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Understanding Changes in Land and Forest Resource Management Systems: Ratanakiri, Cambodia*

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Abstract

This paper draws on case studies from three communities in Ratanakiri to illustrate both the forces driving land-use and tenure change as well as how effective community stewardship can guide agricultural transitions. The study combines a time series of remotely sensed data from 1989 to 2006 to evaluate changes in land use, and relates this data to in-depth ground truth observations and social research from three villages. The methodology was designed to evaluate how indigenous communities who had historically managed forest lands as communal resources, are responding to market forces and pressures from land speculators. Krala Village received support from local non-government organizations (NGOs) to strengthen community, map its land, demarcate boundaries, strengthen resource use regulations, and develop land-use plans. The two other villages, Leu Khun and Tuy, each received successively less support from outside organizations for purposes of resource mapping and virtually no support for institutional strengthening. The remote sensing data indicates that in Krala, over the 16 year study period, protected forest areas remained virtually intact, while total forest cover declined at an annual rate of only 0.86% whereas in Leu Khun and Tuy the annual rates were 1.63 and 4.88% respectively.

Keywords: land use, land cover, forest management, resource management systems, Cambodia

I Introduction

Over the past decade, Ratanakiri Province has experienced unprecedented changes in land use and tenure. This study analyzes remotely sensed images taken in 1989 and December 2006 to assess changes in vegetative cover in three areas near Banlung the provincial capital, and draws on in-depth case studies from three communities in the research area. The researchers were particularly interested in how forest cover changed over the 17 year period, and what replaced it. We sought explanations for changes in land and forest management practices in social, economic, and demographic factors. Since

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all study communities and their surrounding land and forests were traditionally under similar forms of indigenous resource management characterized by swidden farming, we wanted to understand how these human ecosystems were adapting, or not adapting, to agricultural commercialization and the influx of migrants and investors in the region, as well as an annual population growth of over 4%.

The research was conducted in 2007 in collaboration between Community Forestry International (CFI) and the East-West Center (EWC). CFI has been supporting community networking in the province since 2003, while EWC researchers have been engaged in studying the area for over a decade [Fox 2002]. The concept of the methodology was to analyze a time series of satellite images to identify changes in land cover, and to conduct in-depth studies with communities, to understand why changes in land use are occurring and to assess the social implications of these changes.

II Introduction to Place

The Cambodian province of Ratanakiri, "the mountain of precious stones," lies about 600 km northeast of Phnom Penh. It is bordered by Vietnam on the east and Laos on north and covers approximately 12,500 km^2 (Map 1). Due to its distance from major regional centers and a high prevalence of malaria, the province remained remote and isolated from Western influences until recently [Bourdier 1995]. With the exception of two ethnographies [Fontanel 1967; Matras-Troubetzkoy 1983], no study of human geography or anthropology had been undertaken in the province until the 1990s.

The Sesan and Srepok Rivers cross the province flowing west from Vietnam to the Sekong River, a tributary of the Mekong. The northern portion of the province, between the Sesan River and the Laotian border, is covered with broadleaf evergreen forest. Approximately 12,600 people, 18% of the province's population, live here. South of the Srepok River, the province is covered with a tropical deciduous forest. Approximately 7,000 people, 10% of the population, live here [Bourdier 1995]. The remaining area, between the two rivers, is composed of red basaltic soils on a high plateau (300 m elevation) and is covered with tropical secondary forests, forests "formed as a consequence of human impact" [Brown and Lugo 1990: 3]. This area includes the provincial capital, Banlung. Approximately 51,000 people, over 70% of the population of the province, live here. Ethnic communities in Ratanakiri include the Brao, Jarai, Kachah, Kraveth, Krung, and Tampuen [Lebar *et al.* 1964].

This study was conducted in the high plateau area in the *Khums* (communes) of Ting Chac and Ke Chong in Bar Kaev District, and Poey in O Chum district (Map 1). Elevation ranges from 100 to 400 m. The region has a monsoonal climate, with a rainy season beginning in May or June and lasting until October or November. Annual rainfall is always above 2,000 mm, and can reach 2,950 mm in Banlung

Map 1 Research Sites in Ratanakiri Province

[Bourdier 1995]. Almost no rain falls between December and April. Vegetation is composed primarily of broadleaf evergreen and deciduous forests [*ibid.*].

Krala Village, Poey Commune

Krala is a Krung village of about 420 people in O Chum District, located about 25 km north of Banlung. The research team selected Krala to represent a community with the least amount of change as well as a community where indigenous community institutions remain in control of communal lands, with support from local non-government organizations (NGOs). Krala was re-established immediately following the fall of the Khmer Rouge, and the current settlement area of the village was established at its present site in 1984. During the Khmer Rouge regime much of the community's population were relocated to Voensai District where they were forced to farm paddy rice. Unlike many of the indigenous communi-

ties adjacent to major roads in the province (although the Voensai road has been a target of less change than the highway to Vietnam), Krala has managed to maintain control over 100% of its traditional land, and stands as a model for other communities who are facing a similar struggle. While the ownership of Krala's traditional land has not changed, the use of their land has seen a significant transition from entirely swidden agriculture in the early 1990s to the current mosaic of swidden fields and cashew plantations. In 1994, only four families in the village had planted cashew trees, but by 2000, nearly 100 of the 135 families in the village had planted cashews on their land. Now, it is estimated that every family in the village has at least 0.5 ha of cashew trees. Krala has been the focus of several prior research studies that have resulted in a considerable amount of NGO attention and support in the village.

Leu Khun Village, Ke Chong Commune

Leu Khun is a Jarai village that the research team selected to represent an established indigenous community where land-use change is accelerating. Leu Khun was re-established in 1979, when community members returned from lowland areas where the Khmer Rouge had forced them to relocate. At that time there were 70 families who resettled the village, with a total population of 250. The population has since grown gradually to 130 families with 639 people. From 1986 to 1992, Vietnamese logging companies felled much of the larger, old growth forests surrounding Leu Khun. Much of the remaining forest was felled by the Cambodian military throughout the 1990s, ending around 2002. Smaller-scale illegal felling continues.

Tuy Village, Ting Chac Commune

Tuy is a predominantly Tampuen village located along the main road (Road 78) between the provincial capital of Banlung and the Vietnamese border, approximately 20 km east of Banlung. The research team selected Tuy to represent "high land use change," based on reports that extensive land sales were taking place in the village and the surrounding communities. While the village has existed in its present location for many generations, the entire community was forced off their land in order to work lowland rice areas during the Khmer Rouge period. In 1982 approximately 85 families (210 people) returned to resettle the village. By 2005, the population had grown to 103 families (458 people), at which time 23 of the families chose to break away in order to form a new village (Trang Village) as a result of internal conflicts between two community leaders. Tuy's forests were logged extensively from 1985 to 1989 by Vietnamese companies, and later by the Cambodian military from 1990 to 1993. Since 2000, Tuy has seen significant changes not only in land use, but also in land tenure with estimations of more than half of the community's productive land having been acquired by outsiders. People in Tuy increasingly see

land and forests as market commodities and indigenous institutions as having diminished ability to guide community policies and behavior.

III Methods

To understand both the nature and extent of land-use changes, a series of focus group and individual interviews were conducted in each of three villages representing varying degrees of land-use and land tenure change. The selection of villages was based on anecdotal evidence and reports from NGO members working throughout the province. Data for this report was collected during two field visits to the selected villages during the first half of 2007. The first visit was conducted in January 2007, and comprised focus group discussions with community members in each of the three villages, followed by individual interviews with two to three selected individuals from each community. The focus group discussions were designed to identify overall community attitudes and practices surrounding land management decision-making, and broad patterns of land use within the community. The discussions also aimed at revealing areas of conflict surrounding land and natural resources and at assessing the status of communal land tenure as reflected in incidence of land sales, land grabbing, and efforts by the community to preserve their lands. Additional effort was made to identify changes over time in social conditions and economic/food security status that might serve as a metric in measuring the social impact of observed changes in land use and tenure.

Individual interviews were conducted to provide concrete examples of individual practices surrounding land use, and to identify the actual prevailing conditions and procedures by which land is either converted to other uses or transferred to new owners.

These interviews were also aimed at gauging the family's economic status and possible impacts of their particular changes in use or availability of resources. A second field visit was conducted in April, 2007, as a means to both clarify data from the first visit, and to collect additional geospatial data surrounding changes in land use. Sketch mapping was conducted to identify patterns of land use, and areas of current and ongoing land conflict.

Sketch mapping is a method for collating and plotting information on the occurrence, distribution, access and use of resources within the economic and cultural domain of a specific community. Sketch mapping should be conducted at the onset of a community based activity, but only after rapport has been established with the community because the community may consider resource distribution, use and access as sensitive issues [IAPAD 2009]. Some additional information used in this report was derived from interviews with government officials from the Department of Land and NGO workers from several

organizations with experience working in the study communities. Among those NGOs consulted in the making of this report were the Non-Timber Forest Project (NTFP),[1] the Highlander Association (HA)[2] and the Indigenous Community Support Organization (ICSO).[3]

In order to assess the spatial patterns of land cover and land use (LCLU) change in the three villages, remotely sensed satellite image data, ground truth information, and derived land cover products were analyzed with emphasis on changes occurring in the 17-year period between early 1989 and late 2006. Baseline land cover for the three villages was derived from a Landsat Thematic Mapper image acquired on 8 January 1989 and obtained from NASA's Global Orthorectified Landsat Data Set. More recent land cover was derived from an Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) satellite image acquired on 25 December 2006 and obtained from the NASA/USGS Land Processes Distributed Active Archive Center (LPDAAC).

A 13-class GeoCover land cover map product was obtained from MDA Federal (www.mdafederal.com) for the 8 January 1989 Landsat image as an independent land cover data source. Additional ground truth data sources included 1:50,000 scale scanned topographic maps, an IKONOS 1-m resolution panchromatic image acquired on 29 December 2001 for Krala village and surrounding area, and 243 GPS ground truth data points obtained during field work in January of 2006 and 2007. Using the orthorectified Landsat TM as a georeferencing source, all imagery and raster datasets were rectified to the UTM coordinate system, WGS84 datum, and units of meters. In addition, official land-use planning maps were obtained for each village from the provincial land office in Banlung. The planning map for Krala was finalized in 2006, and completed in 2005 and 2004 for Leu Khun and Tuy villages, respectively. These maps were coregistered to the georeferenced datasets above, and village boundaries and designated land-use planning boundaries were digitized and added to the GIS database.

Remote sensing image analysis involved a combination of unsupervised and supervised classification approaches. First, given the limited amount of ground reference data from 1989 for the study region, an unsupervised classification using a maximum likelihood algorithm was performed on the 1989 Landsat image using ERDAS Imagine image processing software and resulting in separated spectral

1) The Non-Timber Forest Products Project (NTFP) was founded in August 1996 by a group of donors interested in establishing a long-term project to address issues of land tenure and management of natural resources by indigenous communities in Ratanakiri. Activities undertaken by the NTFP include natural resource management (NRM), land-use planning, informal education, community health, agriculture, gender training, and advocacy.
2) Highlanders Association is an association of indigenous community people in Ratanakiri.
3) Indigenous Community Support Organization is a Cambodian NGO that supports indigenous peoples retaining their rights and resources —— while undertaking a form of development that is designed by indigenous peoples, for indigenous peoples.

clusters. In addition to the six visible and near-infrared bands of the Landsat scene used in the unsupervised classification, a normalized difference vegetation index (NDVI) enhancement was generated as a separate map in order to distinguish relative differences in standing green vegetation biomass throughout the study region. Using knowledge of the study area, available ground references, and the NDVI map, clusters were assigned to one of 10 land cover classes, including deciduous forest, evergreen forest, shrub/scrub, grass, barren, settlement, non-paddy agriculture, paddy, wetland, and water.

Analysis of the 2006 ASTER image involved first generating an NDVI enhancement map from the 15 m resolution red and near-infrared image bands (ASTER image bandwidths for bands 1–4 are comparable spectrally to Landsat bands 2–5). Image-to-image radiometric calibration was performed to allow comparison between sensor data. An image-pair comparison of the 1989 NDVI and 2006 NDVI was performed in order to readily identify and map areas of significant change (and little change) in biomass between the two dates.

By creating two-date NDVI composite images, areas with significant changes in biomass between dates (e.g., due to clearing land, clearing land followed by regrowth of natural vegetation or agriculture, or maturity of younger vegetation in the 1989 image to mature vegetation in 2006) are evident (appear bright red in composite displays). For those areas of relatively little or no change in NDVI, an initial assumption was made that the basic land cover had remained relatively stable.

This was further verified using visual interpretation of the higher resolution ASTER bands, consulting ground truth GPS field data and photos, and village land-use planning maps, and, in the case of Krala, visual inspection of the 1 m IKONOS panchromatic image. For the areas (and associated pixels) of relatively little or no change, the land cover information class from 1989 was carried forward to the 2006 land cover map. Areas exhibiting changes in biomass between the two dates were isolated for further spectral analysis using a supervised classification approach. Using available reference data, including 2006 and 2007 GPS field data, spectral training sets were created for each of the ten land cover classes mentioned above. A supervised classification was then implemented using a maximum likelihood classifier and the resulting clusters were evaluated for separability and further split or aggregated until a final classification map was produced.

Final class maps for both 1989 and 2006 dates were smoothed using a 3×3 majority filter to remove inherent speckle in the underlying satellite data. For comparison of classification maps between dates and across the three villages, the classification scheme was further simplified (and classes aggregated) into seven classes, including forest (deciduous and primarily evergreen), young fallow and immature cashews (includes shrub/scrub and grass), non-paddy agriculture, paddy, settlement, wetland, and water. Finally, land-cover class area and percent cover statistics from 1989 and 2006 class maps were calculated,

summarized and compared by village area and also by the specific land-use planning zones demarcated for each village. This allowed for assessing overall village land cover change and also in analyzing the extent to which each village managed its land according to its respective participatory land-use plan.

IV Results: Changes in Land and Forest Resource Management Systems

Table 1 shows changes in land cover and population in the three villages between 1989 and 2006. In 1989 villagers in Krala had access to approximately 11 ha of forests per person. By 2006 this had dropped to 5 ha per person. This represented a loss of approximately 13% of the forest cover (almost all forest cover in this region is composed of broadleaf evergreen species). Most of this forest cover was converted to various types of agriculture including cashews and other cash crops. Permanent agricultural land cover grew by a rate of approximately 15% per year during this period. In 1989 villagers in Leu

Table 1 Changes in Land Cover and Population in the Three Villages in 1989 and 2006

Land cover as mapped \ Village/Year		Krala 1989	Krala 2006	Leu Khun 1989	Leu Khun 2006	Tuy 1989	Tuy 2006
Forest	Ha	2,479	2,142	1,034	782	1,143	488
	% of land cover	**94**	**81**	**65**	**49**	**79**	**34**
	Ha/loss per year	20		15		39	
	Annual rate of change (%)	–0.86%		–1.63%		–4.88%	
	Years left under current loss rate	**108**		**53**		**12**	
	Ha/person	11	**5**	3	**1**	5	**1**
Young fallow and immature cashews	Ha	129	112	408	216	236	72
	% of land cover	5	4	26	14	16	5
	Annual rate of change (%)	–0.83		–3.67		–6.75	
	Ha/person	0.5	0.25	1	0.34	1	0.16
Agriculture (permanent, cashews, rubber, and paddy)	Ha	38	386	153	574	53	854
	% of land cover	**1**	**15**	**9**	**36**	**4**	**59**
	Annual rate of change (%)	14.61%		8.09%		17.76%	
	Ha/person	0.16	**0.86**	0.5	**0.9**	0.25	**2**
Other (water and settlements)	Ha	0	6	0	24	12	30
	% of land cover	0	<1	0	1	1	2
	Annual rate of change (%)	45.69%		58.07%		5.54%	
	Ha/person	0	0.01	0	0.04	0.06	0.06
Population	Total population	235	450	320	639	210	458
	Annual rate of change (%)	3.9%		4.15%		4.69%	
	People/km^2	**9**	**17**	**20**	**40**	**15**	**32**

Khun had access to less forest land (3 ha per person) than villagers in Krala had in 2006 (5 ha per person). Between 1989 and 2006 villagers in Leu Khun lost approximately 16% of their forest cover resulting in approximately 1 ha per person in 2006. Permanent agricultural cover increased during this period by 421 ha or 8% per year. In Tuy we see a loss of almost 45% of forest cover and an increase in agricultural cover of approximately 54%. In 2006, however, villagers in Tuy had access to twice as much permanent agricultural land per person as villagers in both Krala and Leu Khun (2 ha as opposed to approximately 1 ha per person).

Participatory land-use planning (PLUP) and small scale land-use mapping began in Ratanakiri in 1996–97 and a GIS Unit designed to support community land mapping was established in Banlung in 2000. PLUP is a standardized process supported by the Cambodian government where villagers receive training in how to read topographic maps and aerial photographs. Under the PLUP program, the GIS Unit assists villagers to draw sketch maps of their current land and to develop maps (known as PLUP maps) that represent an effort by development workers, local government officials, and community leaders to clarify territorial boundaries and to develop coherent zones of land-use activities. When we overlay the PLUP maps with the remotely sensed images we can observe how well land-use practices conform to village land-use zoning objectives.

Krala Village, Poey Commune

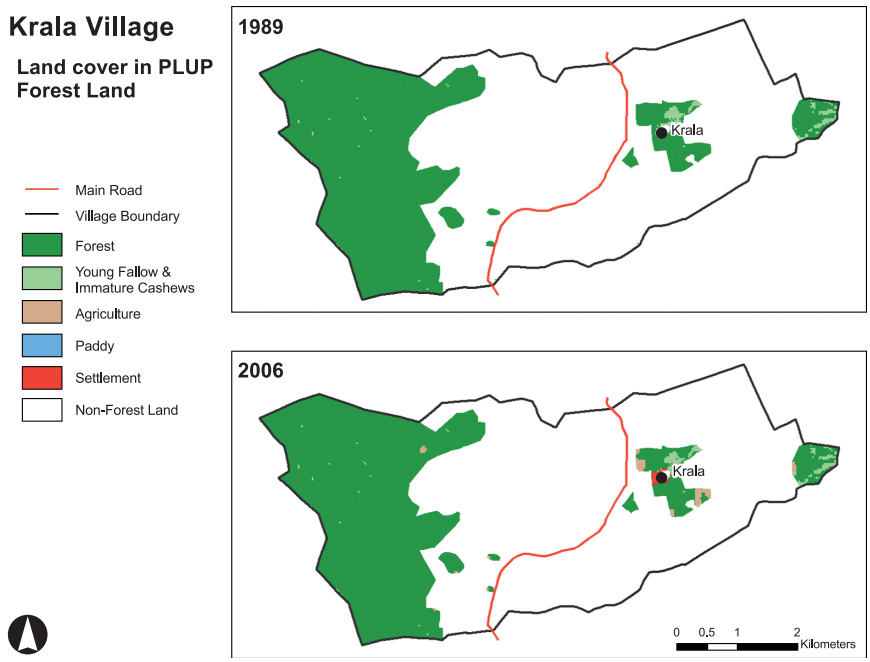
Table 2 summarizes land-use zoning and land cover in Krala in 1989 and 2006. Reading left to right across the table, villagers in Krala sought to protect 35% of their land base as protected forest. In both 1989 and 2006 the remotely sensed images suggest that the villagers successfully achieved this goal (34%) (see Map 2). The areas villagers zoned to use for both swidden (mixed used) and permanent agriculture have seen the most change during this period although a large majority of this area still remains forested (Map 3). The most pronounced change in land use in Krala was the expansion of cashew trees from just a few ha in 1994 (<1% Table 2) to an estimated 500 ha in 2007 (8% Table 2). Villagers consider planting cashew to be an easy task as they can be planted in June along with rice. The trees become fully established within the course of the rainy season and are able to grow without irrigation or fencing. Villagers report that they do not need to be fertilized and that they do not have any problems with pests. Most farmers plant the field with both upland rice and cashew trees and continue to intercrop rice with the cashews for three to four years until the trees become mature and begin yielding nuts.

CIDSE (Coopération Internationale pour le Développement et la Solidarité) now known as DPA (Development Partner in Action) assisted villagers in Krala in developing their cashew cultivation, often

Table 2 Land-use Zoning and Land Cover in Krala 1989 and 2006

Land use as zoned \ Land cover as mapped		% Krala PLUP	% Forest 1989	% Forest 2006	% Young Fallow and Immature Cashews 1989	% Young Fallow and Immature Cashews 2006	% Agriculture (permanent, cashews and paddy) 1989	% Agriculture (permanent, cashews and paddy) 2006	% Other (water, settlement) 1989	% Other (water, settlement) 2006
Participatory Land-Use Planning	Protected Forest (and bamboo, spirit, others)	**35**	**34**	**34**	1	<1	<1	<1	0	<1
	Mixed-use (trees and swidden)	36	33	28	2	2	**1**	**6**	0	<1
	Agriculture (cashews, private, barren, paddy, etc.)	28	26	19	2	1	**<1**	**8**	0	0
	Other (settlements, wetlands)	1	1	1	<1	0	0	<1	0	<1

Note: The first column (% Krala PLUP) shows that villagers zoned 35% of their land as forests, 36% as mixed used, 28% as agriculture, and 1% as other. The second column shows that in 1989 that almost all the land zoned for protected forests was still in protected forests (34%). In addition, however, most the village's land based zoned for mixed use was still forest (33%), land zoned for agriculture was still forests (26%), and all the land zoned for other was still forest (1%). The third column shows that in 2006 that almost all the land zoned for protected forests was still in protected forests (34%). In addition, however, most the village's land based zoned for mixed use was still forest (28%), land zoned for agriculture was still forests (19%), and all the land zoned for other was still forest (1%).

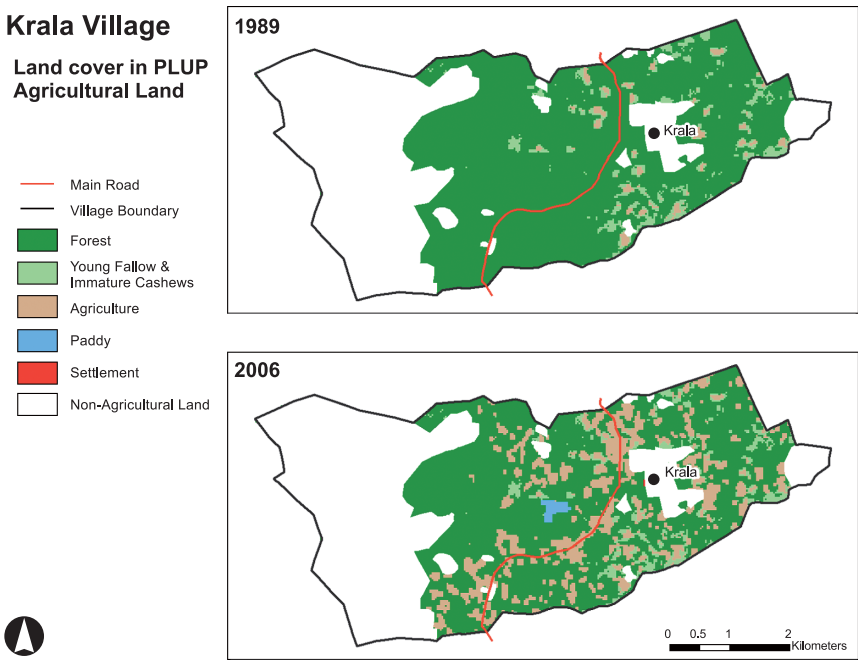


Map 2 Land Cover (1989 and 2006) in Krala in Areas Zoned as Forest in the PLUP Exercise

Note: Zoning indicates intended use, not necessarily current use. Hence, some land zoned as forest in 1989 and already been converted to agriculture.

providing seeds to farmers, as well as some training in the practices of cultivation. CIDSE also assisted a number of village families to establish mango trees. Today, as people continue to plant cashews and other fruit trees, they purchase their seeds either in Banlung or from others in the community. The practice of cashew cultivation within the community has spread largely through social networks or peer learning. Individuals watch or participate in the planting of cashews in the field of a friend or family member and then apply those same techniques within their own fields. They describe a strong sense of cooperation and willingness to assist others in growing cashew and do not perceive any sense of competition or threat from others entering the market.

Villagers, however, do not collaborate in the harvesting, transporting, and bargaining or selling of the nuts. Each family harvests and sells their nuts individually, sometimes swapping labor during the harvesting activities, but without any consolidation of product or collective bargaining. Most community members take their cashews to the Banlung market to sell because they can get a better price than if they sell to the people who come to the village. Last year they received 2,500R for cashews in Banlung, but only 2,300R if they sold to the buyers who come to the village. While most people prefer



Map 3　Land Cover (1989 and 2006) in Krala in Areas Zoned as Mixed-use and Agriculture in the PLUP Exercise

Note: Zoning indicates intended use, not necessarily current use. Hence land zoned as agriculture in 1989 was still in forest in both 1989 and 2006.

to travel to the market in order to yield the higher price, some community members still prefer the ease of conducting the transaction in the village.

Although all families are now producing cashew nuts, and most have begun to see profits from this activity, the people of Krala seem to agree that swidden agriculture is still extremely important for their food security. One community member explained that even if he could entirely purchase paddy rice with cashew money, they would prefer the upland rice that they produce, and intend to continue farming in this way into the future.

Villagers in Krala have not yet started to cultivate rubber. One community member, Mr. Hayoen Tang, indicated that he wanted to begin planting rubber during the 2007 season, and hoped to demonstrate the benefits of planting rubber to others in the community. Individuals generally recognize that rubber can be significantly more profitable than cashews and is something that they are considering for the future. Their chief concern is that it is very expensive to start and requires at least seven years before they can begin reaping any profit. At the moment, few members of the community have the financial and food security to risk the initial investment. However, other individuals indicated that they

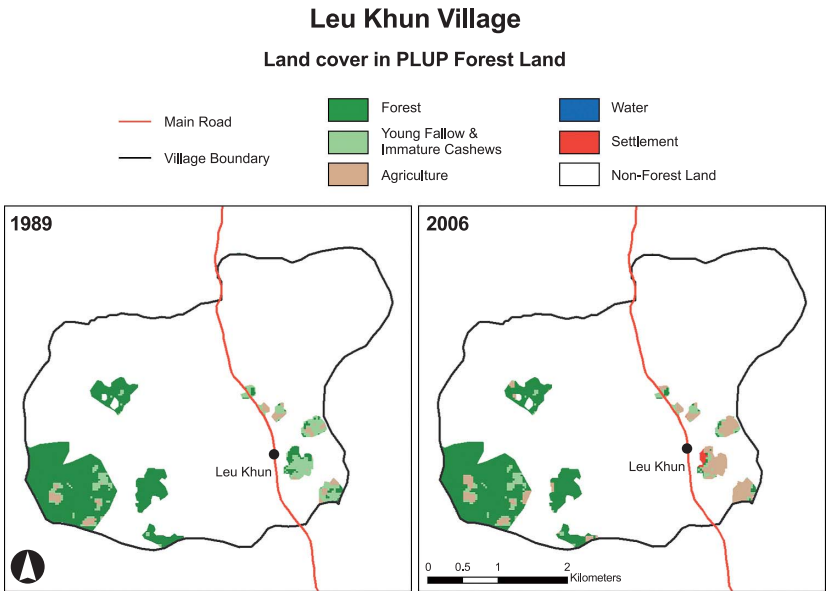
have begun to think about saving some of their profits from cashews for developing rubber trees on their land. This offers a timely alternative to the current model of rubber production where powerful individuals purchase land from communities to develop rubber plantations.

The NTFP, a local NGO, has worked steadily in Krala since 1996 assisting villagers to form an 11 member natural resource management (NRM) committee which meets weekly to map land use and develop land management plans. As part of the agreements established within the NRM committee, each community member is allowed up to 5 ha of land for permanent cultivation, which at the moment means cashews. While not all families are using all of the allotted land for cultivation at the moment, an estimated 30–40% of the families are using the entire 5 ha that is permitted by the community. There are no limits set for how much land a family can use for swidden cultivation. In general, though, most families tend to use between 1 and 2 ha on which they grow upland rice, cassava and some short-lived fruit trees like banana and papaya.

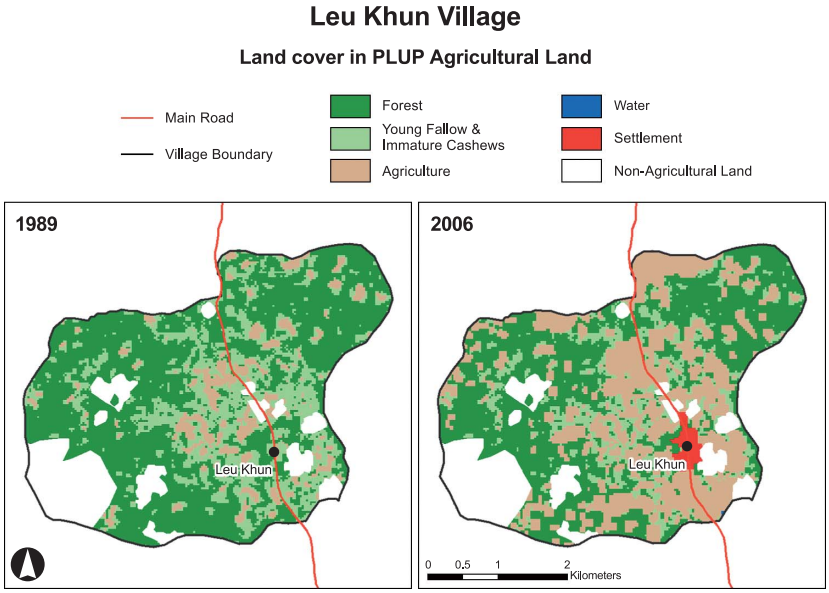
All the families in the community also plant fruit trees, such as orange, mango and jackfruit within their swidden fields. Because they are now planting fruit trees within these fields, they are less likely to use fire for clearing the field at the start of the subsequent farming season. As a result of this, they feel that there may be a greater problem with insects that would normally be killed during the burning and clearing of the field. While they recognize that there may be a problem associated with this change in their field preparation practices, they are unsure of what they should do about their insect problem.

Leu Khun Village, Ke Chong Commune

Table 3 shows changes in land-use zoning and land cover in Leu Khun village. The land zoning data for Leu Khun village was collected as part of a "fast mapping" exercise at the commune-scale, performed by the Provincial Rural Development Committee with minimal input from members of the affected villages [Sarem, Ironside and Van Rooijen 2005]. The PLUP mapping exercise did not define individual village boundaries, and the boundaries reflected here represent the results of a consultation with village members conducted as part of this investigation. Of the land area which Leu Khun residents identified as their domain, the earlier PLUP map designated only 13% as protected forest (Table 3). Within areas designation as protected forest, forest clearing persists and there remains no active effort at protection (Map 4). The PLUP map also designates 86% of Leu Khun's land base for mixed trees (forest fallow) and swidden agriculture (Table 3). The villagers have kept almost half of this land as forest fallow and converted the rest to cashews (Table 3 and Map 5).



Map 4　Land Cover (1989 and 2006) in Leu Khun in Areas Zoned as Forest in the PLUP Exercise



Map 5　Land Cover (1989 and 2006) in Leu Khun in Areas Zoned as Mixed-use and Agriculture in the PLUP Exercise

Tuy Village, Ting Chac Commune

Table 4 shows changes in land-use zoning and land cover in Tuy village. The PLUP mapping exercise conducted there in 2002 was done with considerably more community input than the Leu Khun mapping exercise. In Tuy, villagers sought to zone 27% of their land as protected forest (Table 4). By 2006, half of this protected land was converted to agriculture (primarily rubber planted by outsiders) (Table 4 and Map 6). Villagers zoned about 68% of their land for various types of agriculture (both swidden and permanent) (see Table 4). By 2006 most of this conversion had been completed (again mainly to rubber, which was entirely planted by outsiders who purchased the land illegally (Map 7). Villagers have only about 15% of their land base left for conversion to agriculture if they wish to keep anything under protected forests.

V Driving Forces of Change

Land-use practices are changing rapidly in most indigenous communities in Ratanakiri. Part of this reflects a broader agricultural transition that has been occurring in the uplands of Southeast Asia for decades [Fox and Vogler 2005]. Traditional forms of subsistence agriculture that relied on a cycle of farming followed by lengthy fallow periods are being replaced by sedentary, market oriented farming systems. While a few rubber estates were established in Ratanakiri during the colonial period [see Matras-Troubetzkoy 1983], the advent of cash crop farming by indigenous communities has largely emerged since 1993 when Cambodia opened up for international investments and new road networks began to reach further into rural Ratanakiri.

Theories of agrarian transitions have been around since Malthus [1798] first proposed that population growth drove land degradation; and Ester Boserup [1965] much later suggested that population pressure drives a change from shifting cultivation towards annual cultivation. Harold Brookfield [1972; 1984] recognized that change is not only driven by pressure, but by new opportunities that change the productivity or quality of labor. He suggested that 'pressure of population' should be replaced by the idea that the social and cultural contexts within which people produce and consume must be central to any understanding of agricultural systems and agrarian change. Jonathan Rigg [2006] argues that today, scholars of agrarian transitions struggle to keep up with the pace of change as individuals and households restructure their lives and livelihoods in response to a wide assortment of influences ranging from aspirational changes through to emerging physical resource scarcities and state interventions.

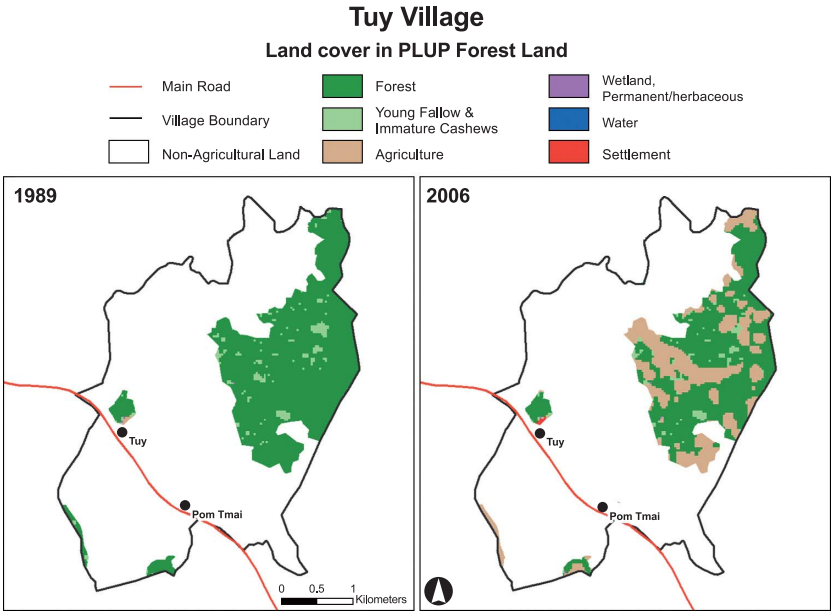
Driving forces that affect all three villages include national policies to liberalize trade and markets, and high market prices for rubber and cashews. Annual population growth in all three villages over the

Table 3 Land-use Zoning and Land Cover in Leu Khun 1989 and 2006

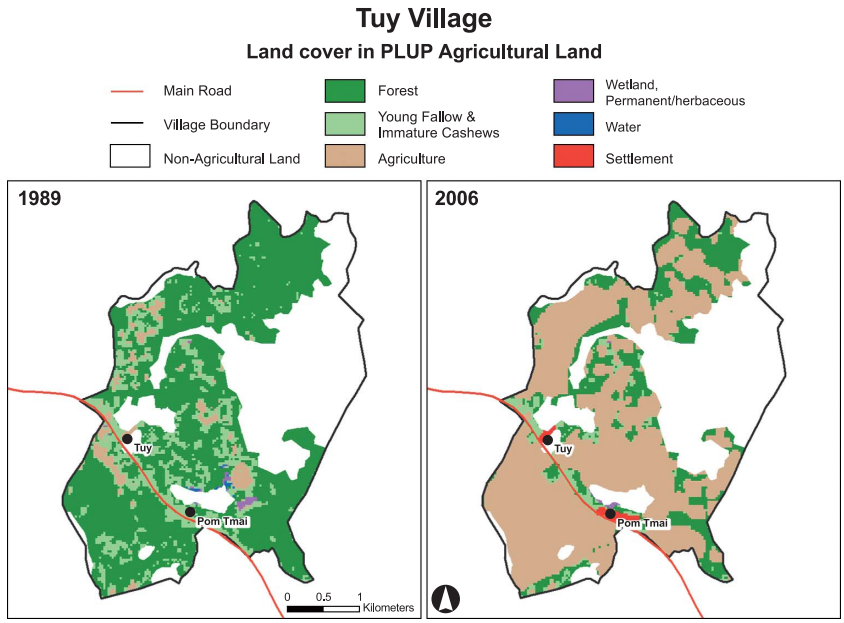
Land use as zoned \ Land cover as mapped		% Leu Khun PLUP	% Forest 1989	% Forest 2006	% Young Fallow and Immature Cashews 1989	% Young Fallow and Immature Cashews 2006	% Agriculture (permanent, cashews and paddy) 1989	% Agriculture (permanent, cashews and paddy) 2006	% Other (water, settlement) 1989	% Other (water, settlement) 2006
Participatory Land-Use Planning	Protected Forest (bamboo, spirit, others)	13	**10**	**9**	2	1	1	2	0	<1
	Mixed-use (trees and swidden)	86	**54**	**40**	**23**	**12**	**9**	**33**	0	1
	Agriculture (paddy, etc.)	<1	<1	<1	0	0	<1	<1	0	0
	Other (settlements, wetlands)	<1	<1	<1	<1	<1	0	<1	0	0

Table 4 Land-use Zoning and Land Cover in Tuy 1989 and 2006

Land use as zoned \ Land cover as mapped		% Tuy PLUP	% Forest 1989	% Forest 2006	% Young Fallow and Immature Cashews 1989	% Young Fallow and Immature Cashews 2006	% Agriculture (permanent, cashews, rubber and paddy) 1989	% Agriculture (permanent, cashews, rubber and paddy) 2006	% Other (water, settlement) 1989	% Other (water, settlement) 2006
Participatory Land-Use Planning	Protected Forest (bamboo, spirit, others)	27	**26**	**16**	1	1	**0**	**10**	0	0
	Mixed-use (trees and swidden)	42	**34**	**12**	7	1	**1**	**29**	0	
	Agriculture (rubber, etc.)	26	**16**	**3**	7	2	**2**	**19**	<1	1
	Other (settlements, wetlands)	5	3	2	1	<1	<1	1	<1	1



Map 6 Land Cover (1989 and 2006) in Tuy in Areas Zoned as Forest in the PLUP Exercise



Map 7 Land Cover (1989 and 2006) in Tuy in Areas Zoned as Mixed-use and Agriculture in the PLUP Exercise

last 15 years was relatively the same ranging from 3.9% in Krala to 4.69% in Tuy (Table 1). Population density (people per square kilometer) in Leu Khun, however, was already greater in 1989 (20 people) than in Krala in 2006 (17 people) (Table 1). Dove [1982] estimated the territorial needs of swidden cultivators in West Kalimantan, Indonesia, to be approximately 16 people per square kilometer. This suggests that population pressure may have been one of the forces driving land-use intensification in Leu Khun and Tuy, and perhaps to a lesser extent in Krala.

Other forces that affected the villages differently include the development of the road infrastructure that made it much easier to get to Tuy than the other villages, illegal logging which occurred primarily in Tuy and Leu Khun, and the active engagement of NTFP and other NGOs in assisting villagers in Krala to develop land-use plans, and to promote education.

Signs of an emerging cash economy are abundant within the three villages. Many families possess motorbikes and several have televisions and VCD players, which they power with batteries that are charged in Banlung. Villagers also collect money for sacrifices and other community needs. In Leu Khun village, one villager explained that when the water pump in the village breaks, leaders collected 10,000R (US $2.50) from each family to get the pump fixed. She said that people generally do not complain or resist making such contributions. Additionally, villagers receive regular visits from a variety of vendors on motorbikes, selling items such as ice cream, used clothing, assorted plastic wares and even family portraits. Portrait vendors offer a variety of templates in which an individual's photo may be inserted, such as standing by a new car in front of a large house. During one visit to a village, a large group of people were seen selecting and ordering their photographs that ranged in cost from 10,000R (US $2.50) for a single picture to as much as 30,000R if purchased with a frame.

Moreover, the need for cash has grown rapidly in indigenous villages in response to new opportunities to educate children. Some parents noted that an education is necessary in order to be able to negotiate better prices for goods in the market, and to be able to talk with government officials. Yet, the level of education available within the study communities was low. Some students have left their villages to study in the district township or in Banlung. While there are no "official" fees associated with attending district schools, teachers regularly expect students to seek them out for individual tutoring sessions (which are considered vital for a obtaining a passing grade), for which the students must pay. There are many stories of outright payment for passes in higher grades. Also many students do not have relatives to stay with while attending schools in towns making the cost that much higher. The NGOs working in Krala have helped the village to develop two schools that are fully functional and attended by most children.

There are currently nine students from Krala who are studying at the high school level in Banlung

while there are none from Leu Khun.

Perhaps the most significant common denominator among the three communities from the perspective of land-use change is the nearly universal reliance on cashew nut or rubber production as the primary source of cash income. While all villagers from all three communities continue to rely on upland rice farming as their primary means of food production, virtually every family relies heavily on profits from cashew or rubber sales to supplement their family's food needs. Overall, people from all three villages indicate that they are in a better economic position than they were in the 1990s, and they point to cashew and rubber production as the primary factor in this relative increase in prosperity.

The common scenario within all three communities involves an integration of upland rice cultivation with the establishment of tree plantations, whereby rice is intercropped with cashew or rubber trees for a period of three years until the trees mature and become productive. As the trees reach maturity and preclude the continued cultivation of rice, the common practice is to then clear an additional field, or extend the current field, and begin the process again.

While this basic scenario of land usage change is equally descriptive of all three study communities, the most striking distinction can be seen in the level of coordination, planning and an overall awareness of the need for setting limits and maintaining portions of the land for swidden agriculture and forest conservation. Krala village, having been the focus of intensive NGO support for more than a decade, has evolved a strong management structure along with a clearly defined approach to land use planning. As such, each member of the community is highly aware of their rights to land usage as well as their responsibility to the community as a whole. With an eye on livelihood and environmental sustainability, they have developed set limits on the amount of land available for each family, thereby limiting the amount of overall community land that will be converted to commercial production.

VI Conclusions

As land is increasingly viewed as a marketable commodity, especially if planted with valuable crops like cashew or rubber, economic incentives are created to develop forest lands for income or for sale. Demographic growth, both through natural increase and immigration, combined with corruption, economic expansion, challenges the viability of more traditional land management models as natural resources become scarce.

It is clear that land use is changing rapidly in all three study villages, reflecting broader patterns operating in Ratanakiri and other parts of the uplands of mainland Southeast Asia. Some of this change reflects a broad-based agricultural transition from forms of swidden farming to commercial cash crop-

ping, especially the adoption of cashew trees. The commercialization of farming systems has created a new source of income for many indigenous families, while at the same time stimulating land markets and accelerating land alienation. The Krala case study demonstrated the vital role NGOs can play in strengthening indigenous institutions and establishing clear policies on land use and tenure. Because of this support, villagers in Krala are successfully building on new market opportunities while sustaining their forest resources and cultural institutions.

By contrast, communities like Tuy which did not have the support of NGOs are being rapidly transformed into areas where villagers sell their land and migrants move into the areas. At the present time, many Ratanakiri villages are like Leu Khun, struggling to maintain community lands and forests in the face of growing pressures. Whether these communities will share the fate of Tuy and experience a chaotic pattern of land-use and tenure change, or stabilize their resources like Krala and systematically move into new modes of production depends on a number of factors. Even Krala may succumb to disintegration if social systems are not respected.

A key variable is the extent to which these communities will receive support from outside agencies including both NGOs and government programs, and receive some protection from illegal land speculators. In all study areas, villagers noted the importance of NGOs in helping them to retain their communal land and learn how to deal with local government and market forces. The study also showed that long term, sustained community building is a key to success in establishing viable community institutions that can guide land-use and tenure policy making.

Finally, local government officials and community leaders require training and guidance in national land policy and an open and transparent framework for dialogue at the commune, district, and provincial level. There is an urgent need to clarify land and forest resource management rights and responsibilities throughout the province, especially in an effort to protect the ancestral domain claims of the region's indigenous communities. The Forestry Administration has the role and responsibility to demarcate the state public forest domain and to determine which areas are suitable for community forestry. The Forestry Administration also has the role of coordinating with the Ministry of Land Management, Urban Planning and Construction in order to delineate land for inclusion in communal titles of indigenous communities. While much of the legal framework is in place to begin establishing recognized community forestry sites and to begin issuing communal titles, the priority must be placed on the mobilization and strengthening of communities.

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