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DOI: 10.1007/s00267-003-0289-6

Land-Use and Land-Cover Change and Farmer Vulnerability in Xishuangbanna Prefecture in Southwestern China

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ABSTRACT / This study investigated land-use and land-cover change in three hamlets and two state rubber farms in the Nan-e watershed of the Xishuangbanna prefecture of Yunnan province in Southwestern China. The overall objective of the study was to understand how state policies affected land use and land cover and how changes in these variables affected farmer vulnerability to economic, social, and political events. Emphasis was placed on the cultivation of rubber (*Hevea brasiliensis*), promoted in southern Yunnan province since the 1950s as a means to meet the demands of rapid economic development. The study combined remote sensing analysis with secondary data and in-field interviews in order to understand the coupling between land-use and land-cover change and farmer vulnerability in light of the geographic, historical, and sociopolitical situation.

Changes in land use and land cover are among the most important human alterations affecting the surface of the earth (Lambin and others 2001). Land-use and land-cover changes (LULCC) directly impact biological diversity (Sala and others 2000), contribute to local and regional climate change as well as to global climate warming (Chase and others 1999, Houghton and others 1999), and may cause land degradation by altering ecosystem services and livelihood support systems, thereby disrupting the sociocultural practices and institutions associated with managing those biophysical systems (Vitousek and others 1997). Such changes also affect the vulnerability of people and places to climatic, economic, or sociopolitical perturbations (Kasperson and others 1995).

KEY WORDS: Land-use/land-cover change; GIS; Farmer vulnerability; Plantations; China; Yunnan

Published online June 28, 2005.

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Paying attention to the vulnerability of people and places to global changes shifts our focus from the physical environment to the ''human dimensions'' of environmental change. The lives of local farmers are increasingly affected by decisions made at regional, national, and global levels (Barham and others 1999). Hence, vulnerability emerges as a key theme in global environmental change research (Bilsborrow and Ogondo 1992, Turner and others 1995, Verburg and others 1999).

This project used the theoretical framework developed by Amartya Sen (1981) to analyze the relationship between LULCC and farmer vulnerability. There are two basic concepts in Sen's entitlement approach: endowments and entitlements. Endowments refer to the rights and resources that social actors have, including land, labor, skills, and so on. Entitlements refer to legitimate effective command—both formal

and informal—over alternative commodity bundles based on the exercise of endowments. Entitlements include items such as food or cash that the household can obtain through production, exchange, or social networks such as kinship obligations. The process of transforming endowments to entitlements, thereby enhancing capabilities, is termed ''entitlement mapping'' (Gore 1993, Osmani 1995, Sen 1981). According to this framework, multilevel institutions mediate the conversion of endowments into entitlements. However, within existing power relations, some actors' claims are likely to prevail over those of others. In addition, certain social actors may not be able to mobilize some endowments (e.g., capital, labor) that are necessary in order to make effective use of other endowments (e.g., land) (Boyce 2001, Leach and others 1999).

Vulnerability in this framework is the risk that the household's entitlements will fail to buffer against famine, dislocation, or climate uncertainty. Vulnerability is shaped by ongoing political–economic processes of extraction, accumulation, social differentiation, and marginalization, within a given set of property relations (ownership and access) shaped by relations among various groupings within society. These relations are mediated by state policies (such as land conversion, economic development, and resettlement). Different social groups have differing assets as well as differing patterns of access to productive resources. Their assets and access are critical aspects of their vulnerability (Ribot 1995).

Vulnerability is a function of geographic location, production system, social identity, and income, which are partly driven by processes of land reallocation, uncertainty of climate, lack of access to inputs to the productive process, processing, marketing, and declining or fluctuating market prices (Swift 1989, Ribot 1995). Since the 1950s, the national government of China and the provincial government of Yunnan have introduced a series of policies and development interventions that have affected landscapes and land-use practices. One of these changes was the introduction of rubber (*Hevea brasiliensis*), a strategically important raw material for use in the defense industry, as a major agricultural crop. Rubber was first introduced into Xishuangbanna in 1948 from Thailand. In 1951, the Chinese government passed the ''Decision on Cultivating Rubber Trees'' in order to ensure a supply of natural rubber for national defense and industrial construction. In 1953, a mission was organized to study the feasibility of developing rubber plantations in Xishuangbanna, and in 1956 the first state rubber farm was formally established.

Little is known in Xishuangbanna about the impacts of changes in state policies on land cover and land use or on local livelihoods. This project sought to investigate the impacts of these policies on local livelihoods in three hamlets and two state rubber farms in Nan-e watershed. Project goals included understanding the impact of rubber plantations on primary and secondary vegetation in the uplands as well as understanding how changes in land cover and land use affect local livelihoods.

Background: Place, People, and Policy

Xishuangbanna, located in southeast China bordering Laos and Myanmar, is a transition zone between the tropics and subtropics (Figure 1). Its topography consists of alternating valleys and hills with elevations ranging from 2429 m in the north to 477 m in the south. The valleys have a tropical monsoon climate and the hills are subtropical. Summers (June through September) are characterized by high temperatures and humidity, whereas winters (December through March) are characterized by little rain and heavy fog. The region is largely frost free, but cold winds render this region relatively cool and dry in relation to the tropics of mainland Southeast Asia.

Xishuangbanna is a biologically diverse region that covers only 0.2% of the land area of China, yet contains 25% of all plant species in the entire country (Guan 1998). Over the last decades, forest cover has decreased dramatically from 63% to 34% (Yan and Chen 1992). Currently, forests remain primarily in nature reserves and state forests, whereas previously forested lands have been largely converted into rubber plantations.

The project site, one of the main rubber-growing areas in China, is located in the Nan-e watershed, Menglong Township, Jinghong county of Xishuang–banna Prefecture (Figure 1). The site borders Myanmar and has a total area of 10,835 ha with altitudes ranging between 650 and 1450 m above sea level. The Menglong meteorological station shows an average annual rainfall of 1377 mm, with a mean temperature of 22.7°C. Menglong consists of 31 hamlets and 33 state rubber farms governed by two administrative villages with a population in 2000 of 7182 people.

Xishuangbanna is the traditional home of upland minority peoples (''hill tribes'') including Dai, Hani (called Akha in Thailand), and Bulang. The Dai are Hinayana Buddhist, but also worship nature as exemplified in the form of ''holy hills'' (*manyangguang*), protected cultural landscapes that often form the only primary vegetation found in a Dai village (Pei 1991). Coward (2002) notes that the Dai have played long and important roles in organizing social institutions in the

uplands and in establishing economic relationships between valley inhabitants and upland swidden cultivators. The Hani are animists and place a strong emphasis on worshiping their ancestors, as exemplified in their strictly protected cemetery forests. They practice a composite swiddening system that includes traditional tea gardens in the forest (Xu 2002), intensively terraced rice paddies in the river bottoms, and livestock grazing and shifting cultivation on the hillslopes. The Bulang culture is based on a mixture of beliefs and religion practices including Hinayana Buddhism, polytheism, and ancestral worship. They are swidden agriculturalists and often grow cotton and tea.

Since 1950, China has implemented numerous, and sometimes conflicting, policies affecting the ownership of land, both agricultural and forest (Xu and others 1999). During the collective period between 1958 and 1978, the state farms and the People's Communes collectively owned agricultural and forest lands. Land-use decisions, however, were not based on collective consent from within the commune but were administered through a centrally planned state quota system. Under the Household Responsibility System, implemented between 1978 and 1983, agricultural lands, such as paddy, were contracted out to individual farmers while forests remained under state control. In 1983, Yunnan Province implemented a policy called *liangshanyidi* (freehold and contracted forestlands and swidden fields) with the objective of stabilizing forestlands and swidden fields through land titling and demarcation. The main goal of this reform was to shift forest management from the state to individuals for forest regeneration. Under this reform, both freehold plots and collectively held forests were leased or contracted to individual households.

Han Chinese farmers from Hunan Province were resettled in Xishuangbanna in the 1960s to establish state rubber farms. Some 200,000–300,000 participants in the ''Educated Youth'' were assigned to quasimilitary units of the ''Production Construction Army Corps'' in Xishuangbanna in order to open ''wastelands'' and to defend the national borders by expanding rubber plantation into the more extreme latitudes and altitudes. The influx of this large number of people displaced local people, who either lost their land or access to resources, and caused land tenure conflicts that continue until today.

The total area of rubber plantation in Xishuangbanna increased significantly from 6130 ha in 1963 to 136,782 ha in 1998 (Jiang 2003). State farms drove most of this change. A second but much smaller wave of rubber planting followed the development of rural township enterprises in the 1970s. Local farmers who were members of People's Communes converted fallow forests (secondary forests) into rubber plantations. After forest allocation (*liangshanyidi)* was implemented in 1983, a total of 4000 ha of forest (out of 7000 ha of collective forest in Menglong township) were converted into rubber plantations based on township government statistics. A combination of domestic protection of rubber prices, the introduction of the Household Responsibility System, and the introduction of new technology all encouraged small-scale farmers to plant rubber as a cash crop, particularly during the period between the 1980s and mid-1990s.

Methodology

This project integrated the development of socioeconomic and spatial databases with information collected through household interviews, land-use/land-cover mapping, and policy reviews. We created thematic base layers by digitizing and attributing features from 1:50,000 topographic maps. These layers consisted of administrative boundaries, hydrographic features (rivers and streams), roads, elevation contours, and settlement areas.

The project obtained two sets of aerial photographs from the Land Survey Bureau of Yunnan (April 1965, 1:35,000 and March 1992, 1:32,000). The photographs were manually interpreted and land-cover categories were delineated on mylar overlays based on a hierarchical classification scheme established for the area and its vegetation types. Six classes were identified, including dense forest (≥ 70% canopy cover), sparse forest (10–20% to 60–70% canopy cover), bush/grass (shrub, bamboo, grass, bare mix), rubber, paddy, and upland/swidden agriculture. During the photo interpretation, the minimum mapping unit varied by class. The smallest resolvable areas were 1.6 ha for paddy, 1.8 ha for swidden, and 1.3 ha for forest (includes rubber) in the 1965 interpretation and 1.4 ha for paddy, 2.5 ha for swidden, and 3.8 ha for forest (includes rubber) in the 1992 interpretation.

After interpretation, the overlays were digitized and registered to the UTM coordinate system and WGS84 datum using 60 control points obtained from the 1:50,000 scale topographic maps. They were then appended to form a single, seamless coverage for each year. The digitized land units were attributed in the GIS according to the six classes assigned during the interpretation.

In lieu of a statistically based accuracy assessment, the final classifications for both dates were examined carefully and compared against all available reference data and the authors' extensive knowledge of and

experience in the study area. The classifications were deemed reasonably accurate.

The project collected secondary data on biophysical and social science variables such as meteorological data, population, size of cultivated fields, amount of food produced, rubber-processing facilities, market access, and land tenure from different government agencies and state rubber farms at local, township, county, and prefecture levels. In particular, we relied on information collected by the state household census in 2000.

Project personnel conducted key informant interviews with government officials in order to reconstruct state strategies, and the planning and implementation of government policies in different stages of governing access to land resources, land-use planning, and development interventions. We also interviewed older people and village chiefs in order to construct a timeline of historical events and land-use change trends. We analyzed relations between government officials and local people under different land tenure systems to show how tenure affected the access of villagers to forest resources. We conducted structured interviews using a questionnaire in 60 randomly selected households (approximately 25% of all households).

Finally, we constructed oral histories for the three study hamlets and two rubber farms, and we conducted participatory mapping to construct timelines, identify land uses and transects to walk, and clarify resource tenure boundaries. Topographic and land-use maps were used in the field as tools for facilitating discussion among farmers, officials, and different communities on past land-use practices, present land-use conflicts, and their plans for the future.

Results

Oral Histories of the Three Hamlets and Two State Rubber Farms

The study investigated land-use and land-cover change in three hamlets and two state rubber farms in the Nan-e watershed of the Xishuangbanna prefecture. The three hamlets (Manguang, Mangelong, and Manbeng) are inhabited by members of Dai, Hani, and Bulang ethnicities, respectively.

The Dai hamlet, Manguang, has a long history of settlement. Its population increased from 50 households in the 1930s to 151 households in 2000. Villagers planted rubber during the collective period in the 1960s and 1970s while continuing to manage paddy, homegardens, and fishponds. Vegetables such as chili, watermelon, and cucumber are still intensively cultivated in the paddy during the dry season. The village used to be surrounded by secondary forest and fallow fields that have been converted into rubber plantation. Villagers manage a ''holy hill'' that covers an area of 53 ha and contains 311 plant species belonging to 108 families and 236 genera (Wu and others 2001). The hamlet's agroecosystem consists of primary vegetation associated with the holy hills, watershed forests, fallowed secondary vegetation, fuelwood plantations or home-gardens, and rice paddies.

The Hani hamlet, Mangelong, was established in 1967 when villagers were resettled here with the assistance of the Chinese Liberation Army. The oral histories suggest that before 1950, the Hani of Mangelong moved nomadically around the uplands, partially in response to oppression by the Dai ruling class. The State Working Team for Ethnic Affairs assisted Hani farmers in constructing paddy fields at lower elevations. People started to plant rubber in 1964 before they moved down in 1967. By 1981, their main land-use practices included paddy, swidden, and rubber cultivation. The hamlet decided to set aside two large areas for swidden cultivation and to rotate between these areas every 5 years. Mangelong still has 100 ha of forestland under state and collective title that serve as a natural buffer along the Sino-Burmese border and from which villagers still collect substantial amounts of nontimber forest products. As state programs to expand rubber plantations into primary and secondary forests in the lowlands were implemented in the 1950s, farmers in Mangelong attempted to develop rubber plantations at elevations above 1000 m without much success.

Manbeng, the Bulang hamlet, has a population of 149 and controls 8.5 ha of agricultural land and 8.5 ha of rubber plantation. Farmers traditionally practiced shifting cultivation in the uplands and cultivated paddy in the lowland. When new paddy fields were opened in 1950, however, many households abandoned shifting cultivation and moved to lower elevations. Their customary lands were squeezed between the Hani community above them and the state rubber farms below them. Today, land scarcity is the main constraint on village livelihoods. Rubber was introduced in 1964 during the collective period and was further expanded in the 1980s. Villager livelihoods are based on paddy rice and rubber supplemented by vegetables grown in paddy fields during the dry season and by livestock (pigs, chickens, etc.) raised for cash income. Over the past 3 decades, the average size of village land holdings has decreased and forests have completely disappeared. The area under rubber cultivation has expanded significantly. Concurrently, agricultural production has been transformed from land extensive to intensive (intercropping, winter vegetable rotation, etc.).

Table 1. Land-cover change in Menglong between 1965 and 1992

Land use	Year	Number of patches	Mean size of patches (ha)	Total area (ha)	% of area
Dense forest	1965	41	96	3912	36
	1992	18	147	2647	24
Sparse forest	1965	22	72	1587	15
	1992	23	73	1690	16
Bush/grassland	1965	95	30	2852	26
	1992	17	93	1579	14
Swidden	1965	34	8	263	2
	1992	47	8	390	4
Paddy	1965	20	64	1275	12
	1992	8	181	1448	13
Rubber	1965	20	42	832	8
	1992	9	319	2875	27
Other[a]	1965	42	3	105	1
	1992	56	3	189	2
Total	1965	274	40	10,825	100
	1992	178	61	10,825	100

[a]The category ''other'' includes residential area, roads, water bodies, nursery and vegetable gardens, denuded land, and unresolved class assignment errors.

The state rubber farms were established in 1956 when retired army personnel and young Han Chinese farmers from Hunan province in central China were resettled in Menglong. Although the number of workers has decreased in recent years, there are approximately 7000 state rubber farm workers in Menglong township (16.4% of the total population).

Administratively, state rubber farms are organized according to subunits (*xiaodui*) as the smallest unit (often with less than 50 ha of land). Subunits are combined to form units (*dui*); units are combined to form farms (*chang*); and farms are combined to form the Xishuangbanna Bureau of Agricultural Reclamation (*nong ken ju*), an agency that is totally independent of local government administration. Individual households that live on state farms were allocated plots to manage on a contract basis in the late 1980s. Although state rubber workers were subsidized during the collective period, at present these workers must earn their income from the land they have contracted. They must also pay rent to the state farm. In this sense, both state rubber workers and smallholders are vulnerable to climate and market uncertainty.

State rubber farm workers began replanting old rubber trees in 1990 (Chapman 1991). The newly replanted rubber trees are often intercropped with other cash crops such as pineapple and coffee. Some rubber farms, such as State Farm Unit 3, cultivate half of their arable land with rubber and the other half with paddy rice. Boundaries were demarcated between state and local communities and households in 1983, but conflict over customary boundaries has never been resolved and people from indigenous communities still farm and utilize lands claimed by the state farms.

Changes in Land Cover

Changes in land cover in Menglong between 1965 and 1992 are summarized in Table 1 and shown in Figure 2. The major land-cover changes documented during this period consisted of a loss of forestland from 36% to 24% of total land, loss of bush/grassland from 26% to 14%, and an increase in rubber plantation from 8% to 27%. Fragmentation does not appear to have increased during this period. Overall, the number of patches decreased by just over 33% from 274 to 178, and the size of the average patch increased by around 50% from 40 to 61 ha. This was due to the expansion of monoculture rubber plantation and merging of smaller patches to form larger contiguous stands. The number of rubber patches decreased from 20 in 1965 to 9 patches in 1992, while the mean size of rubber patches showed a dramatic increase from 42 ha in 1965 to 319 ha by 1992. Other major land-cover categories, including dense forest, bush/grassland, and paddy, followed this pattern of decrease in the number of patches with increasing mean size of patches. In terms of fragmentation, sparse forest, upland agriculture, and other (mainly residential and water) categories remained relatively stable.

Table 2 is a transition matrix showing how land cover changed between 1965 and 1992. During this period, 2317 ha of dense forest were converted to sparse forest (861 ha), rubber (816 ha), bush/grassland (393 ha), and swidden, paddy, and other uses (total of 247 ha). On the other hand, 616 ha of bush/

Table 2. Transition matrix of land-cover classes in Menglong between 1965 and 1992

Land use/Land cover	Dense forest (ha)	Sparse forest (ha)	Bush/grassland (ha)	Rubber (ha)	Swidden (ha)	Paddy (ha)	Other[a] (ha)	Total loss (ha)
Dense forest (ha)	—	861	393	816	138	79	30	2317
Sparse forest (ha)	389	—	364	364	29	67	22	1235
Bush/grassland (ha)	616	416	—	747	143	154	26	2102
Rubber (ha)	16	13	7	—	15	102	20	173
Swidden (ha)	20	28	55	88	—	50	14	255
Paddy (ha)	11	15	9	190	53	—	49	327
Other[a] (ha)	4	4	3	12	4	50	—	77
Total gain (ha)	1056	1337	831	2217	382	502	161	0
Net gain/loss (ha)	(−1261)	102	(−1271)	2044	127	175	84	—

[a]The category ''other'' includes residential area, roads, water bodies, nursery and vegetable gardens, denuded land, and unresolved class assignment errors.

Table 3. Land holdings by village (hectares/capita)

Sites and ethnicity	Population	Paddy	Permanent upland	Rubber	Swidden	Total land	Net income[a]
Manguang—Dai	728	0.06	0.01	0.06	0.00	0.13	189
Mangelon—Hani	258	0.05	0.07	0.17	0.06	0.35	246
Manbeng—Bulang	148	0.05	0.01	0.05	0.00	0.11	157
State farm unit 5—Han	41	0.01	0.10	1.43	0.00	1.54	909
State farm unit 3—Han	164	0.19	0.00	0.22	0.00	0.41	1068

[a]US dollar/capita/year in 2000.

grassland and 389 ha of sparse forest reverted to dense forest (Table 2). The greatest net gain was 2044 ha of rubber created primarily from dense forest (816 ha), bush/grassland (747 ha), and sparse forest (364 ha).

Livelihood Uncertainty and Vulnerability

During the collective period, People's Communes planted some rubber, particularly during the late 1970s and early 1980s, under the guise of Rural Township Enterprises. After the 1982–1983 reforms, these plantations were either abandoned or allocated to individual households. For the most part, local people have been able to plant only rubber since 1982–1983. Table 3 shows that by the year 2000, a farmer's income (for both state plantations and smallholders) was highly correlated with the amount of land he planted in rubber. State rubber farmers have higher net incomes than others and have more diverse sources of income, including intercropping, fruit tree plantation, and processing and third-sector business development (shops and restaurants). Note that net income is closely correlated with both the total amount of land and the amount of rubber land a farmer owns or manages. Tables 1 and 2 show that the main land-use change that occurred in Menglong between 1965 and 1992 was the conversion of forests and bush/grasslands to rubber plantations.

The commercial production and marketing of rubber depends on three factors: land, market, and climate—all beyond the control of farmers. The vulnerability of a farmer's livelihood, once he becomes dependent on rubber production, can hence be assessed in both biophysical and socioeconomic terms.

Mainland China's geographic location north of the tropics (between 18° and 24° N latitude) means that rubber is only marginally suitable to the prevailing weather conditions. Hence, the rubber-tapping period in Jinghong is very short: 7 months as opposed to the 9 to 10 months in Hainan Province, China, and the year-round tapping in Thailand, Malaysia, and Indonesia (Cheo 2000). Periodically, harsh winters (with minimum temperatures dropping below 10°C) that kill or damage rubber trees in the early stages of their growth occurred in 1963–1965, 1969–1971, 1973–1974, 1980, and 1999–2000.

Approximately 60,000 ha of rubber plantations are located in Jinghong County (Wu and others 2001). Of these, two thirds are owned and managed by the state and one third are owned and managed by small-scale farmers. Interpretation of the 1965 aerial photographs revealed that 832 ha of rubber (100%) were planted in environmentally suitable habitats (elevation of less than 700 m asl). By 1992, the state rubber farms planted 1039 ha of rubber at elevations below 700 m asl, whereas small farmers cultivated an additional 1209 ha of rubber located mainly between 700 m and 850 m asl.

Given the marginality of the location, farmers in Yunnan should have been provided with information

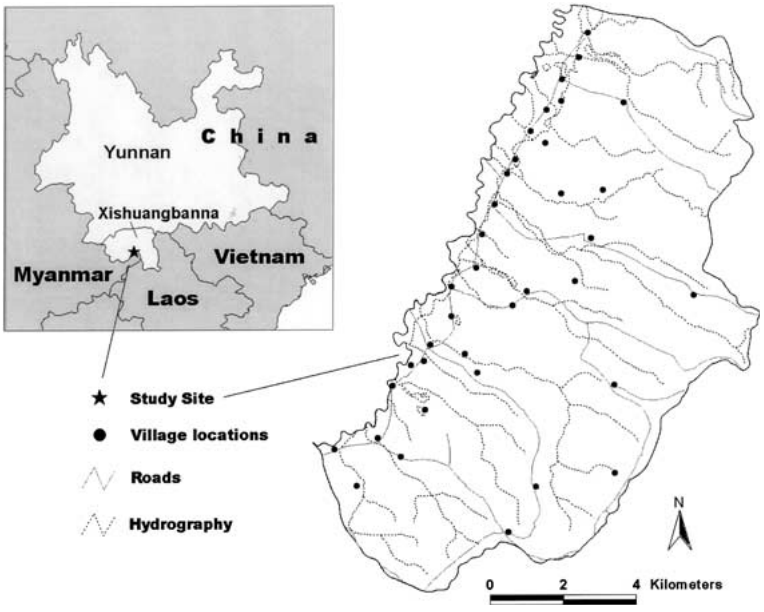

Figure 1. Location of study site: Nan-e watershed, Menglong Township, Jinghong County of Xishuangbanna Prefecture.

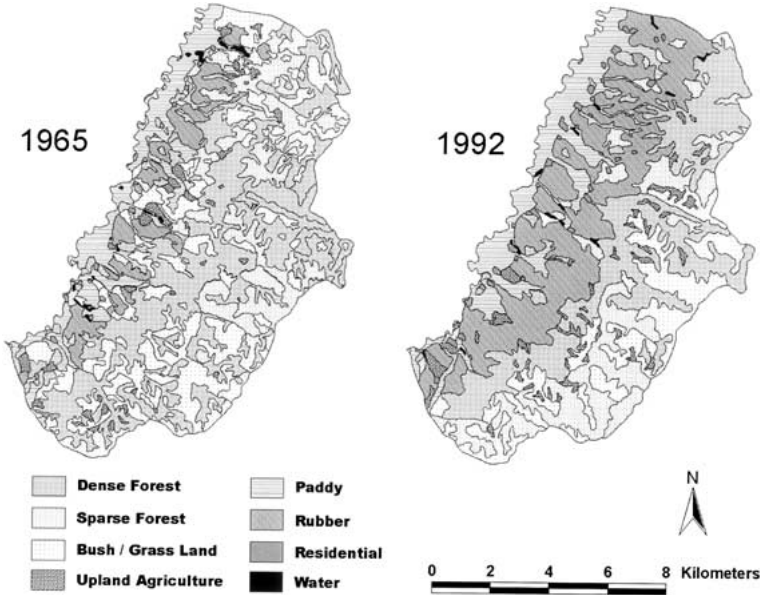

Figure 2. Land-cover class maps for Menglong Township, 1965 and 1992.

on the hazards and risks of growing rubber in areas of extreme elevation—anything above 700 m asl—and less than 10°C (Feng 1982, Ma 1989). The periodic visits of cold temperatures have greatly impacted the rubber production, which results in unstable income generation (Chapman 1991). For subsistence smallholder farmers, even a short-term cold and drought can be disastrous, especially for those farmers whose only security is a small piece of swidden field on which to grow food and monoculture rubber as cash crop.

Since the 1950s there has been large-scale resettlement of Han Chinese into the foothills and the establishment of rubber farms on the gently sloping lands. These lands, which used to serve as a common resource and buffer zone for environmental goods and services for upland and lowland peoples, are also the most suitable for rubber plantation. The indigenous people, both Dai and Hani, have faced land scarcity or had to open additional marginal lands for rubber plantations. Consequently, conflicts on land use and land tenure practices between indigenous people and immigrants have significantly increased.

The mosaic landscapes of swidden-fallow vegetation, ''holy hills,'' and natural forests that used to exist have

been replaced by landscapes dominated by rubber trees. Indigenous people have increasingly less space to practice traditional livelihoods such as grazing livestock and collecting nontimber forest products (NTFPs). Most farmers have sold their cattle and water buffalo, bought or hired tractors to plough paddy fields, and shifted to using chemicals to control weeds and pests (Wu and others 2001). The traditional exchange of NTFPs from the uplands for rice from lowlands between Hani and Dai people, which is a strategy for climate uncertainty and maintenance of social relations, has been gradually abandoned.

In the late 1980s, China terminated subsidies to state rubber farmers and reduced the tariff on imported rubber. These actions pushed both state and small-scale rubber farmers to compete in the international market. Stagnant market prices immediately affected rubber producers and made rubber production less commercially profitable. The break-even price for both state and small-scale farmers is approximately US $915 per ton. The small-scale rubber farmers in the upland have to rely on lowland township enterprises or state rubber farm for rubber processing and marketing access, which decreases profitability to even a greater extent for those small-scale farmers at a distance from processing and market.

The Chinese state claims to have successfully alleviated poverty in upland communities by introducing small-scale farmers to rubber processing and marketing enterprises. In reality, however, this development model has placed poor farmers into a market over which they have no control. For example, an elderly Hani man reported that he began planting rubber in 1979 at the insistence of local government officials who were eager to collect the tax placed on special agricultural products such as rubber, which was much higher than the tax on grain products. Currently, the collective forest and swidden-fallow fields of his village are completely planted with rubber. The man reported that he has more income than he did before, but it is dependent on the market price of rubber and cold-free winter weather. In 2001, his income decreased drastically because the price of rubber was low.

The widespread introduction of rubber plantations significantly affected local livelihoods by eroding customary institutions and marketing networks as well as the norms and rules followed by upland and lowland communities. A livelihood dependent on rubber is much simpler than a livelihood dependent on traditional swidden and secondary vegetation ecosystems. Lowland–upland institutions that were established to manage watershed activities and to provide a sustainable livelihood in this mountainous region have been irrevocably altered by the adoption of rubber.

Examination of the historical causes of vulnerability in the rubber-dependent local economy demonstrates how broader political and socioeconomic processes produce this vulnerability. The contemporary production and reproduction of vulnerability occurs at international, state, regional, community, and household levels through state policies, social relations, land-use changes, and demographic shifts. State policies have played major roles in both security and vulnerability through their efforts on land allocation, resource access, market infrastructure, and population movement.

In China, democratic elections for local leaders take place only at the hamlet level. All other local officials are appointed and are consequently accountable upward to higher-level government officials instead of downward to local communities and farmers. Hence, although policies can be implemented honestly or dishonestly, government officials have incentives to please their bosses rather than the public. Many farmers have learned that development projects are often implemented to enhance the political ''image'' of governmental officials rather than for their benefit. Consequently, farmers do not trust state policies. Furthermore, because the processing and marketing of large-scale cash crops, such as rubber and tobacco, are controlled by the state and sometimes by large-enterprise companies (which are often state owned), the prices for products are often dishonestly manipulated. Large state farms and private enterprises control rubber processing and marketing in Xishuangbanna, and small farmers are often forced to shoulder the market risk of low prices.

Conclusions

This study investigated changes in land cover and landscape patterns in Xishuangbanna through a 27-year period. Analysis showed land cover in the region has been both stable and dynamic. Between 1965 and 1992, 55% of the Menglong landscape remained under forest or some type of secondary forest, while at the same time the area devoted to agriculture increased by 21% (a net increase from 22% to 42% of the total study area). The most significant changes were the loss of dense forest (36% to 24%) and the gain in rubber (8% to 26%).

Rubber plantations in Xishuangbanna have eroded not only customary boundaries and resource management institutions but also the capacity of farmers to manage ecologically diverse landscapes and to participate in market networks. Vulnerability is shaped through individually differentiated access to invest-

ment, and productive resources such as land, irrigation, credits, information, and participation in decision-making. Both the state's control of access to resources and the concentration of the economy by state enterprises contribute directly to the ecological deterioration of local environments that makes marginal people more vulnerable. Vulnerability analysis must take into account both environmental degradation due to land-use and land-cover change, as well as its consequence on local livelihood, political structures, and institutions.

This study showed through an analysis of the sociopolitical situation how upland resources, people, and space are dominated by the state and by lowland-based monoculture-cropping technologies. Furthermore, the greater part of benefits derived from the exploitation of mountain resources flowed down to lowland economies and political centers. Challenges exist for both state and lowland institutions to design policies and marketing systems that are more transparent for indigenous people and that are more supportive of indigenous knowledge, cultures, and livelihoods. This can be achieved through decentralized state policies, transparent markets, capacity building, and participatory land-use planning at local and watershed levels. Capacity building for indigenous people that enables them to cope with environmental variability and socioeconomic change can be achieved through endowment (of natural assets), empowerment, entitlement, and enfranchisement, which provide a counterbalance to the ongoing political–economic processes that produce vulnerability (Ribot 2001). Land-use and land-cover change can serve as an indicator of the political-economic causes of environmental change and vulnerability.

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