national target. The national goal for forestry is to maintain forest cover at 60% of the total land area (Ministry of Agriculture, 2010; Ministry of Planning, 2010).

The diminishing Cambodian forest can be attributed to many factors. For example, while shifting cultivation is a traditional agricultural system, it impacts the proportion of forested area. This agricultural system is prevalent in the unbounded fields of Cambodia's northeastern province (SCW, 2006), where, according to FAO (2002), it is recognized as the greatest threat to the forest (Bann, 2003; FA, 2010). Some evidence suggests that Chamkars (swidden cultivation) could transform when political and economic conditions improve (Butterfield, 1998). For now, swidden cultivators increase their production to meet the current open market forces for higher demands; thus, they attempt to enlarge their Chamkar (Ung et al., 1999).

1.2. Changing land use in Ratanakiri province

Ratanakiri Province, located in the northeastern region of Cambodia, is home to indigenous people who practice shifting cultivation. During the 1990s, the province opened itself to development. Since then, land use has been modified.

Fox et al. (2009b) examined three villages in the province. In the first, the forest area remained virtually intact, decreasing at 0.86% per year. In the second village, the forest area decreased at an annual rate of 1.63%, and at an annual rate of 4.88% in the third. Two triggers initiated changes in land use and land cover in these villages, namely national government policies to liberalize trade and villagers' access to the agricultural market. Together, these triggers influenced indigenous communities to initiate land-use schemes for cash. The highest rate of forest loss in two of the indigenous communities was caused by land alienation, because villagers increasingly viewed land as a marketable commodity. Therefore, they responded to market forces by developing their forested land for cash crops or for sale. Consequently, land resources came under pressure.

Trade liberalization policy aims for socio-economic development so that villagers can access the agricultural market to exchange agricultural products. This is a common practice in developing countries. However, land change scientists such as Fox et al. (2009a) report that trade liberalization policies, which initiate the transition of traditional swidden cultivation into cash crop production, exacerbates forest degradation. Understandable confusion is evident between transforming farming systems and socio-economics causing forest degradation.

The diminishing forest cover may impact the livelihood of villagers. Bann (2003) reported that the value of forest products might be as high as US$ 3,922 per hectare of forested land. Non-timber forest production is an important source of subsistence. In Ratanakiri Province, the forest is an important mechanism by which to alleviate poverty, and forest loss could lead to the loss of natural subsidy.

1.3. Research objectives

This study investigates land-use dynamics related to changes in swidden cultivation. The outcomes of this study are expected to contribute toward solving the problem of the diminishing forest cover due to swidden cultivation. Thus, the study aims to explore the traditional practice of swidden cultivation and identify the dynamics of forest degradation.

The first objective of this study is to explore the origin and implications of Djarai swidden cultivation. Djarai is an ethnic community residing in the east of Ratanakiri Province. This baseline study is conducted through a descriptive survey to generate information (Anyaegbunam et al., 2004) related to swidden cultivation. To explore the origin of swidden cultivation, three measurable factors for this objective are traditional beliefs, farming practices, and land tenure practices. To understand the origin of shifting cultivation, the focus will be on spiritual beliefs and land tenure practices. Characterizing farming activities will reveal crop decisions and farm management. Furthermore, classifying land-use patterns enables an exploration of new land-use practices introduced to indigenous territories. These are the starting points to explain reasons for changes to swidden cultivation.

The second objective is to analyze the dynamics of forest cover changes caused by agricultural expansion. Agricultural expansion changes patterns of agricultural land use and land resource accessibility. As such, agricultural land use is key to explaining changes in swidden cultivation, which is a new land-use practice adopted by Djarai farmers to introduce cashew production. Land resource accessibility focuses on two features, namely migrant encroachment and agricultural development cooperation. Migrants access resources by purchasing land resources from indigenous people, creating chaotic market properties. Here, the research explores migrant resettlement in the study area. Since 2001, the Royal Government of Cambodia has enforced a policy of economic land concession pursuing agricultural development cooperation to reclaim forested land for industrial plantation. Land resource accessibility and changes to swidden cultivation are resulting in forest degradation in remote areas of Cambodia.

1.4. Framework of the study

Traditional swidden cultivation comprises three essential elements: a) traditional beliefs, b) multiple cropping, and c) no land alienation. A change in any of these elements may influence land resources, including forest cover.

In addition, changing traditional beliefs into new ones or discarding them completely may affect forest cover. Djarai traditional beliefs are related to the land-use system and land resource management. In farm management practices, Djarai swidden cultivation has a fallow period, which is critical for forest regeneration. Without the fallow period, the core of swidden cultivation, forest cover may diminish. In land tenure practice, there is no land alienation in Djarai swidden cultivation. Changes to traditional resource management systems cause land alienation, which in forested areas, could result in scarce land resources.

New land-use practices could be referred to as swidden transformation when these components are modified. The changing agricultural system can be referred to as agricultural expansion, which may cause forest degradation. Hence, this study argues that the transition of farming systems may cause forest degradation (Figure 1.1).

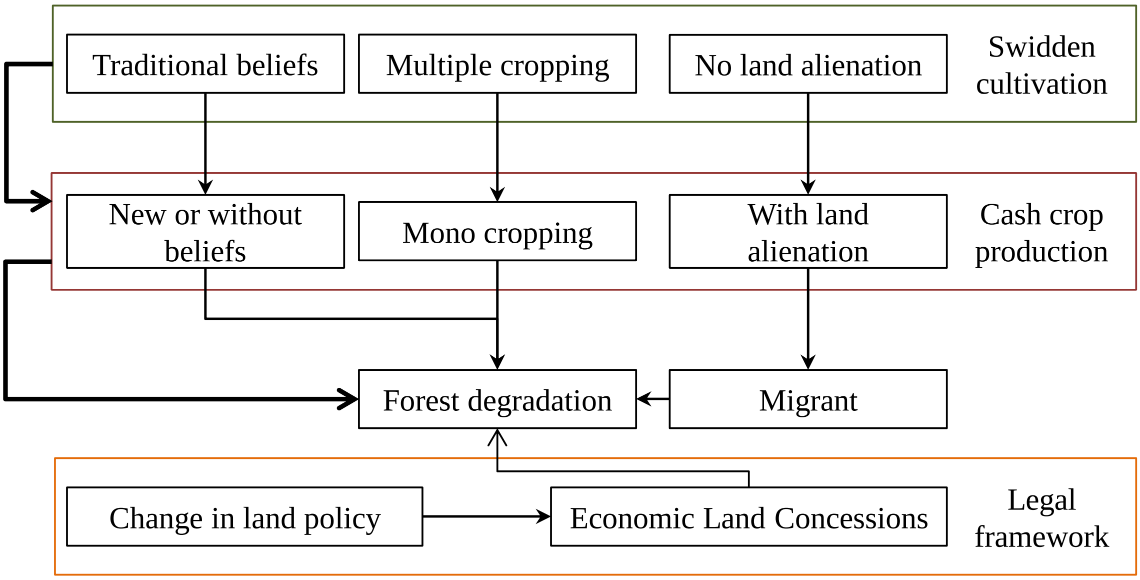

Figure 1.1. Conceptual framework

1.5. Organization of the thesis

This thesis comprises seven chapters. This chapter explicated factors related to forest degradation, including shifting cultivation, trade liberalization, and market access. Chapter 2 provides an overview of land-use problems ranging from shifting cultivation to land resource ownership. Chapter 3 introduces the study location and briefly explains the study methods. More detail on study methods is provided in Chapters 4 and 5, which also describe the results of this study. Chapter 4 explores the traditional practice of shifting cultivation, while Chapter 5 focuses on the impact of agricultural expansion on forest cover. Chapter 6 summarizes the study, and provides conclusions and recommendations pertaining to forest degradation due to the transformation of swidden cultivation.

Chapter 2: Shifting cultivation and land resource ownership: a literature review

Shifting cultivation is a complex farming system, and its practices relate to the environment and culture. To clarify shifting cultivation and provide a comprehensive understanding of the concept, this chapter provides an overview of the literature including previous studies and reports on shifting cultivation.

2.1. Shifting cultivation

Shifting cultivation is an age-old agricultural practice. In the 1960s, a three-dimensional view of shifting cultivation focused on cultural, environmental, and temporal dimensions. The cultural dimension focuses on technological, social, and ethno-ecological factors. The environmental dimension highlights biotic, edaphic, and climatic factors. The temporal dimension encompasses the implementation of shifting cultivation from selecting forest lands, clearing and cutting trees, burning dead vegetation, cropping, and the fallow period (Conklin, 1961) (Figure 2.1.). These dimensions are common to every model of shifting cultivation, and are key in research on the practice in Cambodia.

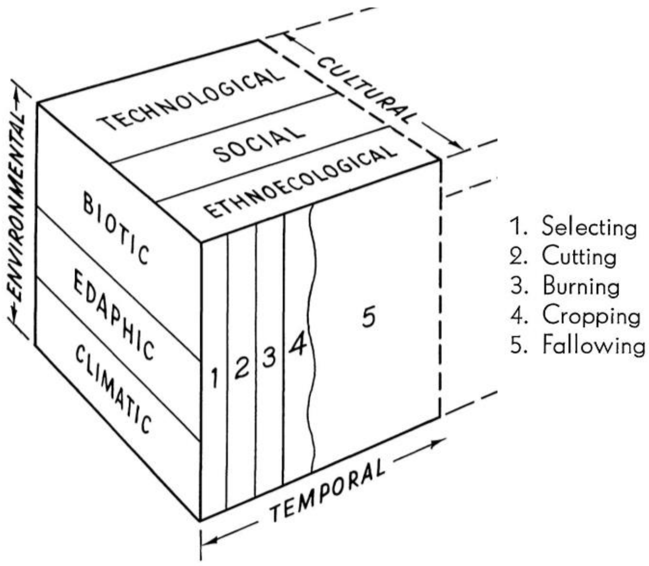

Figure 2.1. The study of shifting cultivation (Conklin, 1961)

In the literature, shifting cultivation is conceptualized according to context. As such, no clear definition exists, as this varies depending on the personal views of researchers studying the practice in various countries or ethnic communities. However, there is some commonality with regard to the defining elements of shifting cultivation.

For example, according to Lanly (1985), the Food and Agriculture Organization and University of Ibadan suggested that shifting cultivation is a system related to short periods of continuing cultivation followed by long periods of fallow. This definition encompasses every element of the temporal dimension, and reflects the nature of shifting cultivation worldwide.

Shifting cultivation has been re-conceptualized according to study area. For example, McGrath (1987) reported that many documents related to swidden cultivation ignore the exploitation of natural vegetation–soil complex, which was the substitute for human labor. This omission of the biomass contribution considers practices, not underlying strategies. Preoccupation with the renewability of energy sources contributes to various shifting cultivation systems. A definition of shifting cultivation is proposed for a new outlook, which pays attention to the relationship between the nature of the vegetation–soil complex and shifting cultivation.

There is some agreement in the literature on the use of the term shifting cultivation. Swidden cultivation, shifting cultivation, and slash-and-burn agriculture are synonymous, while the meaning of each has not been clarified. Swidden cultivation is the Scandinavian term, which originally referred to land cleared by burning. The term shifting cultivation was specific to mulch-based farming systems on the Pacific Islands or elsewhere. The term slash-and-burn usually refers to a range of land-use practices, not necessarily shifting fields. Swidden cultivation describes the rice- and maize-based systems in Southeast Asia (Mertz et al., 2009).

2.2. Shifting cultivation and forest conservation

Long fallow periods in the swidden cultivation system contribute toward maintaining forest cover and plant diversity in a dynamic balance leading to the regeneration of a secondary forest. For example, the traditional land-use practices of the Lawa and Karen demonstrate considerable potential for natural forest recovery. Lawa and Karen swidden cultivators utilize their vast knowledge of growing plants in swidden fallows, so that forest restoration occurs through the potential of indigenous tree species. This practice promotes natural forest regeneration and biodiversity recovery known as framework species. In fallow land, fire and cattle grazing is prohibited nearby seed sources and seed dispersal mechanisms (Wangpakapattanawong et al., 2010). Shifting cultivation does not influence forest cover. The system is fully adapted to the prevailing climatic and soil conditions in a given forest area.

2.3. Transformation of shifting cultivation

The increasing population density could soon diminish land resources in areas subject to swidden cultivation. Hence, traditional forms of shifting cultivation are impossible to implement in areas experiencing population pressure. Since shifting cultivation involves a long period of fallow, many areas are required per family. Most land is unproductive at any one time. Therefore, shifting cultivation is not possible in population-dense areas (Forestry Department, 1985).

In reality, transforming shifting cultivation practices was the primary cause of deforestation. In Sumatra, Indonesia, recent adaptations among shifting cultivators include an increase in rubber planting that expands into the primary forest. This is in response to increased rubber profitability, which is causing land scarcity. In addition, government land claims significantly amplify effects on forest clearing by changing farmers' expectations and initiating a self-reinforcing landrace (Angelsen, 1995).

Shifting cultivation practices could be harmful to forest cover when cultivators transform this system into cash crop production. For example, the Serampas' (a community settled in Tangjung Kasri and Renah Kemumu village, Sumatra, Indonesia) shifting cultivation practices possibly have no ecological impact. Serampas shifting cultivators prefer using the secondary forest to the old-growth forest. They do not consistently use fire to establish an upland rice-based farming system. Furthermore, as they follow the Islamic calendar (based on the lunar cycle) for agricultural activities, the period of land preparation does not always occur at the beginning of the dry season. The low population density of Serampas, which ranges between 1.5 and 3.8 persons per km^2, also contributes to the sustainability of shifting cultivation. However, their shifting cultivation has progressively shifted to more market-oriented systems, and the change is threatening the secondary forest, which was converted to cinnamon agroforestry (Hariyadi and Ticktin, 2012).

2.4. Deforestation through agricultural expansion

The Asian continent is characterized by various forest ecosystems. At the area's geographic extremes, these ecosystems include extensive boreal forests in Siberia, moist tropical forests in southeastern Asia, subtropical forests in the mountains of southern Asia, and juniper forests on the Arabian Peninsula. Asia houses more than half the global population and, as in other regions, population growth and development have been accompanied by widespread deforestation (FAO, 2012).

In most of Southeastern Asia, shifting cultivation was the primary driver of forest clearing until the late 18th and early 19th centuries. Colonization bore witness to an increasing population, industrial development, and trade, and simultaneously, steadily increasing deforestation. Between the late 19th and early 20th centuries, forests were exploited for selected tropical timbers and cleared to plant various crops such as oil-palm and rubber; nearly 40 million hectares of forest were cleared, mostly for commercial agriculture (FAO, 2012).

In the last decade, agricultural expansion continues to exacerbate deforestation in many Southeast Asian countries. The agricultural area increased from 112 million hectares in 2001 to 127 million hectares in 2011. At the same time, forest areas decreased from 222 million hectares to 212 million hectares (Figure 2.2.).

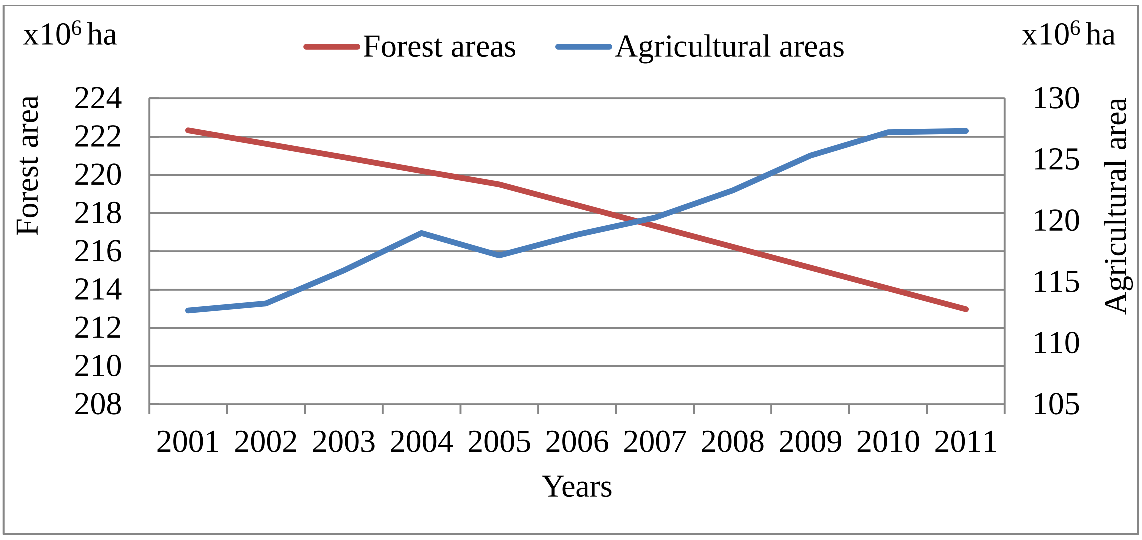

Figure 2.2. Changing agricultural and forest areas in Southeast Asia from 2001 to 2011 (FAO, 2014)

2.5. Land change issues

The effects of social and environmental dynamics on the landscape are becoming increasingly visible. Societies and nature are dynamic; thus, this change is an inherent characteristic of the landscape. Landscape change is the primary cause of severe environmental problems (Bürgi et al., 2004). The study of causes and consequences of landscape change with regard to land use and land cover is a central research topic in landscape ecology (Wu and Hobbs, 2002). Land cover and land use changes have various ecological effects, for example on soil and water quality. Even subtle changes in farming practices can adversely affect the landscape and its function in rural areas (Houet et al., 2009).

Changes in land cover such as deforestation underlie serious problems in forest-dependent communities and the environment. Forests are necessary for rural livelihoods and a healthy environment, and a vital source of staple foods and wood products for many of the poorest people (FAO, 2012; Hansen and Neth, 2006). As such, forests provide poverty alleviation strategies (Wunder, 2001). Forests are a response to maintaining climate change through their role in carbon sequestration (Salati and Nobre, 1991). Deforestation has negative ecological and environmental consequences (Zhao et al., 2006) through the release of CO_2 (Detwiler, 1986; Houghton, 1999; Searchinger et al., 2008), impact on water quality (Johnes and Heathwaite, 1997; Sliva and Williams, 2001; Tong and Chen, 2002), alteration of regional climates (Zhang and Mcguffie, 2001), and loss of biodiversity (Haines-Young, 2009; Reidsma et al., 2006).

2.6. Land resource ownership

Land ownership is linked to forest stewardship. Governments in many *de jure* states tried to manage forested land by developing a common property regime. Thus, this section provides an overview of land resource ownership as it pertains to shifting cultivation trends.

2.6.1. Land and land resources

Following the Land and Water Development Division (1995), the elements of natural land systems are termed land resources, including the natural, bionic, environmental, infrastructural, social, and economic components fixed to land systems. Sustainable use of land resources is important; thus, land resource management should include land-use planning and be achieved through political, legal, administrative, and institutional bodies.

2.6.2. Land related to the livelihood assets of indigenous people

Members of a family combine their capabilities, skills, and experiences with various resources to conduct activities related to their livelihood. This enables them to create a profitable livelihood for their families. Everything contributing toward creating this livelihood can be considered a livelihood asset. While not definitive, there are generally five types of assets (see Figure 2.3.). Livelihood assets can also be classified according to local context. Different households may have different levels of access to different ranges of assets. The diversification and volume of assets households have at their disposal impact rural livelihood (Messer and Townsley, 2003).

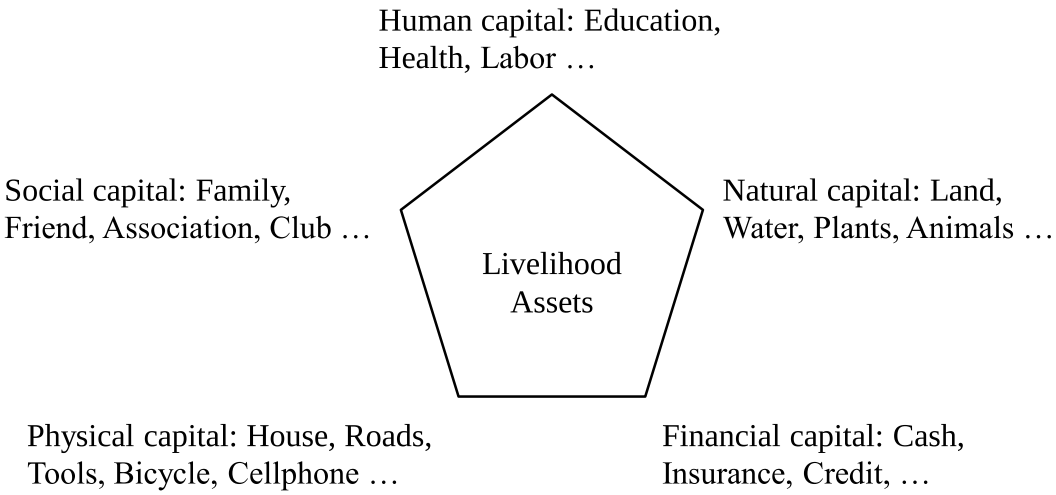

Figure 2.3. Livelihood assets (Messer and Townsley, 2003)

For example, indigenous people living in the forest of a remote area have strong ties of kinship and mutual exchange (social capital), ample access to forest resources (natural capital), and intimate knowledge of their local environment (human capital). Practically, financial and physical capital is limited. They use their knowledge to exploit different types of natural resources in different ways, and aim to ensure a supply of food, clothing, fuel, and shelter. As such, their livelihood reflects their social environment (Messer and Townsley, 2003).

The ties of kinship and mutual exchange within their community are to overcome a series of vulnerabilities such as sickness or deaths without external support. On the other hand, the physical capital available to them is unique and appropriate to their circumstances only. As a result, indigenous people have difficulty in adapting to any changes introduced by outsiders, such as destruction of or intrusion into their forest environment. In addition to physical capital, indigenous people are unfamiliar with financial capital, a distinct disadvantage when becoming involved in market-oriented systems (Messer and Townsley, 2003).

2.6.3. Common-pool resources and common property regime

McKean and Ostrom (1995) and McKean (1998) define "common-pool resources" as the physical qualities of natural resources, and not the social institutions of human beings attached to resources. Common property or a common-property regime refers to a particular property rights arrangement whereby a group of resource users share the rights and duties pertaining to use of a resource. Therefore, these terms refer to social institutions, not to inherent natural or physical qualities. The use of the term "common property resources" should be avoided, because it is easy to confuse property (a social institution) and resources (part of the physical and biological world).

Open access is separate from private property (Figure 2. 4.). The letters of the alphabet in this figure represent land resource users who access open-access resources without clarified property rights. Common property and individual property are private properties, for which users' access rights are limited to groups or individuals.

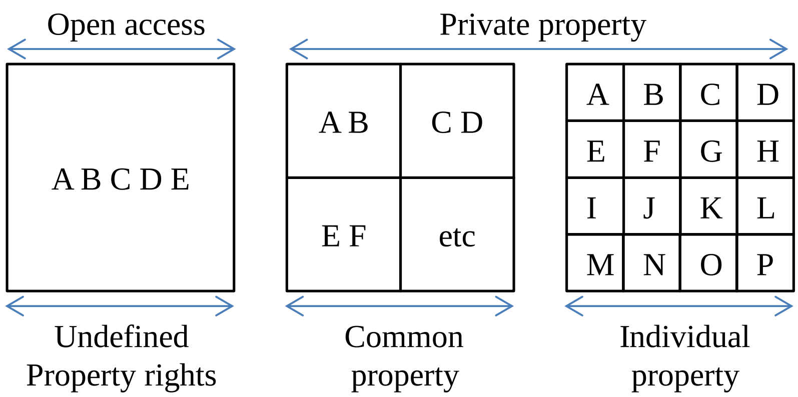

Figure 2.4. Differences between open-access resources and common property compared to the individual property regime

Common-pool resources have two characteristics. First, common-pool resources are costly to develop institutions to exclude potential beneficiaries. Moreover, these resources include goods and services referred to as public goods. Resource users can overuse common-pool resources without proper management. Second, the quantity of resources harvested by individual users is not available to other users. Thus, resource users extract common-pool resources as private goods, which could lead to depletion (McKean and Ostrom, 1995).

Common-pool resources have rapidly been subject to increased pressure consequent to reduced areas and population growth. A consequence of increased pressure on common-pool resources due to over-exploration is declining product volume, which is a primary indicator of physical depletion. Common-pool resources have decreased from 55 to 30%. Since the early 1950s, land reforms have been introduced to many parts of India to overcome common-pool resource issues (Jodha, 1995).

The main problem is that management rights or duties are not defined for open-access or common-pool resources (Alchian and Demsetz, 1973; Demsetz, 1967; Gordon, 1991; McKean, 1998; Scott, 1955). To sustainably use common-pool resources, a communal property regime (Dale & McLaughlin, 2003) is required.

2.6.4. Land tenure

Whether defined legally or customarily, land tenure is the relationship between individual or group users with regard to land, which might include natural resources such as water and trees. Land tenure is a social institution to regulate the behavior of resource users. The rules of tenure define property rights concerning land allocated within societies and how access is granted to the rights of uses, controls, and transfer of land property. Furthermore, it imposes responsibilities and restraints. Simply, land tenure determines the operational rights to use land resources (Munro-Faure et al., 2002).

For example, the Philippines, Thailand, and Costa Rica are trying to stabilize forest cover by securing land tenure. In the Philippines, the government secured land tenure by establishing the Integrated Social Forestry Program. In Thailand, the national forested land allotment project was established to assign rights to use forested land to individuals to manage state land (Arnold, 1998). In Costa Rica, governance of common property extends and links protected areas across a mosaic of property types (Kitamura and Clapp, 2013).

2.6.5. The collective rights of indigenous people

Indigenous people depend on forest resources for various livelihood activities, including hunting and forest product collection (Brosius, 1997). Of these, agricultural activities such as shifting cultivation commonly represent the most intensive use of forest resources and the most important source (Castro, 1991). A common characteristic of indigenous people is the centrality of their connection to their land resources and natural surroundings, which provide for social identification and spiritual and cultural distinctiveness. This reflects indigenous peoples' economic and cultural dependence on ancestral lands (Andersen, 2011).

Regarding the physical characteristics of goods (Figure 2.5.), the livelihood of indigenous people is connected to and dependent on common-pool goods such as forests, pastures, fisheries, and environmental sink over time. Excluding public or private users from common-pool goods is dangerous and costly. Growth demands of common-pool goods would be the failure of natural resource governance if the resource governor overlooked the common property regime (McKean, 1998).

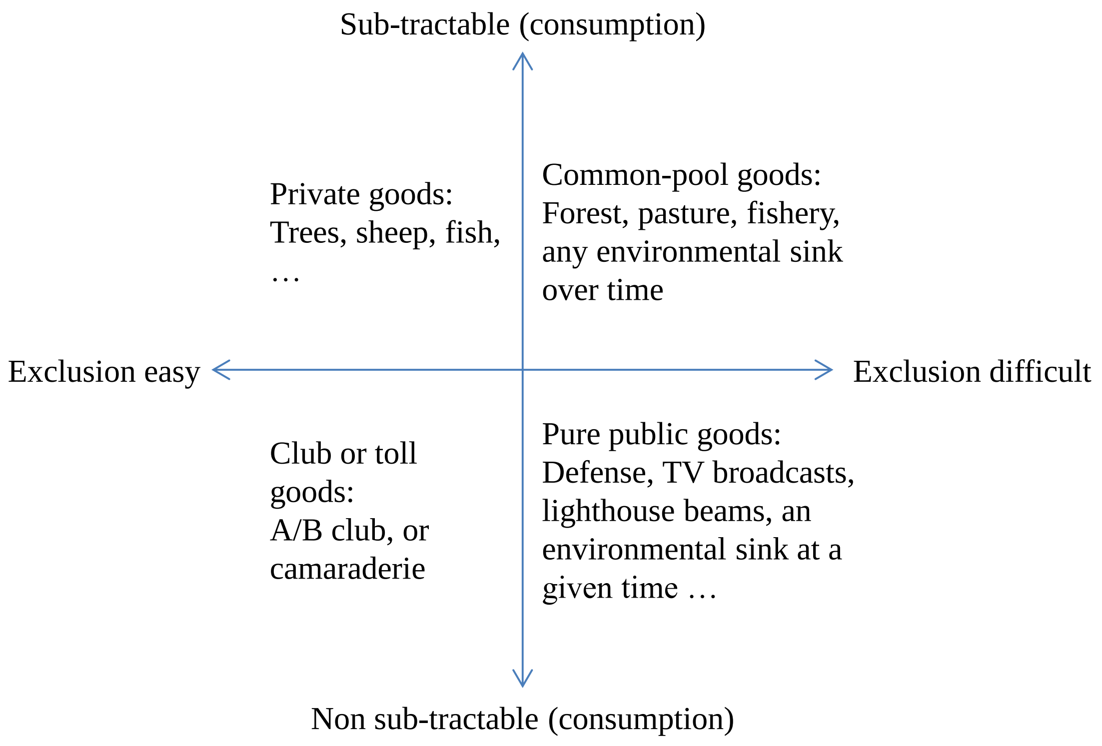

Figure 2.5. Physical characteristics of goods (McKean, 1998)

Indigenous people are strongly tied to land resources (Figure 2.3.). The forest is a type of common-pool good attached to land (Figure 2.5.). Moreover, the forest is sub-tractable and vulnerable to depletion. Thus, excluding indigenous people is very difficult (Figure 2.4.), and a common property regime is needed to govern land resources.

2.7. Definition of indigenous or tribal people

In many countries, there are no particular records of the situation of indigenous people. Even basic demographic information regarding their numbers and location is sometimes lacking. Therefore, an analysis of the situation in indigenous communities often relies on rough estimates or the use of proxies. For example, to assess a particular geographic area predominantly inhabited by indigenous people, disaggregated data describing the situation in *de jure* states or within indigenous communities is difficult to find.

The population of indigenous people of at least 5,000 distinct ethnic groups totals approximately 370 million in 70 countries. This diversity is difficult to capture in a universal definition; consequently, a formal definition of “indigenous people” is neither essential nor desirable, and no internationally common definition exists. Furthermore, the International Labour Organization (ILO) does not clearly define the term; rather, they describe the people (ILO Convention, Article 1). The ILO convention No. 169, Article 1 regarding indigenous people in independent countries stipulates indigenous people as those whose social, cultural, and economic conditions distinguish them from another section of the national community. Moreover, their status is regulated partially by their own customs, conditions, laws, or regulations (ILO, 2009).

The same Article regards people in independent states as indigenous based on their descent from the population inhabiting the country or geographic region. At conquest, colonization, or establishment of present state boundaries, the state shall retain some or all the indigenous social, economic, cultural, and political institutions irrespective of the legal status of states. Moreover, self-identification as indigenous people is regarded a fundamental criterion for determining the grounds on which provisions apply to this convention.

Article 23 of the Cambodian Law on Land (2001) defines the indigenous community as a group of people residing in the Cambodian territory who cultivate land in their possession according to the customary regulations of collective use. These groups manifest ethnic, social, cultural, and economic unity, and practice a traditional lifestyle. The law on communities prioritizes their legal status. The group should continue managing their community and immovable property according to their customary rules (RGC, 2001).

2.8. Summary of the literature reviews

In summary, there are three dimensions of shifting cultivation, although a formal definition is lacking. While shifting cultivation does not harm forest cover, its transformation does have considerable impact. This transformation includes the introduction of cash crop production or agricultural expansion. Deforestation due to agricultural expansion exacerbates environmental problems. Swidden cultivators are firmly tied to land resources; thus, excluding them from their ancestral domains is difficult. Moreover, the forest, used as a common-pool resource, is vulnerable to depletion. Here, a common property regime may need to address forest degradation.

The literature including previous studies and reports reviewed in this chapter focus mainly on agricultural expansion and resource governance of forest degradation. Few studies document the changes in swidden cultivation causing forest degradation. In addition, this literature does not demonstrate land-use dynamics related to the transformation of swidden cultivation.

Chapter 3: Study area and study methods

Ratanakiri Province is mostly covered by forest, and home to indigenous people who practice swidden cultivation. Since opening to development in the 1990s, the province has experienced increased deforestation. This study was conducted in the province to identify the implications of swidden cultivation and reveal the dynamics of forest degradation. This chapter outlines the study area and methods.

3.1. Overview of Ratanakiri province

Cambodia (known as Kampuchea in the Khmer language) is located in the south of the Indochina Peninsula, Southeast Asia. With a total landmass area of 181,035 km^2, it is bordered by Laos to the north, Vietnam to the east, Thailand to the west, and the Gulf of Thailand to the south. Southeast Asia's trans-boundary Mekong River runs from the Tibetan Plateau and crosses Cambodia to the south of Vietnam (Figure 3.1.).

Table 3.1. summarizes the study area. The indigenous population and information is fraught with problems in Cambodia (Moul and Sovathana, 2012).

Table 3.1. Summary of study area

No.	Items	Cambodia	Ratanakiri Province
1	Capital	Phnom Penh	Banlung
2	Official language	Khmer	Khmer
3	Area	181,035 km^2	8,431.32 km^2
4	Population 1998	11,437,656 persons	94,243 persons
5	Population 2008	13,388,910 persons	150,466 persons
6	Indigenous ethnic groups	17 groups	8 groups
7	Indigenous population 1998	101,000 persons	No information
8	Indigenous population 2008	No information	94,242 persons

Source: (The National Committee for Sub-National Democratic Development [NCDD], 2009; National Institute of Statistics [NIS], 2008, 1998)

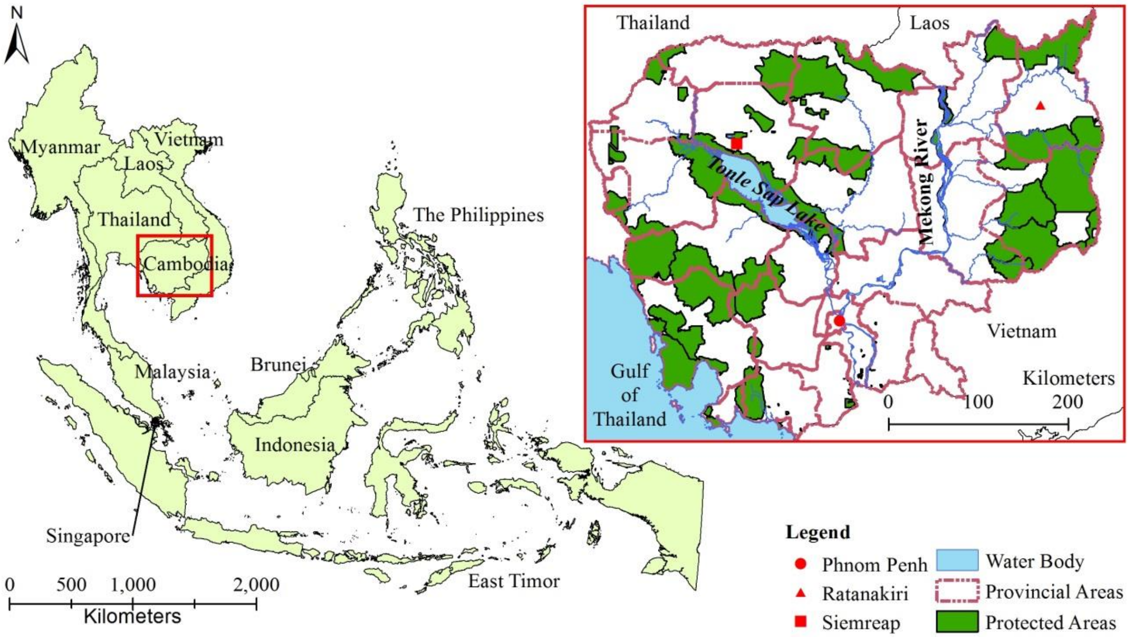

Figure 3.1. Map of Cambodia in Southeast Asia

Ratanakiri Province, located about 588 km northeast of Phnom Penh, is a mountainous area with elevation ranging from 70 m to 1,600 m above sea level. The province population totaled 94,243 people in 1998, increasing to 150,466 in 2008 (NIS, 2008, 1998). The annual growth rate was 4.6%. Eight ethnic minority groups comprised 62.6% of the provincial population.

The province has a total area of 8,431.32 km^2 (NCDD, 2009), and borders the provinces of Mondol Kiri to the south and Stung Treng to the west. Virachey National Park is located in the northern part of the province. Lumphat Wildlife Sanctuary and Nsok Protected Forest are located in the south. The Sesan and Srepok Rivers cross the province, flowing from western Vietnam to the Sekong River, a tributary of the Mekong River (Figure 3.2.).

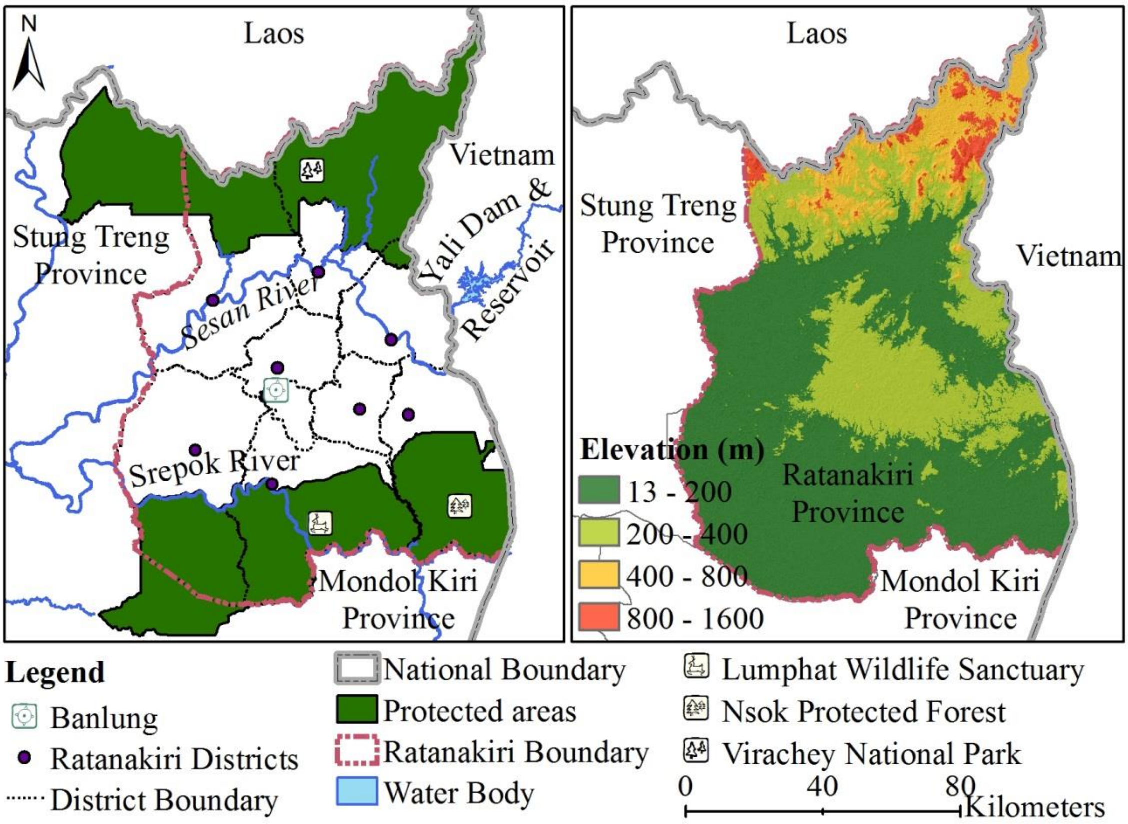

Figure 3.2. Map of Ratanakiri province

Lands and livelihoods of indigenous groups are subject to increasing pressure from foreign agribusiness, logging concessions, and land-market speculators. Access to land resources is limited for indigenous people, who are finding it difficult to secure their livelihoods. Cambodia’s two Prime Ministers approved all land in the province (excepting the national park and wildlife sanctuary) for a 30-year concession by the Indonesian company Macro-Panin. Increasing numbers of lowland Khmer are migrating to the province, and they often obtain land titles, particularly near business centers such as Banlung and Bokeo, as well as in the southern part of O Chum and O Yadao districts (Colm, 1997).

In the past, indigenous people residing in villages respected their elders and village administrators; they demonstrated solidarity and preserved their cultures, traditions, and natural environment. Now, several problems have emerged. For example, young people no longer pay attention to elders, and they no longer wish to follow the animist traditions of their people. Some become Christians, and most no longer adhere to resource administration customs. It seems the younger generation merely wants to listen to the radio and watch DVDs. They do not consider playing traditional instruments such as Gongs. Currently, the biggest problem is that indigenous people sell their land to Khmer people from the lowlands to the south to obtain money to buy objects such as motorcycles and DVD players. People now prefer wooden Khmer-style to traditional housing, which requires more wood and money. Some people use money obtained from land sales to visit karaoke bars and prostitutes in Banlung (Baird, 2008).

3.2. Study area

The study area includes the Sesan Commune and the southern area of the Nhang Commune located 61 km east of the provincial capital Banlung. The Sesan Commune is administered by the district of Ouyadav, while the Nhang Commune falls under the administration of the district of Andong Meas (Figure 3.3.).

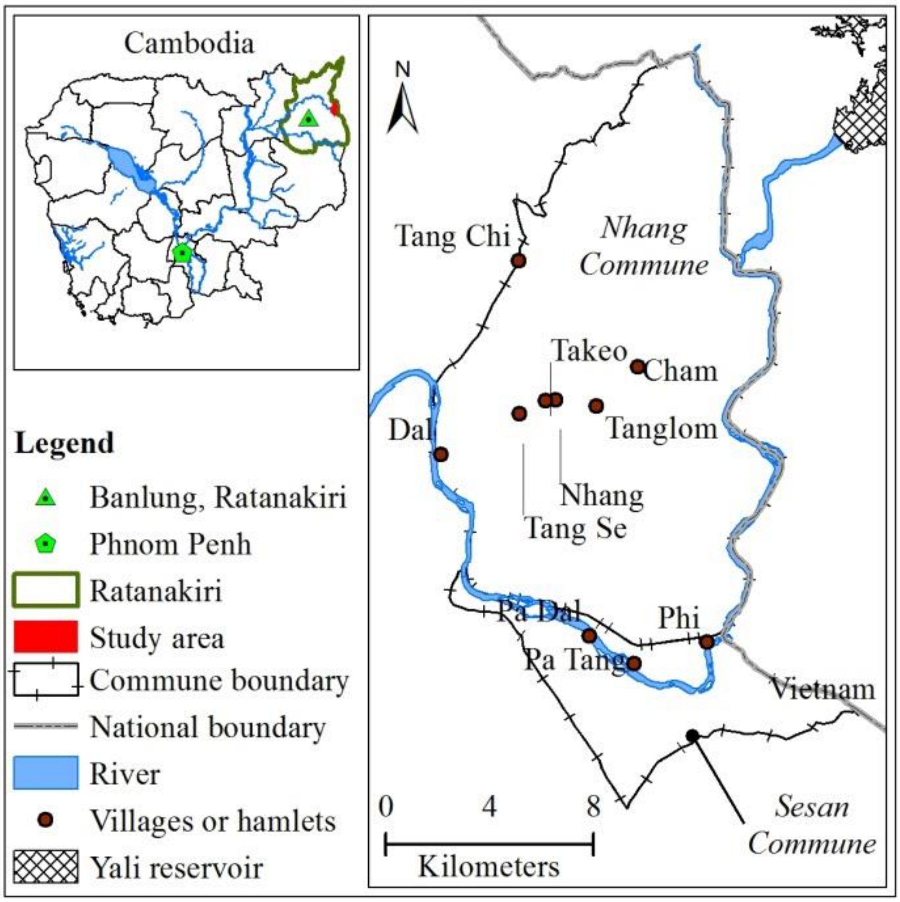

Figure 3.3. Map of the study area in Ratanakiri Province, Cambodia

The study area houses seven villages, one hamlet, and two migrants' villages. It was populated with 557 households with an average of 6.74 individuals per household. Approximately 102 households were in Phi Village, 79 in Pa Dal Village, 40 in Pa Tang Village, 25 in Nhang Village, 130 in Tang Se Village and its hamlet Tanglom, 63 in Tang Chi Village, and 65 in Dal Village. More than 90% of the total population in these villages depend on agricultural livelihoods (NIS, 2008) and belong to the Djarai ethnic minority group. The hamlet of Cham comprised 46 households, with most villagers originating from Kampong Cham Province, located north of Phnom Penh. The "Cham" ethnic label, as used in Cambodia, covers most Muslims in the country (Trankell, 2010). The population of the hamlet of Takeo comprised only seven households of the total population of the study area. Residents of this hamlet belong to the Khmer, the predominant ethnic group in Cambodia.

In addition to the land needs of the above-mentioned indigenous people, migrants are also increasingly seeking land on which to develop their livelihoods, largely from agriculture. We selected Phi Village as a leading example because of its remoteness and traditional practices, while the other villages were targeted to validate information collected. For the individual interviews, 30 families were randomly selected from Phi, 7 from Pa Tang, and 10 from Pa Dal. As key informants of agricultural practices, land use, and livelihoods, the village chief and security keeper from Tang Se, the village chief from Nhang, religious leaders from Cham, and one migrant from Takeo contributed to this study.

The government also requires land use for economic development; for example, Cambodia's 2001 Land Law introduced economic land concessions to increase revenue. These concessions allow agricultural development companies (ADCs) who receive government contracts to develop industrial plantations (RGC, 2001). This multi-faceted competition for land within the country exacerbates the pressure on limited land resources, with agricultural expansion affecting forest cover. Thus, there is a corresponding need to characterize the dynamics of changes to the forest cover.

Forest degradation is evident in this area. Villagers in Phi village reported their attempts to establish cashew farms. Some swidden fields have already been converted to cashew farms. Cassava, a cash crop, is also cultivated in some swidden fields around the village. Villagers have access to the agricultural market in Vietnam (Figure 3.4.).

Figure 3.4. Cashew apples, a cashew farm, and cassava harvesting

3.3. Djarai people in the study area

Djarai villagers in this study area remain loyal to their traditional beliefs and customary tenure. Their traditional beliefs are related to animalism and land resource management. In this society, land is managed by customary tenure, and village elders bear witness to land users. In addition to traditional beliefs and customary tenure, swidden cultivation according to the lunar calendar is also evident (Figure 3.5.).

Figure 3.5. Djarai swidden cultivation

3.4. Research methods

This study applied two research methods, namely a remote sensing technique (RS) and qualitative methods (QM) to explore the transformation of swidden cultivation.

RS plays a vital role in the study of land use and changes to land cover. In land change science, RS can provide valuable, timely information about land resources and environment as necessary basic information (Rahman, 2001). The analysis of land changes relies on remotely sensed data (Southworth and Gibbes, 2010). In addition, RS is the most important tool in the land use and land cover inventory (Dimyati et al., 1996; Lindgren, 1985). In the forest sector, RS using supervised classification methods has proven useful (Musa et al., 2003).

In the remote sensing technique, supervised classification methods with a maximum likelihood classifier are applied to quantitatively generate the volume of land use and land cover. While complicated, supervised classification with maximum likelihood classification is useful in extracting quantitative information (Gao, 2009). Keuchel et al. (2003) explain that maximum likelihood classification occurs before classifying the complexity of land use and land cover.

Furthermore, this study employed qualitative methods to understand the implications of the changing human environment, land use, and land cover. A popular method to collect qualitative data is interviewing people and groups (Levesque, 2012). Hence, land change science may need data collected during qualitative interviews to understand agricultural landscape changes (Sorrensen, 2004).

The combination of RS and QM applied in this study are deemed appropriate for studying land use dynamics in indigenous territories. For example, Erazo (2011) used two research methods, namely internal meetings (group interviews) and satellite image analysis (RS) to understand human-environmental relations, which differentiate between states and indigenous organizations, landscape ideologies, indigenous governance, and changing land uses in the Ecuadorian Amazon. More detail regarding research methods is provided in Chapters 4 and 5.

Chapter 4: The Traditional Practice of Swidden Cultivation in the Djarai Ethnic Communities of Northeastern Cambodia

4.1. Introduction

Many researchers have studied the traditional practices of shifting cultivation and have reported various problems caused by it, particularly the deforestation of some areas (Angelsen, 1995; Goldammer, 1988; Mittelman, 2001). The Cambodian northeastern province of Ratanakiri is the home of ethnic minority groups that have practiced a traditional farming system of shifting cultivation (Hean and Monie, 2002). Shifting cultivation, slush and burn agriculture, and swidden cultivation are synonymous uses, but swidden cultivation describes the rice-based system in Southeast Asian (Mertz et al., 2009). Fox (2002) finds that land uses and total tree covers remained stable in the period of 1953 to 1996 in many parts of Ratanakiri Province.

Ratanakiri Province opened for development in the 1990s. Since then, swidden cultivators have been affected by recent economic development (Colm, 1997). Large and small-scale land acquisitions have seriously threatened indigenous livelihood (NGO Forum, 2006a, 2006b; Rosette, 2005). Recent economic development has generated market pressure that encouraged swidden cultivators to engage in new and different forms of commercial agriculture, which resulted in major changes in land use (Fox, 2002).

The results of previous studies raise a series of questions: What is traditional swidden cultivation? In practice, what kind of crop species are the swidden cultivators growing? What is the reality of swidden cultivation? The goal of this study is to examine the traditional practice of swidden cultivation, farming activities, and land-use patterns related to livelihood of local people who belong to the Djarai ethnolinguistic group.

4.2. The definition of shifting cultivation

Shifting cultivation has been prevalent since the Neolithic era, and it can be best understood by examining its environmental, temporal, and cultural dimensions (Conklin, 1961). The environmental dimension refers to biotic, edaphic, and climatic considerations; the temporal dimension refers to a series of swidden practices; and the cultural dimension includes technological, social, and ethnoecological considerations (Conklin, 1961). In 1982, the Food and Agriculture Organization and the University of Ibadan defined shifting cultivation, which is also referred to as the swidden farming system, as "a system in which a short period of cultivation is followed by a long period of fallow" (Lanly, 1985). Shifting cultivation was also found to be closely related to the natural vegetation-soil complex and cultivators (McGrath, 1987). Furthermore, various groups have changed the meaning of shifting cultivation in order to support specific political interests (Jarosz, 1993), and it is currently defined according to the characteristics of actual land-use practices (Upadhyay, 1995). Therefore, the meaning of shifting cultivation conjoins environmental, chronological, cultural, political, land-use, and livelihood strategies in an area.

Based on a series of questions and literature reviews presented in the previous section, we were provided a hypothesis, which mainly focuses on the origin of swidden cultivation including traditional belief and customary tenure. The hypothesis is "Djarai swidden cultivation is a multiple cropping system interweaving with traditional belief and tenure."

4.3. Research methods

4.3.1. Remote sensing and GIS approach

This study used remote sensing and GIS approaches to outline the exact amount of land use and land cover (LULC) by utilizing three types of satellite images: ALOS AVNIR-2, ALOS PRISM, and Worldview-1's panchromatic data. Land use (LU) refers to human activities undertaken in a certain land cover (LC), which refers to the observed biophysical or physical cover on the earth's surface (Gregorio and Jansen, 1998). ALOS AVNIR-2 data were used for deriving vegetation covers. ALOS PRISM data were used for supporting ground truthing. Worldview-1 data were used for understanding agricultural land uses. Both ALOS AVNIR-2 and PRISM data were taken on February 16, 2011, while Worldview-1 data were taken on February 13, 2012.

The image interpretation was separated into three steps: (1) pre-classification, (2) classification, and (3) post-classification (illustrated in Figure 4. 1.).

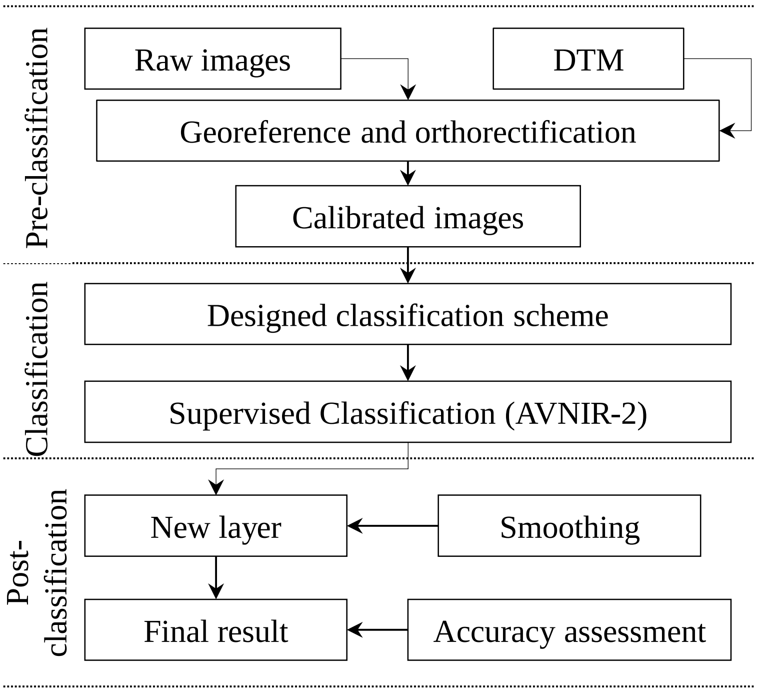

Figure 4.1. Image classification procedure

First, I performed image geometric rectification, which included georeferencing and orthorectification. The study performed image direct georeference on ALOS PRISM and Worldview-1 data with 10 GCPs for 3 polynomials. Then, I georeferenced the ALOS AVNIR-2 data based on the rectified ALOS PRISM data. I generated a DTM using raster interpolation tools before I performed the image orthorectification. I created the DTM based on ASTER GDEM and topographical map data. The topographical map data was produced by the Cambodian Ministry of Land Management, Urban Planning, and Construction and the Ministry of Public Works and Transport. All raster and vector data used in this study was projected to the UTM coordination system (UTM WGS1984 zone 48N meters).

Second, I developed a classification scheme before I conducted supervised classification (Anderson et al., 1976) with 273 training samples, which were categorized into 11 classes of land use. I randomized 102 points for accuracy assessment and 171 points for signature development. Every band (band 1 through band 3) of ALOS AVNIR-2 data was used for supervised classification. The process of supervised classification was repeated several times until results were consistent with the training samples.

Third, a statistical filter was applied to eliminate clump areas smaller than 3×3 pixels, after which I performed an accuracy assessment. The results of this accuracy assessment are presented as an error matrix (Foody, 2002).

4.3.2. Qualitative research

I used the qualitative method to investigate human activities related to the agricultural system. I followed Maxwell (2013) in designing our qualitative method and focused on research questions, goals, conceptual framework, and validity.

Individual interviews were conducted with 30 key informants during field surveys through a semi-structured questionnaire in order to understand the swidden cultivators' activities, and group discussions were also conducted to clarify land-use patterns in detail.

Participatory rural appraisal methods, including participatory mapping, flow diagrams, and seasonal calendars, were partially adopted during interviews (Chambers, 1994a; Narayasamy, 2009).

I analyzed the qualitative data based on five steps: (1) initial coding and memo writing, (2) focused coding and memo writing, (3) new data collection via theoretical sampling, (4) continued coding, memo writing, and theoretical sampling, and (5) shortening and integrating memos (Charmaz, 2006).

4.4. Results

4.4.1. Image classification results

Defined through the results of the image classification of ALOS AVNIR-2, the land areas of each land-use type are identified in Table 4.1., and the LULC map is presented in Figure 4.2. As a result of the accuracy assessment, a good signature reparability was achieved for each classified image. The overall accuracy value and overall Kappa statistics were 89.2% and 0.8 respectively (Table 4.1.).

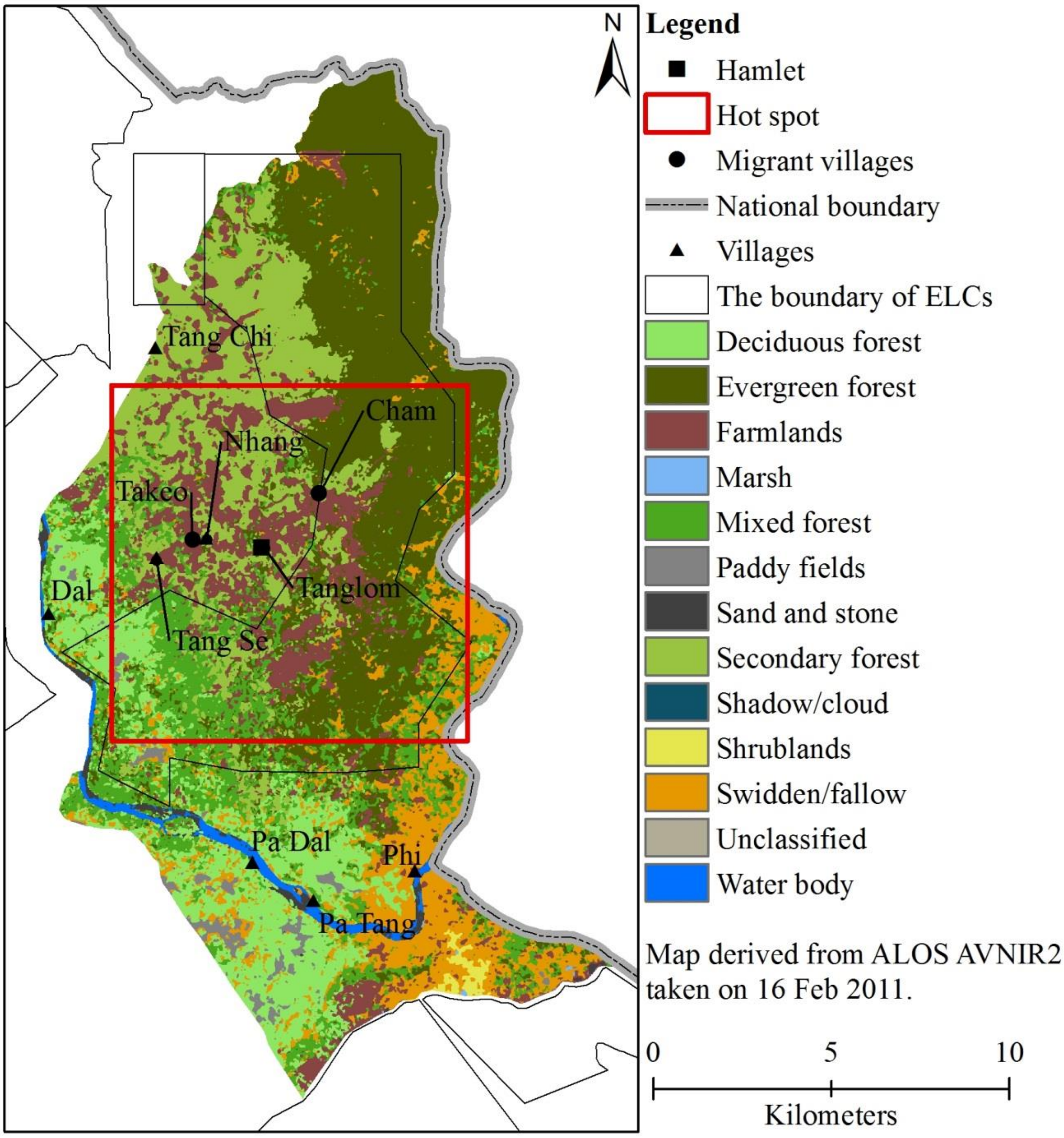

Figure 4.2. Land use and land cover map

Table 4.1. Error matrix, accuracy totals, Kappa statistics and image classification results

Classified Data	Farmlands	Paddy fields	Swidden/ Fallow	Deciduous forest	Evergreen forest	Mixed forest	Secondary forest	Shrub	Marsh	Sand/ stone	Water body	Row total	Producer's accuracy (%)	Kappa	Area (ha)
Farmlands	61	1	0	0	1	0	0	0	0	0	0	63	92.4	0.9	3,327
Paddy fields	0	6	0	0	0	0	0	0	0	0	0	6	85.7	1	297
Swidden/Fallow	4	0	5	0	0	1	0	1	0	0	0	11	100	0.4	2,685
Deciduous forest	0	0	0	2	0	1	0	0	0	0	0	3	100	0.6	2,923
Evergreen forest	1	0	0	0	5	0	0	0	0	0	0	6	83.3	0.8	7,200
Mixed forest	0	0	0	0	0	1	0	0	0	0	0	1	33.3	1	3,540
Secondary forest	0	0	0	0	0	0	1	0	0	0	0	1	100	1	3,847
Shrub	0	0	0	0	0	0	0	0	0	0	0	0	0	0	104
Marsh	0	0	0	0	0	0	0	0	1	0	0	1	100	1	17
Sand and stone	0	0	0	0	0	0	0	0	0	5	1	6	100	0.8	280
Water body	0	0	0	0	0	0	0	0	0	0	4	4	80	1	467
Column total	66	7	5	2	6	3	1	1	1	5	5	102			24,687
User's accuracy (%)	96.8	100	45.4	66.7	83.3	100	100	0	100	83.3	100				

The overall accuracy value: 89.2% and the overall Kappa statistics: 0.8

4.4.2. Djarai traditional beliefs

The Djarai's swidden system is related to local belief. The swidden cultivators perform rituals at each moment from selecting the forest lands to post-harvest activities. Before clearing the forest, they have a meeting to find a new area in the forest that they will use. They knock on the ground and whisper, "We are going to use this plot" when they find the proper plot. This statement is a request that the gods offer them that land. After this, they return to the village or sleep next to the area to wait for the gods' response.

The response can be provided via a dream or an animals' cry. They could cultivate the forest land if they have a good dream of fishing, rowing a boat, or crossing a desert. If they do not have a bad message within seven days, they could develop the forestlands.

Table 4.2. presents the seasonal calendar related to livelihood activities of Djarai swidden cultivators. As well, the table illustrates the diversification of crop species especially rice variety and spiritual beliefs related to land preparation of Djarai people.

Table 4.2. Seasonal livelihood activities of Phi villagers

Months	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Land preparation									SF*	SF*	CF	B
Rice ceremonies		1st		2nd	3rd	3rd			LE*	LE*		
First rice variety	P	M	M	M	H							
Second rice variety	P	M	M	M	M	H						
Third rice variety	P	M	M	M	M	M	M	M	H			
Vegetable species	P	M	M	H								
Cassava	P	M	M	M	M	M	M	M	M	H		

Legend: SF = Selecting forest land, CF = Clearing forest land, B = Burning, 1st through 3rd = Numbers of rice ceremonies, LE = Land expansion, * = Rituals related to Djarai land tenure practice, categorized by growing period, P = Start planting, M = Managing farmland, H = Harvesting

In contrast, they could not develop the forest land if they have an inappropriate dream within seven days, which might reference sexual affairs or particular animals such as deer, tigers, or sacred birds that had been shot or died in that land. Villagers who experience a bad dream search for a different location.

In the cropping stage, they perform ceremonies that are divided into three rites known as the Rice Ceremony. The first ritual is conducted when the rice's height is about 40 to 50 cm, and the second ritual takes place during the flowering stage. Those rituals call the gods to protect their property. The third ceremony is performed after the rice is harvested and before the rice is put in a warehouse. That ritual thanks the gods and asks them to provide sufficient food in the following year.

To expand the land, they perform another ritual. The new land can be identified by a spiritual stick that divides the old and new lands. This series of rite is outlined in Table 4.2.

4.4.3. Djarai land tenure practice

The forest is one of the main sources of food. The swidden cultivator collects non-timber forest products (NTFP), while wood products are commonly used for housing. Those products stabilize the livelihoods of the swidden cultivators. The villagers carefully use forest and other land resources according to their traditional zoning system, which consists of five categories: (1) housing area, (2) funeral forest, (3) spiritual forest, (4) agricultural land, and (5) fallow land.

The housing area can be relocated if villagers become seriously sick; lightning, or animals hit houses are a threat. The villagers also relocate when they start swidden cultivation in another area. The spiritual forest is the holy place of their animistic belief. The funeral forest, located near the village, is utilized as a cemetery. The spiritual and funeral forests can be accessed, but farming and timber harvesting there are not allowed. The agricultural and fallow areas are located around the village and along the Sesan

River (see Figure 4.2.). Villagers partly use the fallow lands for hunting. The land boundary of each category of zoning is not clearly defined.

Traditionally, transferals of land ownership take place. The current cultivation and fallow plots are properties held by individuals. For example, land can be passed from the older generation to the younger generation. Figure 4.3. provides an overview of land expansion and ownership. In 2011, a young family (a couple who married recently and needed land resources to sustain their family) inherited 0.82 ha of swidden plot from her father a year after married. There was no land title. The witnesses were the village elders.

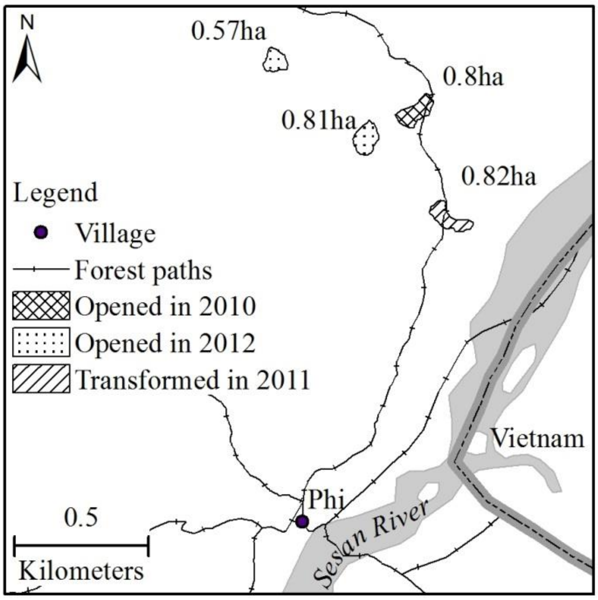

Figure 4.3. Djarai land-ownership transferals and land expansion

In addition, landed families can transfer a plot of land to landless families. To get land, landless families make a proposal to the owner. The village elders are usually the witness of such land transformations. Moreover, land without an owner can be shared among the villagers.

4.4.4. Crop decision and farm management

Swidden cultivators grow different crop species. During the field survey, sixteen crop species were identified, including cucumber, sesame, gourd, pumpkin, mung bean, sweet potato, cassava, maize, pineapple, Chinese long bean, eggplant, banana, banana rough, chili, ridge gourd, and sponge gourd. At least five crop species were found in every swidden plot (see cropping calendar in Table 4.2.). This crop diversity creates the seasonal activities that help establish a more resilient livelihood. Such multiple cropping systems are parts of traditional land-use practices.

In daily farm management, men are responsible for collecting NTFP, fishing, hunting, and preparing swidden plots. Women are responsible for household chores and crop management, including weeding and harvesting. They are also responsible for selecting varieties for the next season. Children assist their mothers depending on their abilities.

Weed competition is a fundamental problem for the farmers because traditional swidden cultivation only uses hand tools such as hatchets, blades, or hoes to manage weeds. The villagers recognize that one effective solution would be to import some agricultural materials such as herbicide or pesticide.

Even though they need cash to buy those agricultural chemicals, the agricultural products that are harvested from typical swidden plots are not bountiful enough to sell. As a result, some farmers have introduced production of cash crop from neighboring villages, in order to increase their family's income.

They sell cash crop products at local markets or export them to outside markets in Vietnam. In turn, they import daily commodities. Their intuitive decision has formed a mobility system (Figure 4.4.) for trading agricultural products.

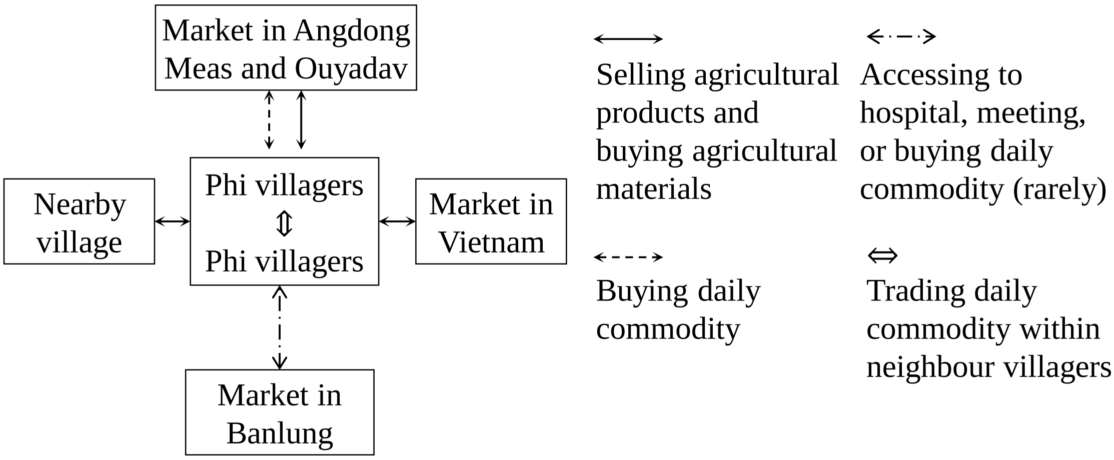

Figure 4.4. Mobility diagram of the Djarai villagers

4.5. Discussion

In this study, I conducted supervised classification with the maximum likelihood classification method because there were many types of land use and land cover in the study area observed during the preliminary study. The image interpretation revealed the exact land use and land cover quantitatively (Table 4.1.). As the accounting of land uses is limited to direct human-induced usage of land, the distinction between natural and human activities cannot be identified using remote sensing data alone; as such, local information may be required in addition to the reality of swidden cultivation (Rosenqvist et al., 2003). Without applying qualitative methods, I could not fully determine how the lands are used (Maxwell, 2013).

4.5.1. Land-use patterns

In addition to the ALOS AVNIR-2 data, a ground truth survey and visual image classification of Worldview-1 data were utilized in order to understand land-use patterns more concretely (Figure 5.3.). A mosaic landscape of agricultural land in the study area displayed the land-use patterns of indigenous communities, migrant communities, and economic land concession (ELC).

Two types of rice production systems were found in this area—wet season and upland rice farming. Wet season rice farming began in the Pol Pot Regime between

1975 and 1979. The paddy fields were located in the western portion of the village, where only seven villagers conducted this farming system from 1979 to 1997. After 1997, the areas were abandoned (Figure 4. 5.).

Figure 4.5. An abandoned paddy field

In 2001, the Cambodian government re-enacted land law. The law allowed the government to claim lands for economic purposes. In 2006, an agricultural development company signed an agreement with the Cambodian Ministry of Agriculture, Forestry, and Fisheries to receive ELC for planting industrial crops, and it received 8,654 ha of land to grow acacia or rubber. In the present, the company develops forest land for rubber plantations (Figure 4.6.).

Figure 4.6. Inside the rubber plantation

In 2002, the villagers found a new territory located north of Phi village that local people called the "Red Soil Area." In the beginning, there were five families in the new area to develop the forest land into a cashew farm. During the field observation, 34.9% of the village households practiced cash crop farming. Older cashew farms were found, and they were reportedly decreasing their production. In the first year, Phi villagers developed forest land into cashew farms by integrating rice and cashew in the same plot (Figure 4.7.). In the second year, swidden cultivators expanded the land, and they were directly seeded with rice and cashews. Reportedly, some Djarai villagers will keep expanding their land until they can collect cashew fruit, and some villagers will try to expand their land without limitation.

Figure 4.7. Swidden change farming

From 2006 to the present, Cham-people from different parts of Cambodia migrated to Tang Se village, which is located in the northern part of Phi village. According to the interview, the migrants came to this area for two main reasons. First, some of them, after returning from work in Malaysia and Thailand, sought private property for conducting agricultural activities. Second, some people who lived along the Mekong River (in the Kampong Cham Province) and whose livelihood depended on rice-based farming and fishing sought access to land resources when their aquatic resources became limited.

4.5.2. Transformation of swidden cultivation

During the interviews, seven interviewees among thirty key informants responded that they had moved away from their traditional belief. One interviewee stopped performing rituals because he transformed his rice farm into a cash crops farm that grew cassava and cashew. Two families decided to stop performing ritual and introduce new agricultural technique because they utilize modern technology to increase agricultural products rather than spiritual belief. Five families became Christians. The Christian farmers stopped performing ritual, and they did not have a spirit forest or funeral forest.

Land tenure practice has also changed since the introduction of cash crops in 2002. The transferal of land ownership, which was previously handled among neighbor villagers and family members, has disappeared due to land alienation. This situation encouraged a drastic influx of rural migrants into this area. Poffenberger (2009) argues that migrants moved in large numbers into Oddar Meanchey Province, in northwest Cambodia, and in the process increased the rural population and made land resources scarce. At the same time, Fox et al., (2009b) find that indigenous people viewed land as a market commodity. The change in land tenure practice affected land resources because Djarai villagers previously used land resources as common-pool resources. In the theory of common-pool resources, the resource users have the right to sell or lease their collective properties (Schlager and Ostrom, 1992).

Swidden cultivation is under transformation in the Phi village. I found that Djarai swidden cultivation practice has been transforming into monocropping systems of agriculture. This transformation of their farming system was not suitable for forest stewardship, as observed elsewhere (Fox et al., 2000; Hariyadi and Ticktin, 2012; Rerkasem et al., 2009). In addition to the transformation of shifting cultivation, Cramb (2009) argue that although cash crops might improve the livelihoods of indigenous people, shifting cultivation can present a safety net in the face of market fluctuations. Today, Djarai villagers are managing both traditional swidden cultivation and cash production. Therefore, villager’s activities will increase pressure on land resources.

4.6. Conclusion

Djarai swidden cultivation systems are multiple cropping systems that intertwine traditional beliefs and tenure. Recently, I found that it has been transformed into monocropping systems of farming. A change in any element that composes the traditional farming system can cause other problems. There are at least two features of composing elements to be considered.

First, in farm management, Djarai swidden cultivation systems have the same temporal dimension in many areas. The swidden change farming systems integrate cashew and rice in the same field. The villagers expand their land every year in order to produce rice. Some of them attempt to expand their land without limiting themselves.

Second, in land tenure practice, Djarai villagers transfer land ownership between neighboring villagers or family members. Recently, land has been used as a commodity market. According to common-pool resource theory, villagers have the right to dispose of their land, but land under open-access resources is vulnerable to forest degradation.

Finally, the combination of the remote sensing technique and qualitative survey applied in this study proved to be a useful approach and will be increasingly helpful in understanding swidden cultivation for the designing area. These results should be considered in further studies of change in land use and land cover in this study area.

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Chapter 5: The Impact of Agricultural Expansion on Forest Cover in Ratanakiri Province, Cambodia

5.1. Introduction

The decline of forests and woodlands in most developing countries has occurred primarily as a result of converting the land for crop production (FAO, 1997). Cambodia is no exception, reporting large forest losses over the last decade (FAO, 2012, 2010a). For example, the proportion of forest cover in Cambodia ranged from 73-74% of country landmass between 1969 and 1990 (Savet and Sokhun, 2003), and decreased to 57% between 1990 and 2010. In addition, the proportion of agricultural land expanded from 26% to 31% between 1997 and 2007 (Broadhead and Izquierdo, 2010) and to 32% in 2011 (FAO, 2014). Agricultural expansion is a significant factor in Cambodia's deforestation (Poffenberger, 2009) and has directly impacted forest cover (Broadhead and Izquierdo, 2010).

In the 2000s, the forest-dependent population comprised about 1.4 million of the 11 million people in Cambodia (Poffenberger, 2006). Forests are necessary for rural livelihoods and a healthy environment, and serve as a vital source of staple foods and wood products for many of the poorest people (FAO, 2012; Hansen and Neth, 2006); as such, forests contribute to poverty-alleviation strategies (Wunder, 2001). In addition, forests play a major role in climate change through their role in carbon sequestration (Salati and Nobre, 1991). Deforestation has had negative ecological and environmental consequences (Zhao et al., 2006) through the release of CO2 (Detwiler, 1986; Houghton, 1999; Searchinger et al., 2008), impact on water quality (Johnes and Heathwaite, 1997; Sliva and Williams, 2001; Tong and Chen, 2002), alteration of regional climates (Zhang and Mcguffie, 2001), and a loss of biodiversity (Haines-Young, 2009; Reidsma et al., 2006).

Land-change scientists acknowledge driving forces (Wood and Handley, 2001), or keystone processes (Marcucci, 2000), that affect the evolutionary trajectory of the landscape (Bürgi et al., 2004). The five major types of driving forces are socioeconomic, political, technological, natural, and cultural (Brandt and Primdahl, 1999; Bürgi et al., 2004). These scientists are also concerned about the transition of farming systems and rural migration, which are considered causes of land-use changes and deforestation (Carr, 2009).

Agricultural practices, especially the swidden practice, have been changing rapidly in Ratanakiri, reflecting a broader agricultural transition (Fox et al., 2009b). The permanent replacement of the swidden practice by other land-use systems could result in the decline of plant diversity (Rerkasem et al., 2009).

Previous research has revealed that migrant encroachment also contributes to changes in forest cover. In the northwestern Cambodian province of Oddar Meanchey, it was estimated that the rural population increased about 12% per annum between 1998 and 2008, of which 9% was due to in-migration (Poffenberger, 2009). Migrants often flow directly to rural areas seeking livelihood opportunities related to agriculture, resulting in the need to convert forests to agricultural land (Carr, 2009, 2004). Thus, detailed analyses at subnational levels are required (Barraclough, 2000) in order to better understand the social dynamics of agricultural expansion and tropical deforestation.

These findings are very important, but a few questions remain, such as how and why changes to the swidden practice are considered a critical factor to deforestation, and how migrants' access to land resources are contributing to forest cover changes. Therefore, this study aims to characterize the dynamics of forest cover changes caused by agricultural expansion, pinpointing patterns of agricultural land at a local level and then specifically addressing the critical question "why does agricultural expansion have such a significant impact on forest cover?"

5.2. Methods

5.2.1. Ground Truth

The subset image (ALOS PRISM 2011) covering the study area, described in Table 5.1. and Figure 5.1., was used in the participatory mapping of land-use patterns through discussion with villagers. After participatory mapping, I conducted ground truth with a GPS device and collected 273 training samples. Based on these, I developed a classification scheme (Anderson et al., 1976) containing three types of land use or cover: agricultural, forest, and other lands. Within the classification of agricultural lands, there were three sub-types of land use: farmland, paddy fields, and swidden/fallow fields. Farmlands represent land that is currently being cultivated for cashews, cassava, or rubber, and newly opened fields, where farmers had just cleared or burned trees. Paddy fields indicate land that was established during the Pol Pot Regime (1975-1979) and is used for wet-season rice cultivation. Swidden/fallow fields are mixed-use land.

Four types of forest cover – deciduous, evergreen, mixed, and secondary forest – were found and classified in this study area. Deciduous forests contain dry mixed deciduous trees and dry Dipterocarp trees. Evergreen forests are usually multi-storied forests where trees keep their leaves throughout the year. Mixed forests combined deciduous trees and evergreen trees in the same location. Secondary forests contain a dense layer of young trees that belong to the "forest cover" class. The other classes of land use/cover were shrublands, which refer to a combination of shrubs, grass, trees (FAO, 2010b), as well as marsh, sand and stone, and water. Marshes are dominated by herbaceous species, and are found near lakes, river banks, and around paddy fields. In some areas, marsh cover is a mixture of water and soil. Water refers to rivers and streams.

5.2.2. Image Interpretation

Figure 5.1. presents the three-step procedure of image classification: image pre-processing, image classification, and post classification (Gao, 2009). First, raster and vector data were projected to the UTM coordinate system (UTM WGS1984 zone 48N meters). I performed geometric calibration of images, through georeference and orthorectification, and applied these processes to every raster dataset, using 10 ground control points for three polynomials (Gao, 2009). I developed Digital Terrain Models (DTM) from the ASTER Global Digital Elevation Map (GDEM), and identified

elevation points produced in 2002 by the Cambodian Ministry of Public Works and Transportation and Ministry of Land Management, Urban Planning and Construction for orthorectifying images. Second, I interpreted the ANVIR-2 images using the supervised classification method with the parametric rule of maximum likelihood. As part of the supervised classification procedure, 100 points for accuracy assessment and 173 points for developing signatures were randomized. The process of supervised classification was repeated several times, until results were consistent with the training samples. Third, a statistical filter was applied to eliminate clump areas smaller than 3×3 pixels. The overall accuracy assessment resulted in values between 85% and 89%. I applied raster overlapping methods to detect land-use/cover changes (Gao, 2009).

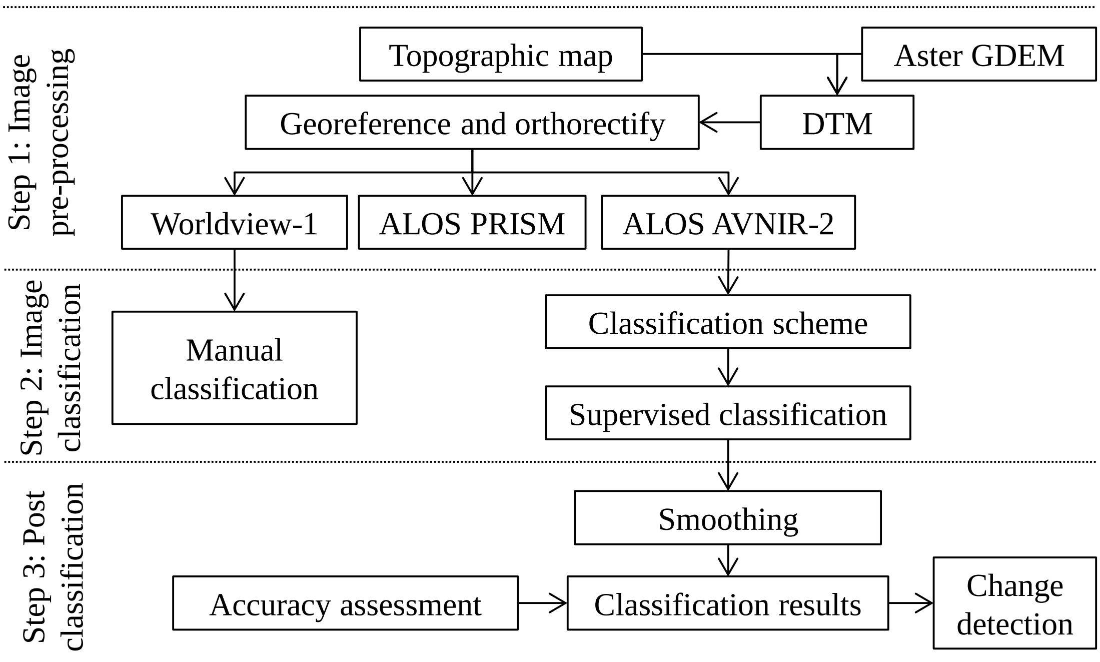

Figure 5.1. Three steps of the image classification process

Table 5.1. Characteristics and usages of remote sensing data used in this study

No.	Sensors/data	Resolution	Acquisition	Usages
1	Aster GDEM	30 m	N/A	Procedure of orthorectification
2	PRISM/ALOS	2.5 m	16 Feb 2011	Support ground truth
3	AVNIR-2/ALOS	10 m	05 Feb 2007	Land cover classification
4	AVNIR-2/ALOS	10 m	16 Feb 2011	Land cover classification
5	Worldview-1	0.5 m	13 Feb 2012	Create mosaic of agricultural land

5.2.3. Processing Qualitative Data

I followed Maxwell (2013) to design our qualitative method, focusing on goals, conceptual framework, validity, and research questions. I also adopted ethnographic methodologies (Gobo, 2011) to collect current information. Individual interviews were conducted during field surveys through a semi-structured questionnaire in order to evaluate actual case studies, and group discussions were also conducted to determine land-use patterns. Participatory rural appraisal methods (Chambers, 1994a, 1994b, 1994c) were partly adopted during interviews, including participatory mapping, flow diagrams, and seasonal calendars (Narayasamy, 2009). I analyzed the collected qualitative data based on five steps: (1) initial coding and memo writing, (2) focused coding and memo writing, (3) new data collection via theoretical sampling, (4) continuing to code, memo and use theoretical sampling, and (5) shortening and integrating memos (Charmaz, 2006, 2000). Finally, I used constructivist grounded theory, a method of constructing theory that researchers systematically developed from collected data (Mills et al., 2006). The method was adopted to express views derived from the collected data, with the intention of transforming social data into theory. Table 5.2. illustrates the field research activities.

Table 5.2. Summary of field surveys

No.	Research periods	Main Activities	Outcomes
1	From 15 November 2012 to 25 December 2012	Ground-truthing	Collection of training samples for image classification
		Individual interview	Understanding of land-use history for every training sample
2	From 02 February 2013 to 23 March 2013	Processing qualitative data	Collection of in-situ information related to changes in land use

5.3. Results

5.3.1. Land Cover Classification

Land use in the study area has undergone dramatic modification (Table 5.3.), and in 2007, land-use transitions became more apparent; for example, farmlands covered 2,525 ha, paddy fields were 271 ha, and swidden/fallow covered 3,013 ha. In addition, deciduous forest coverage was approximately 2,083 ha, while evergreen forests occupied 6,799 ha. Mixed forest coverage was 3,986 ha, while secondary forests and shrublands accounted for 4,698 ha and 453 ha, respectively.

Table 5.3. Results of land-use/cover classification and their changes from 2007 to 2011

No.	Land uses/covers	Classification results (ha)		Land-use changes 2007–2011	
		2007 (Year)	2011 (Year)	Change (ha)	Change (%)
1	Deciduous forest	2,083	2,923	840	-3.4
2	Evergreen forest	6,799	7,200	401	1.62
3	Farmlands	2,525	3,327	802	3.25
4	Marsh	9	17	8	0.03
5	Mixed forest	3,986	3,540	-446	-1.81
6	Paddy fields	271	297	26	0.11
7	Sand and stone	362	280	-82	-0.33
8	Secondary forest	4,698	3,847	-851	-3.45
9	Shrublands	453	104	-349	-1.41
10	Swidden/fallow	3,013	2,685	-328	-0.33
11	Water body	407	467	60	0.24

Note. + = Increase, - = Decrease. The classification accuracy is 85.7% in 2007 and 89.2% in 2011.

By comparing the land-use classification in 2007 and 2011, I could easily see that the land uses was seriously changing during the study period. In 2011, farmlands increased to 3,327 ha and paddy fields increased to 297 ha. The coverage of swidden/fallow lands was 2,685 ha, deciduous forest coverage was approximately 2,923 ha, and evergreen forests occupied 7,200 ha. Mixed forests, secondary forests, and shrublands occupied 3,540 ha, 3,847 ha, and 104 ha, respectively. During the period 2007–2011, farmlands increased by approximately 802 ha and paddy fields by 26 ha, but swidden/fallow lands decreased by 328 ha. Deciduous forests and evergreen forests increased by approximately 840 ha and 401 ha, respectively. The coverage of mixed forests decreased by 446 ha and secondary forests by 851 ha. Shrublands covered 349 ha (Figure 5.2.).

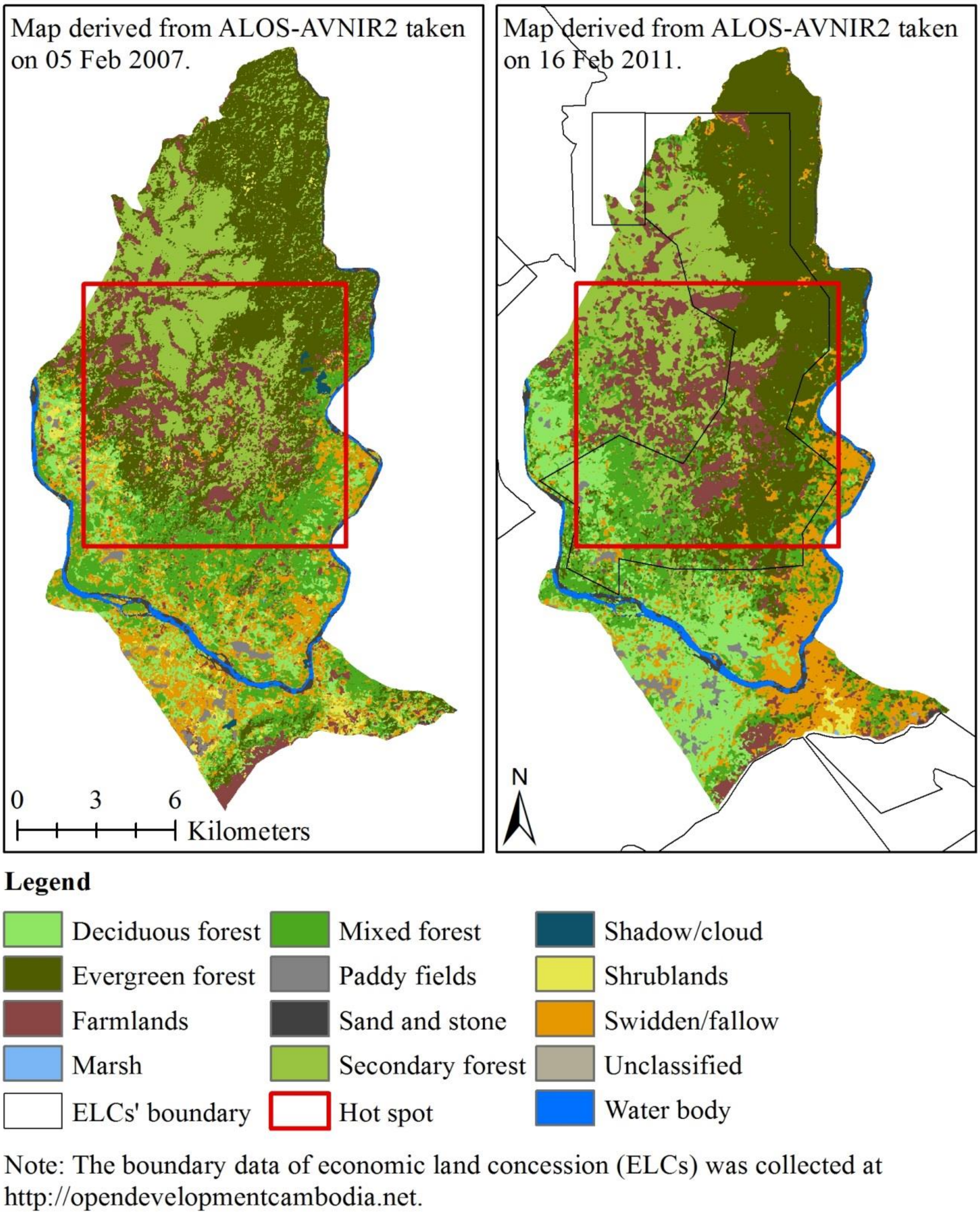

Figure 5.2. Land-use/cover maps derived from satellite images in 2007 and 2011

5.3.2. The Impact of Agricultural Expansion

Table 5.4. illustrates the land-use/cover changes during the study period and the impacts of agricultural expansion on forest cover types. For example, farmlands had an influence on deciduous forest of about 155.3 ha and effected evergreen forest by about 245.1 ha. In addition, 268.7 ha of mixed forest were converted to farmlands and 456.6 ha of secondary forests were developed for cash crop farming. About 10.9 ha of paddy fields were converted to farmlands and 183.4 ha of swidden/fallow lands were transformed into farmlands. Swidden/fallow threatened 1,018.9 ha of deciduous forest and 156.5 ha of evergreen forest. The impact of swidden and its fallow on mixed forest covered 341.4 ha. This traditional farming system also influenced 35.9 ha of secondary forests.

Table 5.4. Land-use/cover changes between 2007 and 2011 detected in raster format (Unit: ha).
The table is read as the change in land cover in 2011 (DOWN) from land cover in 2007 (ACROSS)

2007 / 2011	Deciduous forest	Evergreen forest	Farmlands	Marsh	Mixed forest	Paddy fields	Secondary forest	Shrublands	Swidden/fallow
Deciduous forest	1,057	35	58.7	0.3	369.9	23.8	7.2	15.2	503.5
Evergreen forest	50	4,461.1	424.2	0.3	878*	1.5	790.3*	0.3	181.1
Farmlands	155.3	245.1	1,164.1	1.7	268.7	10.9	456.6	30.1	183.4
Marsh	1.6	0.4	0.0	0.0	2	0.0	0.0	0.1	1.8
Mixed forest	386.7	1,147.9**	184.8	0.2	1,526.2	7.3	197.6	0.7	514.6
Paddy fields	107.6	0.1	1.1	0.0	0.3	155.1	0.0	0.1	6.4
Sand and stone	15.5	26.8	1.8	5.8	5.7	0.7	0.0	0.1	14.3
Secondary forest	6.9	1,064.9**	1,078.5	0.4	110.6	0.2	2,390.1	0.0	44
Shrublands	229	21.6	14.9	1.9	14.6	27.6	0.7	36.3	104
Swidden/fallow	1,018.9	156.5	139.4	3.8	341.4	93.1	35.9	20.3	1,146.7
Water body	20.8	5.4	0.2	0.4	11.4	0.0	1.4	0.0	5.6

Note. * = examples of inherently dynamic, ** = examples of forest disturbance. For a discussion about (* and **), refer to section 4.4.

5.3.3. Agricultural Mosaic

To gain an enriched understanding of agricultural expansion, I digitized land-use parcels from a 2012 Worldview-1 (100 km2) image using ArcMAP 10.1. The flow of image processing was presented in Figure 5.1., and the image in Figure 5.3. illustrated the “hot spot” zone, where agricultural expansion had the greatest influenced on forest cover. To create an agricultural mosaic land-use map, I employed digital land-use parcels combined with ground truth information. The agricultural mosaic signifies diversification of agricultural land uses located in the forest landscape.

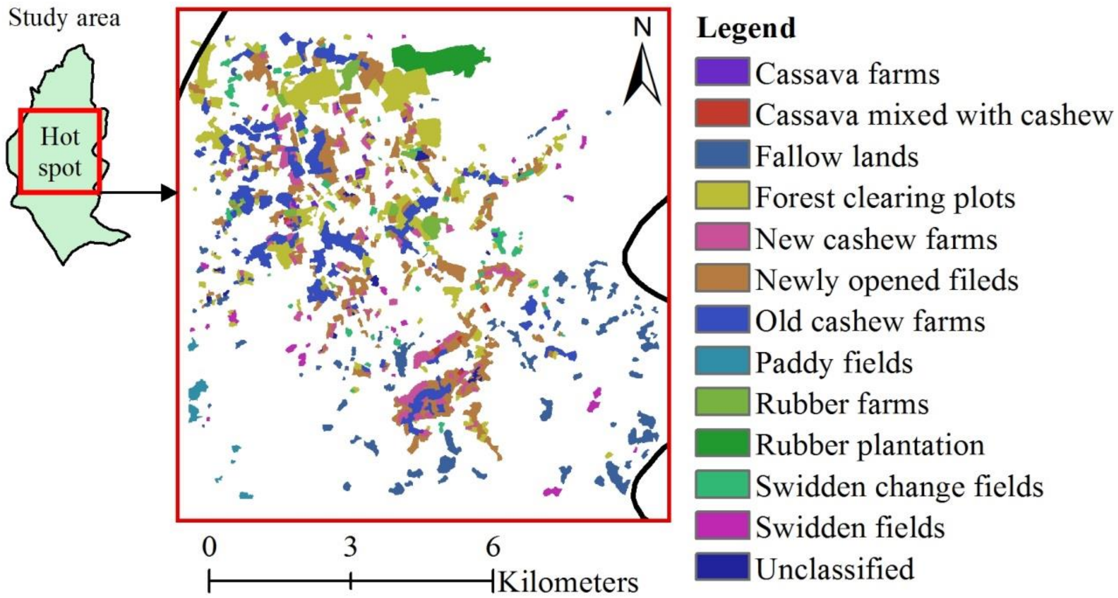

Figure 5.3. Map of exquisite land uses derived from Worldview-1 image illustrating an agricultural mosaic

Every type of agricultural land including cassava farms accounted for 21 ha. Cassava mixed cashew, in which cashew trees were grown alongside cassava plants, accounted for 7 ha. Forest clearing plots covered over 488 ha. Fallow lands amounted to 247 ha and rubber plantation developed by ADC accounted for 97 ha. New cashew farms, which contain young cashew trees, accounted for 153 ha. Newly opened fields recorded the highest extent, at 506 ha. Old cashew farms occupied 408 ha and paddy fields took up 28 ha. Rubber farms developed by the locals covered 62 ha. Swidden fields occupied 47 ha, with swidden changes over 69 ha where swidden agriculture as the multiple cropping systems had been transformed into monocropping system for cash crop production. Unclassified farms totalled 21 ha per the field survey (Figure 5.4.).

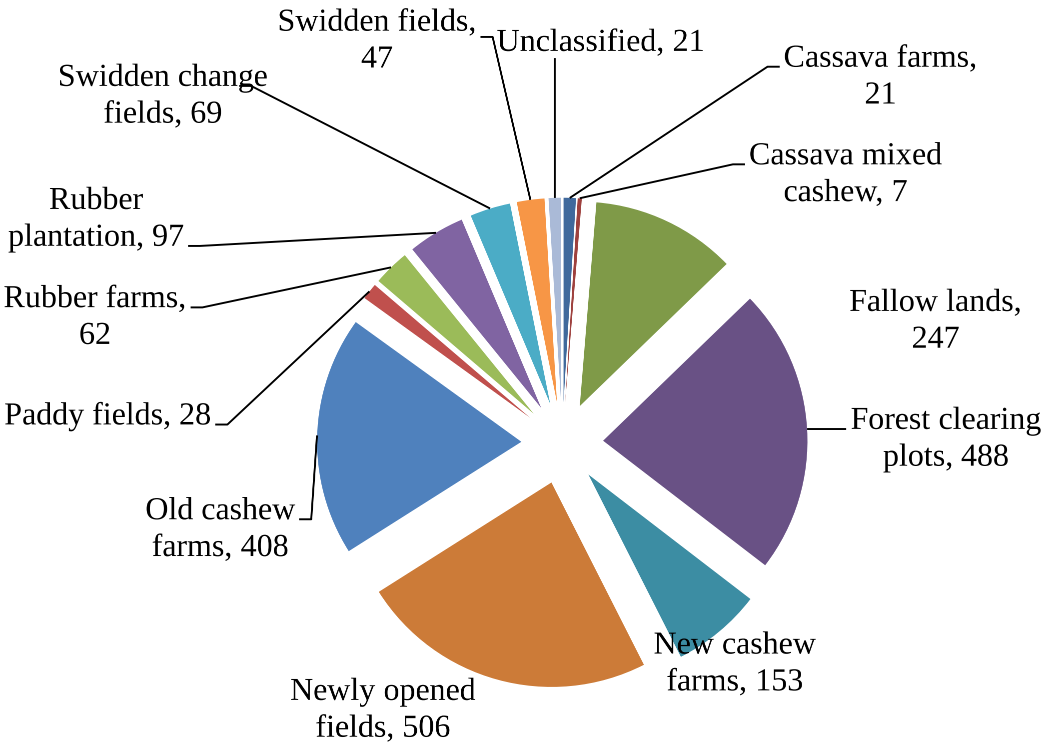

Figure 5.4. Composition of agricultural land uses in the selected area of forest landscape (ha)

5.4. Discussion

In this study, I conducted supervised classification with the maximum likelihood classification method due to the unique information classes on the ground. Results show that trends in land-use changes within the study area primarily originate from forestland that is converted for agricultural uses. While the accounting of land-cover changes is limited to direct human-induced changes, distinction between natural and human-induced changes cannot be identified using remote sensing data alone; as such, contemporary in-situ information may be required (Rosenqvist et al., 2003). Thus, without applying qualitative methods, I could not fully determine how the land use changed (Maxwell, 2013).

5.4.1. Transitions in the Farming System

I generally found a shift in traditional cultivation practices near water sources, such as rivers or streams (Figure 5.5.). Traditional practices are based on a multiple cropping system in which rice, the staple food of indigenous people, is normally cultivated. During fieldwork, 16 different crop species were counted, with five of these species occurring on every plot of farmland. Some shifting cultivators arranged the swidden fields according to their topographical distribution and soil type; for example, fruit trees were grown at the highest elevation or next to the edge of the forest, while vegetable species such as chili peppers and eggplant grew next to the farmhouse. Our sample farmhouse (Figure 5.5.) was a small house built on a swidden farm that was used for storing rice as well as a place to live during planting season. The vegetable crops here included cucumber, gourds, and watermelon, grown alongside rice. Bananas grew next to the water source. Between one and three years ago, many swidden fields were converted to fallow lands, and farmers would often clear a plot of land next to their former field. The size of fallow lands ranged from 0.5 ha to 1.6 ha, similar to the size of the swidden fields. The size was noted to be dependent on the number of family members (Hor, 2012).

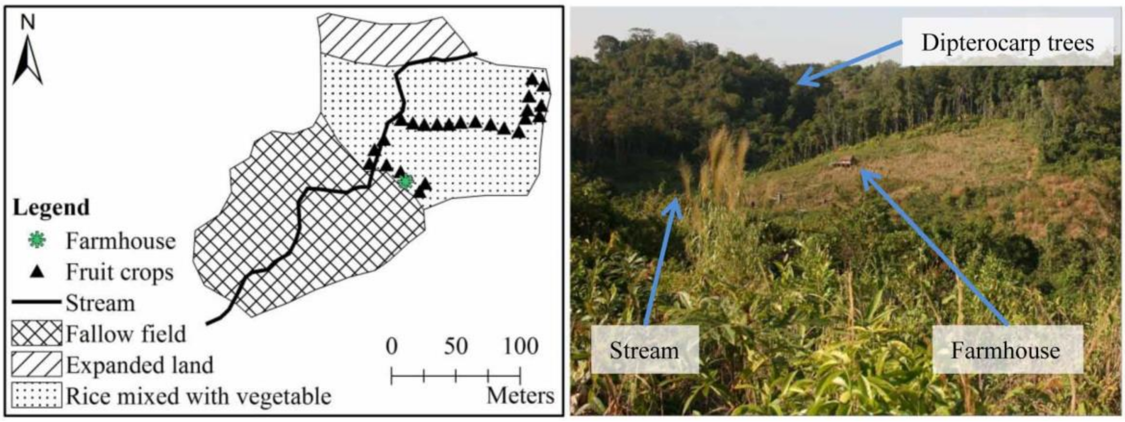

Figure 5.5. A farm arrangement and photo of traditional swidden agriculture

In contrast, most shifting cultivators changed to a monocropping system, focusing on production of cash crops, such as cashew, rubber, or cassava to increase their income. They learned to cultivate cash crops from other villagers or migrants but did not take into account the physical structure of cashew plants, which led to rice being grown under cashew trees, as shown in Figure 5.6.

Figure 5.6. Left image shows a new cashew farm in which cashew trees were one year old. Right image shows three-year-old cashew trees and expanded land for rice production

The swidden-change farming system required additional land every year because indigenous farmers deliberately cultivated rice with cashews. The rice grew well in the first year but the yield gradually decreased due to the shading of the rice field by the maturing cashew trees. Typical farms are usually between 0.5 ha and 5 ha, and the size of the expanded land was usually between 0.6 ha and 1 ha per year (measured by GPS device and Worldview-1 image). Therefore, this transition to a cash-crop farming system has the potential to change the amount of forest cover.

5.4.2. Accessibility of Land Resources

Poffenberger (2009) reported that migrant encroachment is contributing to land-cover change in Cambodia, as they seek forest lands to farm or resell. In Tang Se and Nhang, I found that migrants accessed land resources with the intention of improving their livelihoods through agriculture, and land brokers were paid to provide real estate services. Although the relationship between land brokers and land-use changes has not been thoroughly investigated in previous academic studies, our field survey clarified that land-resource users appeared to more easily access forest lands for farming or resale through land brokers. Overall, villagers have increasingly regarded their local lands as marketable commodities and have responded to market forces by developing more of their forest lands for increased income (Fox, et al, 2008; Fox et al., 2009a).

Migrant farmers primarily develop forest lands for cash crops (e.g., rubber, cashews, or cassava) because they believe that these crops have the greatest potential to improve their livelihood; as such, they tend to access and purchase prime lands for agricultural use. This situation established a revitalized land market of real property investment, in which land is a marketable commodity due to demand.

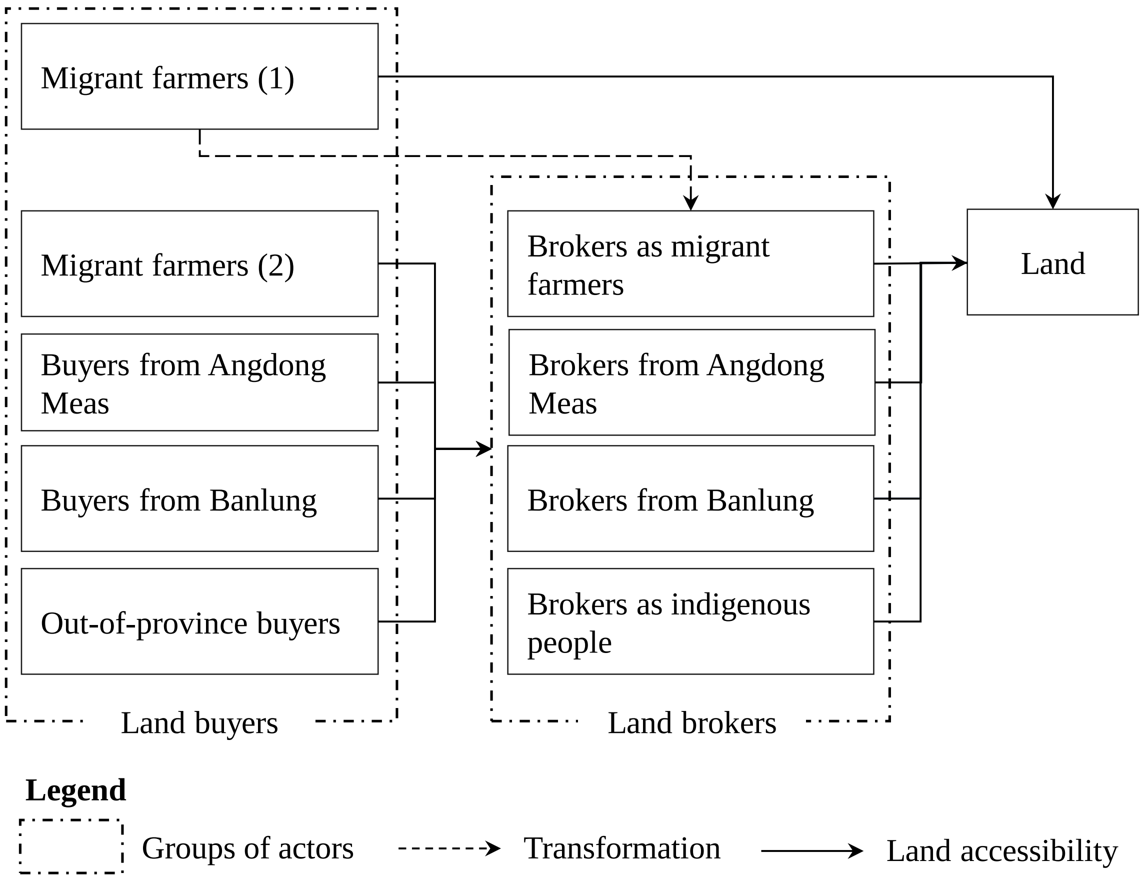

Figure 5.7. Land accessibility conducted at the local level, forming a market structure

5.4.2.1. Land Buyers

Figure 5.7. illustrates land resource accessibility, highlighting the roles of two main actors – land buyers and land brokers – who play important roles in the trading of land resources. Within our study area, lands were increasingly regarded as marketable

commodities when migrants or indigenous people became land brokers, or market intermediaries who matched demands between buyers and sellers (Dowall & Leaf, 1991). Land buyers can be subdivided into five categories. The first category includes migrant farmers [Migrant farmers (1)] who were the first to settle in the area. Based on the interviews, when farmers acquired large areas of forest lands or farmlands, they were initially faced with labor shortages. At the same time, growing demand for lands increased their land value, leading them to sell some parts of their lands to other land users who also relied on agriculture for their livelihood. This situation also led them to become land brokers (Broker as migrant farmers), who served to attract farmers or other buyers.

The second category includes migrant farmers [Migrant farmers (2)] who need lands only to sustain their livelihoods. The farmers in this category came from central Cambodia, where their livelihood depended on fishery. When aquatic resources become difficult to obtain, they sought lands for cash crop production. Some of these farmers were previously workers or house servants in Thailand or Malaysia. After migrating from these countries, they required lands to sustain their livelihood. Primarily, the farmers in this category purchased lands from farmers in the first category.

The third category includes the land buyers [Buyers from Angdong Meas] who live in Ou Kob, the center of the Angdong Meas district. They are mostly "middle men" who exchange agricultural products and try to create opportunities by expanding agricultural lands. The fourth category includes outsiders who live in Banlung [Buyers from Banlung], and the fifth category includes land buyers who are not residents of the Ratanakiri Province [Out-of-province buyers]. Land buyers in this category were people whose primary income is from the agricultural sector. There were a few land buyers in this category who directly bought lands from indigenous people.

5.4.2.2. Land Brokers and the Market

Land buyers accessing land resources through land brokers can be subdivided into four categories. The first category includes land brokers [Brokers as migrant farmers] who transformed land from ordinary farmers [Migrant farmers (1)], as mentioned above, and the second group includes Ou Kob residents [Brokers from Angdong Meas] The third group originated from Banlung [Brokers from Banlung], though members of this category were rare in the study area. The fourth group was comprised of indigenous people themselves [Brokers as indigenous people], the number of which was usually between one and three in the villages of the study areas other than Phi, Pa Dal, and Pa Tang.

The value of each land depends on its characteristics. For example, if a land is used for cashew trees, the value would be equivalent to a new motorbike, with prices ranging between US$500 and US$1,800, depending on the size of the total parcel. If land is covered with secondary forest, the value could be about US$500, again depending on the total size of the parcel and the types of crops currently planted.

Some land buyers enlarged their land through the purchase of new farms or by extending the boundary during subsequent seasons. Extension of boundaries, however, is dependent on land availability around the farmland; for example, if land buyers purchased land from indigenous people, these land boundaries are not often clearly or officially defined, but based on an agreement between the buyer and seller.

5.4.2.3. Land-Use Control

Without land-use control, the accessibility of migrant farmers would likely result in a sense of insecurity about being able to maintain forest resources. In this view, zoning entails the delineation of a community into districts or zones, within which certain activities are permitted and others are prohibited; however, there are no easy solutions to the problems related to accessibility of land (Dale and McLaughlin, 2003), especially, in the context of accessing rural land for livelihood betterment within our study location. Farmers in every village recognized their land ownerships differently.

Djarai villagers who live in Phi Village have created a specific zoning system, classifying land resources into five categories: village area, funeral forest, spiritual forest, hunting area, and agricultural area. These categories are generally used in every village with Djarai people in the study area; however, the exact locations of these areas have not been identified. Pa Dal villagers also created their own resource map in an effort to identify where to farm cash crops, conduct swidden, and cultivate wet-season rice (Figure 5.8.). Although the systems are slightly different between these two villages, those indigenous villagers who live in Phi and Pa Dal villages were eager to possess the communal land title. Due to the 2001 Land Law, however, migrant farmers who accessed land resources in nearby Tang Se or Nhang, are not allowed to receive the communal land title. Therefore, in order to control land uses in this area, effective property rights regimes must specify both individual and collective titles. Unfortunately, these property regimes have not been functioning well in this area.

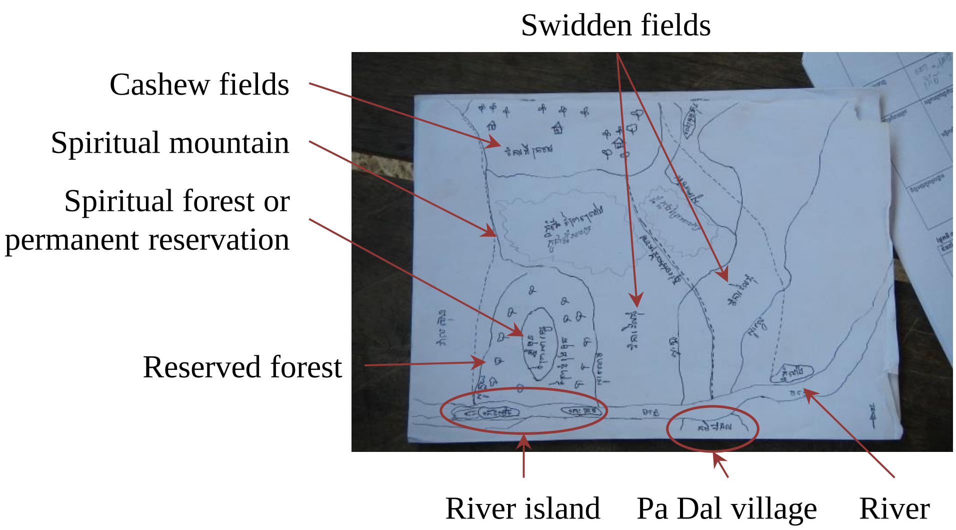

Figure 5.8. Map of natural resources drawn by Pa Dal villagers

I can learn from a successful case in Krala Village, located in the Chum District of Ratanakiri Province. Non-governmental organizations (NGOs) in this area played a vital role in strengthening indigenous institutions and establishing clear policies on land use and tenure, and the villagers successfully built on new market opportunities while sustaining their forest resources and cultural institutions (Fox et al., 2009b). The best scenario to enhance tenure security is a combination of (1) long-term NGO support for livelihood development, (2) high pre-existing levels of community solidarity, (3) processes designed with a view of engagement and with recognition by relevant subnational authorities, and (4) laws to moderate pre-intervention levels of outside pressure on lands (Adler et al., 2009).

5.4.3. Land Concession

In Cambodia, land resources are not only a requirement of local people or landless people but also a requirement of the government, which uses lands for economic development. In 2001, the Cambodian government re-enacted the land law that allowed the government to transfer “state public land” to “state private land,” as a precondition to allocate concessions for various purposes. For example, the Cambodian government allocated some state lands to political elites and foreign investors in the form of an “economic land concession,” which was estimated to cover approximately 50% of the country’s arable lands (Neef et al., 2013). Rubber plantations appeared in this area and the companies signed an agreement with the Ministry of Agriculture, Forestry and Fisheries to receive 8,654 ha for planting industrial crops such as acacia or rubber. Land uses appeared to be diversified as a result.

Our results show that land resource users including indigenous people, migrants, and ADCs actively developed forest lands for cash crop production. Access to natural resources is essential for sustainable poverty reduction (Baumann, 2002) and the government established land concessions in response to this social and economic initiative (RGC, 2001). However, every stakeholder has the same rights to economic development or livelihood improvement.

5.4.4. Inherently Dynamic Landscape

An inherently dynamic landscape is the natural succession in which pioneer vegetation evolves over time to shrublands and, subsequently, into forest (Bürgi et al., 2004). According to the change detection analysis (Table 5.4.), I observed changes in the function of vegetation, creating an inherently dynamic landscape. For example, 790.3 ha of evergreen forests were converted from secondary forest, and 878 ha of mixed forest were transformed into evergreen forest. This illustrates that the quality of forest lands can recover when left undisturbed. In contrast, forest quality decreases when disturbed by logging; for example, I saw 1,064.9 ha of secondary forest and 1,147.9 of mixed forest converted from evergreen forest.

5.5. Conclusion

This study revealed the dynamics of forest cover changes caused by agricultural expansion, pinpointing the patterns of agricultural land uses in the study area. Both remote sensing applications and qualitative methods were applied to understand the relationships between land-use changes and agricultural practices at the community level across a wide range of research questions. The amount and trends of forest cover changes were observed through analysis of remote sensing data and the causes of the changes were revealed through interviews with various actors as well as ground truthing during the field survey. Overall, I found that the introduction of cash crop production and commercial plantations had been effecting agricultural practices and causing drastic changes in forest landscape.

At the local level, I also found three triggers for the forest development: conversion of swidden farming into a monocropping system, access of migrant farmers to land resources without land-use control, and government-induced land concessions. For the first trigger, although conversion of swidden into a monocropping system could be prevented, to some extent, by external support, these changes were found throughout the study area. Within the framework of the monocropping system, indigenous farmers have to expand their lands and develop forests for rice production year after year, regardless of the agricultural market. For the second trigger, migrant farmers have high demands for access to agricultural lands that were converted from forest lands without land administration, though increased regulation would help to form a real property market. For the final trigger, the government re-enacted a land law that allows agricultural development cooperation to develop plantations, resulting in a rapid acceleration of deforestation.

The first trigger can be easily combined with the second trigger, so further unexpected challenges to land resources are likely to appear and affect the forest landscape. At the same time, the third trigger has the potential to confound the situation at a subnational level due to increasing demands on lands for agricultural development. In conclusion, agricultural expansion appears to have been a significant factor that has impacted forest cover at the local level. These have collectively diversified agricultural landscapes, leading to changes in forest landscape.

These results should be considered in maintaining a sustainable agricultural practice in Cambodia. The combination of quantitative and qualitative surveys applied in this study may prove to be a useful approach for designing areas in which forest and agriculture are dominant, and will be increasingly helpful in managing a sustainable landscape both in forest and agriculture.

Chapter 6: Conclusion and recommendation

6.1 Summary

In the first three chapters, this study attempted to delineate the study objectives, review the previous literature, introduce the study area, and explain the research design and methods.

Swidden cultivation is considered a cause of forest degradation. Many researchers and institutions such as Bann (2003), Butterfield (1998), Ung et al. (1999), SCW (2006), FAO (2002), and FA (2010) contend that swidden cultivation affects forest areas in Cambodia's northeastern province. In contrast, Fox (2002) reported that forest and tree cover had remained stable between 1953 and 1996 in Ratanakiri Province. Trade liberalization policies have forced swidden cultivators to transform traditional swidden cultivation practices into cash crop production, resulting in forest degradation in Ratanakiri Province (Fox et al., 2009b). Hence, this study examined land-use dynamics related to swidden cultivation to improve understanding of forest stewardship. This study aimed to explore the traditional practice of swidden cultivation and to identify the dynamics of forest degradation. This final chapter summarizes the thesis. Furthermore, conclusions are drawn and recommendations made.

Chapter 4 outlined traditional practices, farming activities, and land-use patterns related to Djarai swidden cultivation. Remote sensing and qualitative research methods were employed for a supervised classification and visual image analysis of ALOS AVNIR-2 and Worldview-1 data. The study also used qualitative methods to collect and analyze in-situ information. Remote sensing and ground truthing techniques prove that Djarai swidden cultivation is interwoven with cash crop production. At the same time, qualitative methods reveal that Djarai swidden cultivation is a multiple cropping system that works in close relation to traditional beliefs and land tenure practices. These traditional farming systems transformed consequent to development activities in the province, which have led Djarai villagers to transform not only their farming system, but also the social system of their village.

In Chapter 5, the study presented the dynamics of the transformed forest landscape resulting from changes in farming, land accessibility, and policy changes. A multi-temporal dataset comprising two ALOS/AVNIR-2 images in 2007 and 2011 was used to compare changes in land cover. The panchromatic image of 2012 Worldview-1 acquired at 100 km^2 was used to access specific land-use patterns. Qualitative research methods ranging from an ethnographic method to qualitative data analysis were conducted to gather in-situ information to understand human-induced changes in land use. The results identify three triggers at the local level that actively changed the forest landscape: a) indigenous people transforming the swidden farming system to the monocropping system without external support and agricultural market information, b) a chaotic property market consequent to migrants purchasing existing farms or forest land from indigenous people via land brokers, and c) the introduction of land concessions by government via the 2001 Land Law, which allows agricultural cooperation to develop plantations.

6.2 Conclusions

The results of the study described in Chapters 4 and 5 indicate the transformation of Djarai swidden cultivation to cash crop production. The agricultural methods of monocropping systems have led to the total extinction of three intertwined traditional elements, namely a) traditional beliefs, b) multiple cropping, and c) no land alienation. Related to land resource management, these changes do not bode well for forest stewardship. Thus, this study argues that transitioning swidden cultivation causes forest degradation.

In Chapter 4, addressing the first objective, the study determined that Djarai swidden cultivation systems are multiple cropping systems that interweave traditional beliefs and land tenure practices. Recently, Djarai swidden cultivation transitioned into a cash crop production. Two features should be considered here, namely farm management and land tenure practices.

First, swidden cultivation systems have the same temporal dimension in many areas. Changes to swidden farming systems include cultivating both cashew and rice in the same field. Consequently, villagers must expand their land every year to produce rice.

Second, there is no land alienation in traditional tenure practice. As such, Djarai villagers transfer land ownership between village members. Reflecting a market-oriented policy, many Djarai villagers try to develop their forested land to sell it to migrants.

In Chapter 5, the study addressed the second objective, identifying three triggers for forest development: the conversion of swidden farming from multiple cropping systems into monocropping systems, access of migrant farmers to land resources without land-use control, and government-induced land concessions.

First, Djarai villagers have modified swidden cultivation practices. Since Djarai swidden cultivators plant cashew trees with rice, they continue to expand their fields every year, as rice is needed to sustain their families. Moreover, the monocropping system does not provide for fallow land. This confirms that the change from the multiple cropping system of swidden cultivation to the monocropping system of cash crop production affects forest cover.

Second, Djarai villagers transferred land ownership between family and village members. Now, some Djarai villagers have tried to develop their forested land to sell their ancestral domains to migrant farmers. This creates a chaotic property market, and confirms that Djarai land tenure systems have changed because of migrant farmers, who have high demands for access to agricultural lands.

Third, the government re-enacted a land law allowing plantation development through agricultural development cooperation. This has accelerated deforestation.

Overall, the study concludes that the dynamic force behind forest degradation is the transition of the farming system as manifest in the transition of Djarai swidden cultivation to cash crop production. This transition influences the three elements of Djarai swidden cultivation, which has transformed from a) traditional beliefs, b) multiple cropping, and c) no land alienation to new or no beliefs, monocropping, and land alienation.

6.3 Recommendation

A common property regime should be established to stabilize forest cover. Djarai villagers have used land resources as a common-pool resource, which is vulnerable to depletion. At the same time, forest cover has dramatically decreased. It is difficult to exclude Djarai villagers from their ancestral domains, and the indigenous village has the right to use their property according to ILO conversion. It is therefore impossible to exclude them from their land.

According to Cambodian laws, a communal land title should be urgently established to stabilize the land-use situation in the area. To carry out these activities, the Ministry of Agriculture, Forestry and Fisheries must coordinate the Ministry of Land Management, Urban Planning and Construction with concerned local communities and authorities to register the land property of indigenous communities and prepare a national land-use map. Related to titling communal land, Ministry of Rural Development has the rules to identify indigenous ethnic minority groups who applied for registration of their ancestral lands as collective ownership. As well, the government should involve the nongovernmental organization which aims at assisting indigenous people to register communal land in order to accelerate registration procedure.

NGOs should not only pay attention to land rights, but also to the traditional beliefs of Djarai swidden cultivators because the loss of Djarai traditional beliefs could also impact forest cover. Their traditional beliefs are related to land resource management; thus, maintaining the culture of the Djarai villagers is critical for forest stewardship.

These recommendations should be considered in light of maintaining a sustainable agricultural practice in Cambodia. The combination of quantitative and qualitative surveys in this study could be a useful approach for designing areas in which forest and agriculture are dominant, and will be increasingly helpful in managing sustainable landscapes in forestry and agriculture. Further research is needed on sustainable development in Cambodia's northeastern province.

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