Land use history and recent development in the Naban Watershed: the case of rubber

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Abstract:

In Yunnan province, rapid rural development is coupled with a dramatic decline of biodiversity. Within the framework of the "LILAC: living landscapes China" project consortium the authors are looking for relevant options for the introduction, adaptation and diffusion of innovations which may help to conserve the status-quo of biodiversity in the NabanHe National Nature Reserve (NNNR). The project aims at organisational development, i.e., ways to influence local institutions and structures as well as processes of generation, dissemination and use of knowledge including extension and education activities.

Systemic interventions of this kind require profound insights into the historical as well as the present land use situation. Based on a typification and analysis of more recent innovations, the factors and framework conditions for the adoption and dissemination within the local and the formal knowledge system are being assessed in order to make predictions on future scenarios.

The paper is focusing on changes in land usage which were, and still are being, implemented by introducing a new variety: rubber. It is presenting basic findings of an in-depth analysis of economic, ecologic and societal potential and problems for the case of two villages and from a users perspective: The farming system, land relations, household economy and social life are in transition, environmental balance and biodiversity are meeting tremendous challenges.

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1 Introduction

NabanHe National Natural Reserve (NNNR), located in JingHong county, Xishuangbanna Autonomous Prefecture of Yunnan Province, covers about 2600 ha of land. NNNR is multi-ethnic, inhabited by LaHu, Han, Dai, HaNi, Yi and BuLang. The main source of income is agricultural production. Since 1980, the household contract responsibility system has been adopted in NNNR. With the promotion of hybrid rice and development of forestry the economic wealth of the region improved considerably. The introduction of rubber in the 1980s was regarded as a key innovation on land usage. Rubber has become the main source of income for many farming households. Because of its high economic profit, the size of rubber plantations grew rapidly and by 2004, the total planting area covered nearly one quarter of the landscape. This rapid rural development is coupled with a dramatic decline of biodiversity (LI et al. 2007, LANGENBERGER et al. 2008).

Within the framework of the "LILAC: living landscapes China" project consortium the authors are looking for relevant options for the introduction, adaptation and diffusion of innovations which may help to conserve the status-quo of biodiversity. The subproject on "Land use related innovations and knowledge flows" aims at organisational development for a relevant knowledge system of the Naban He National Nature Reserve. Organisational development hereby is seen as influencing institutions, structures and processes of generation, dissemination and use of knowledge. Based on an analysis of former and present land-use problems the factors and framework conditions for the adoption and dissemination of innovations within the local and the formal knowledge system will be assessed. This will give important orientations for the implementation of the LILAC-scenarios, and for further development.

Land use has a history. The present and future of land use, and its influences on the users and on the biodiversity, are based on this history. Through understanding of the history of land use in the Naban He National Nature reserve and in Yunnan Province we get important orientations on the likelihood of the introduction, adoption and diffusion of innovations. Changes of land use interact with changes in ecology, society and economy. A precondition for behaviour change of land users is information that emerges from interactions in the relevant knowledge system. The local and the formal knowledge system and their development provide the information base for individual acquisition of knowledge and the decisions about land use. These issues are to be assessed and reconstructed for the research site. Consequences for extension and education activities will be shown.

Systemic interventions of this kind require profound insights into the historical as well as the present land use situation. Based on a typification and analysis of more recent innovations, the factors and framework conditions for the adoption and dissemination within the local and the formal knowledge system are being assessed in order to make predictions on future scenarios.

The introduction of rubber has brought fundamental changes in land usage. This paper is presenting the basic findings of a potential/problem analysis of the impact of rubber on local

economy, ecology and society from a user's perspective. Starting in January 2007, an in-depth situational analysis has been conducted in order to elaborate the subjective view of local officials and farmers combining (amongst other PRA tools) narrative expert interviews and extensive observations with a stratified, semi-standardized household survey. Two villages (one Dai, one HaNi) have been selected as case studies for "innovation histories". To understand the introduction and dissemination of innovations, framework conditions within the NNNR are being elaborated, particularly the changes in land tenure.

Overview on the two village case studies

Village A is located near the gate of NNNR in an altitude of 670m above sea level (asl). It consists of 56 households with 287 inhabitants and about 170 working population. Three simple restaurants and more than ten new concrete townhouses indicate a quite good living condition, compared with other villages.

The village has some paddy land so the main food source is rice. Two to three households are growing a small amount of maize as a cash and alcohol crop. The main source of income is rubber. The state-owned Rubber Plantation Farm is located nearby, having strong linkages with village A.

Table 1: Description of study villages

	Village A	**Village B**
Altitude	670 masl	770 masl
Households	56	40
Population	270	150
Land size	2457 mu	1049 mu
Farm land		
Irrigated land	205 mu	97 mu
Dry land	53 mu	120 mu
Rotation land	284 mu	144 mu
Rubber plantations	1761 mu	749 mu
Source: NNNR administrative officer		

Village B is on higher altitude than Village A. It is less densely populated with less than half of (farm) land. The village does not origin in the location. It was resettled in 1971 from another county. Until recently, the population in Village B increased from 18 to 40 households and about 151 persons. Population increase is coupled with deforestation. After resettlement, villagers were organized to reclaim paddy land and rotation forest land in the natural forests. In 1982, village B owned 86 mu Paddy land and 1590 mu rotation forest land. In 1997 they

constructed 92 mu terrace land. In 2002 all of the terrace land was reforested with subsidies from the Central government, mainly with rubber. Village B has only a few irrigated paddy fields. Farmers therefore must grow hybrid rice.

2 Land tenure history

Introduction and diffusion of rubber is clearly dependent on the development of land tenure in the NNNR (table 2). Therefore we will give a short introduction:

Table 2: History of land tenure in NabanHe National Nature Reserve

Time	Background	The tenure of land in NNNR
- 1956	Dai Autonomous Prefecture of Xishuangbanna	Landlords
1956-1958	Land Reform	Landlords dispossessed; land distributed to households from local government
1958-1982	People Commune Movement (Renmin Gongshe)	Community: co-operation of villagers, profit distribution by work quota.
1982-1999	First land contract	Villages distributed forest land, rotation land and paddy land to the households; contracts of 15 years
1999 -	Second Land contract	Land contracts adjusted to the population and land resource change; contracts extended to 30 years.
Source: key informant		

Dai Autonomous Prefecture of Xishuangbanna was founded in 1953. Most of the Land belonged to landlords.

After 1958, the villages in NNNR like all over China began a collective agricultural production within the People Commune Movement. The core of the movement was that all the land belonged to the government, and the agricultural production was organized in community level. Profits of agricultural production were distributed by Work Quota.

In 1978, China Central Government decided to implement the so-called Rural Economy System Reform. The key step was a land reform towards a Household Contracted Land System: the ownership right of land still belonged to the community and usu fruct rights contract with the households. Agricultural production in Village A and Village B was mainly dry farming in rotation land and irrigated farming in paddy field. Farmers grew local rice species with low productivity. Due to limited size of paddy fields, the production could hardly meet the grain ration of the households themselves. Therefore, also dry rice was grown on rotation land,

supplemented by local old species maize, peanut and bean, etc., which were adapted to dry land conditions but showed relative low yield.

Table 3: Agricultural production structure before the 1980s

Land type	Crop name	Species	Yield (kg/mu)	Main Function
Rotation land	Maize for dry land	Local	100	Main food
	Peanut	Local	40	Cooking oil
	Bean	Local	40	Cash crop
	Dry rice	Local	25	Main food
	Broomcorn	Local	20	Forage
Paddy field	Rice	Local	100	Main food
Forest land	Natural forest	Local	No information	Firewood
Source: key informant				

NNNR began the land reform in 1982. The core philosophy of the Household Contracted Land System is that each resident of a village has the same chance to get land use rights. An average size of different types of land was rented to each resident without consideration of gender and age. In both villages, inhabitants agreed to categorise land into rotation land, paddy land and forest land according to the altitude and location. The per capita amount of land differs between the two villages because of differences in population and total amount of land (table 4).

Table 4: Land distribution in 1982

Land type	Description	Village A	Village B
Rotation land	Foot area of the mountain / dry rice and maize in history	10mu/person	14mu/person
Paddy Land	Valley and plain area / irrigated rice	1.25 mu/person	0.15 mu/person
Forest land	Mid of the mountain / forest	14 mu/person	Not distributed
Source: key informant			

This system of land tenure is a main reason for intensification of agricultural production in the villages, reduction of varieties, and the introduction of rubber (table 5). Land distribution was adjusted in 1999 to the changes in population structure and contracts were prolonged for 30 years according to the New Land Law in China.

Table 5: Agricultural production structure in 2007

Land type	Crop	Yield (kg/mu)	Main Function
Paddy field	Maize	200	Alcohol crop and cash crop
	Rice	400	Food crop
Rotation land	Rubber	--	Cash income
Forest land	Rubber / natural forest	-	--
Source: key informant			

3 The introduction and diffusion of rubber

The introduction of rubber trees to Xishuangbanna was not before 1940, when a Chinese settler who came back from Thailand planted the first trees in trials. After 1949, rubber has been seen as an important strategic resource by the Government. In 1953, the state started to prove the feasibility of rubber in the area, and in 1955, the first rubber state farm has been founded. This farm was staffed by people from the inland province of Hunan, mostly by retired soldiers and Han Chinese farmers, who had volunteered to "settle the frontiers". Later on in 1960s and early 1970s, it was reinforced by the migration of the "educated youth" to rural areas. As a result, state-owned rubber plantations have been rapidly established in southern China, especially in Xishuangbanna and on Hainan Island (XU 2006).

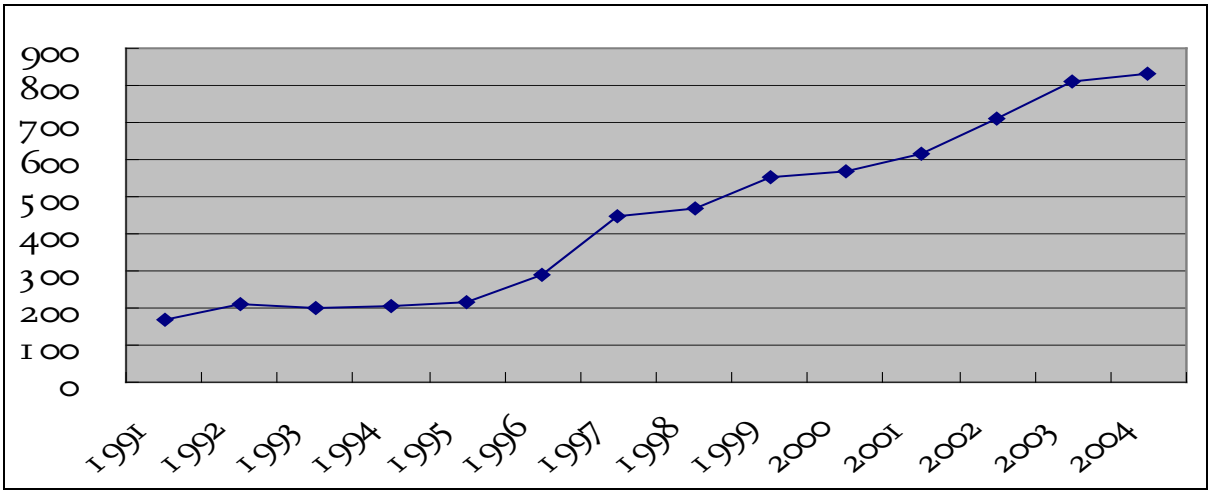
Back in that time, rubber was considered as a perfect way to modernize the savage shifting cultivation practices of local minorities. The first rubber planted by local farmers dates back to the year 1963, and starting from this time up to now, rubber has spread quickly in most of the mountainous areas of Xishuangbanna (XU 2006).

In the late 1980s, the Government incentives led to an increase of smallholder private rubber production, since the state-owned farms faced difficulties with their own production. Rubber plantations have been promoted by the Government. As a result, mostly young people started with rubber plantations as they provided more cash income and were less labor-intensive, which has been desired to purchase modern consumer goods and live a modern lifestyle (XU 2006).

Currently, Xishuangbanna represents the second largest producer of rubber in China next to Hainan Island. In 2007, China's largest natural rubber processing plant was founded in Jing-Hong city with an annual production capacity of about 40,000 tons. Its focus will be on high quality natural rubber for the steel tyre industry (XISHUANGBANNA SINOCHEM 2008). At the moment, rubber tree plantations cover around 400,000 hectares of Xishuangbannas landscape and thereby occupy approximately 20% of the prefectures area.

Rubber is a cash crop, its development clearly driven by market prices. Introduction of rubber was strongly supported by the state. JingHong Farm provides technical assistance and young plants. During the interviews, many villagers revealed their deep affection towards Jinghong Farm. Four stages in rubber development in the NNNR can be identified (figure 1 and table 6):

Figure 1: Rubber plantation in NNNR (ha)



Source: NNNR administrative officer

1. At the beginning, only a few community elites tried to plant rubber although this was strongly supported by government policy. Reasons were a lack of knowledge and experience and risk: rubber was an external and new variety for the villagers, the rubber in JingHong farm was still in the process of growing and did not show yields, and profits could not yet be realised. Usually it takes 8 years to have any economic return.

2. The Situation changed after rubber trees in JingHong farm could be tapped and market income was realised. Village A and Village B both are neighbouring JingHong farm, the villagers were easily convinced to invest in rubber plants.

3. With falling prices for caoutchouk in 1991 also the interest of farmers declined.

4. From 1996 the price of rubber juice rose, farmers realised great profits and enlarged plantation size. At the same time the central government started the Natural Forest Protection Project (NFPP) with the aim on environmental protection[1]. It was forbidden to transfer forest land into agricultural land and the natural forest areas were stronger protected. Local farmers wanted to “catch up the last bus” for rubber plantation which led to a rubber boost, and further deforestation.

[1] Since the launch of the National Program of Natural Forest Resource Protection, forests covered by nature reserves are prohibited from logging.

The introduction of rubber in Village A

"In 1984, 48 mu of rubber were planted for trial on collectively owned land, 8 rubber trees per farming household. At that time, nobody in the village planted rubber trees but some neighbouring state-run farms had already started to practice. The township government selected one person from each of its villages to learn techniques of rubber planting in Gadong Town Office of Tropical Crops. Y.-X. was chosen as the representative. In order to share risks, rubber trees were firstly planted on collectively-owned forest land. Every farmer was asked to plant 8 trees and be responsible for management. In other words, farming households provided labor, and the collective village provided land. If the planting failed, farmers would not have any direct economic losses.

In 1985, 5 farming households, among others Y.-X. planted another 35 mu of rubber trees on their own land. In 1986, Y.-X. planted another 7 mu of his own land. In 1987, the village government promoted rubber planting and the township institute of tropical crops helped to dig tree planting holes and distributed young rubber plants free of charge. Farmers were only responsible for field management. They were asked to plant at least 2 mu of land and 70 young plants were provided to each farmer. At this time, most farmers in the village began their rubber planting practice. However, the total acreage was still not large and most people took a wait-and-see attitude.

In 1989, Jinghong Farm began rubber tapping and the price was pretty high that year. Dry rubber was 18 yuan per kg and staff members made money out of rubber sales. As a result, farmers of Village A started to plant rubber trees at a large scale after 1989 and they planted all their fallow land with rubber trees. From 1991 to 1994, rubber price fell down and the lowest price of dry rubber was only 5 yuan per kg; therefore, farmers stopped the expansion of rubber planting. But rubber price began to climb up in 1995 and dry rubber was 20 yuan per kg that year; accordingly, farmers began to plant rubber trees in their contracted mountains in 1996.

The Government of China launched the National Program of Natural Forest Resource Protection in 1998 and carried out the logging quota management system in 1999. Many farmers had somehow learned this information beforehand and they knew that forest in their mountains could not be logged arbitrarily after 1997. Therefore, they fell all the trees in their contracted mountains and replanted rubber trees. Some villages in the Nature Reserve planted all their collectively-owned forest land with rubber trees due to the policy." (summarised from various interviews).

The introduction of rubber in Village B

"Rubber planting was a bit later than that in Village A. The former head recalled that both villages are part of the same administrative village. Y.-X., the technical instructor of village A, came for rubber planting promotion. In 1986, three farming households played the lead in

rubber planting, namely the father of persons in charge at that time, who had many friends from the state-owned farm. In 1987, with the promotion activity of the township government and the leading role played by the three households, many other farmers in the village began to plant rubber trees. Village B didn't contract mountains to any farmers when the land contract responsibility system was implemented. Only fallow land was allocated to farmers and by 2003, all fallow land in the village has been planted with rubber trees." (summarised from various interviews).

4 Changes implemented by rubber

Extensive rubber plantation in NNNR has positive and negative impacts on local development, namely in the field of farming systems, household economy, livelihood, environment and biodiversity, but also on the land tenure.

4.1 Farming system

Before rubber introduction to NNNR, the traditional agricultural production system could be described as a four-field crop rotation (table 6). The arable land was cultivated for 2 or 3 years, followed by a fallow of 4 to 12 years to recover land capacity naturally.

Table 6: Four-field crop rotation in village B

Year (c.)	Land piece 1	Land piece 2	Land piece 3	Land piece 4
1965-1968	Dry paddy	Fallow	Fallow	Fallow
1968-1971	Dry Maize	Dry paddy	Fallow	Fallow
1971-1974	Fallow	Dry Maize	Dry paddy	Fallow
1974-1977	Fallow	Fallow	Dry Maize	Dry paddy
1977-1980	Dry paddy	Fallow	Fallow	Dry Maize
Source: key informant				

With rubber increase, local residents aimed at transferring all the rotation land, particularly the fallows, into rubber plantation. This was made possible by the cultivation of hybrid paddy rice with its considerable higher yields. Food production area could be reduced to a minimum. Recently, almost all slopes in both villages are covered with rubber.

Table 7: Fertilizer application in rubber plantations

Age of tree	Kinds	Amount	Fertilizing time	Source	Price yuan/kg
1-3 year	Urea	60 kg/ha	April and November	Market	2
3-8 year	Compound fertilizer	215 kg/ha	November	Market	3
8 year ff	Compound fertilizer	600 Kg/ha	April and November	Market	3
	Urea	450 kg/ha		Market	2
	Manure	7500 kg/ha		Farm	-
Source: key informant					

Different kinds and amounts of fertilizers are being applicated in the growing phases: after plantation twice a year urea, later once a year compound fertilizer to stimulate growth. When the trees are harvested, compound fertilizer, urea and also manure are being used. Detailed information is given in table 7.

To control white powder sickness (Baifenbing) and scale insects, the farmers are spraying pesticides (table 8). According to local statistics, in village B 190.000kg fertilizer and 2.700kg pesticide are used each year.

Table 8: Pesticide application in rubber plantations

Pest / Disease	Phenomenon	Pesticide	Amount	Spaying time
White powder sickness	White dots on leaves	Sulfur Powder or Triadimefon	37.5kg/ha	Regularly: End of February / Beginning of March
Scale insects	Leaves turn black	Rogor	"Some"	Immediately
Source: key informant				

4.2 Household economy

Economic returns from rubber are by far more than that from other crops or trees such as teak, longan or litchi (table 9). Rubber can be gathered in the 8th year of planting. After a village expert, farmers earn about 2,000 yuan from every mu of rubber trees in the first 5 years after the first tapping, and 5,000 yuan from 5th year to 12th year. If farmers are good at field management, they can get 3,000 yuan from each mu of rubber trees from 13th to 40th year of rubber tapping (prices: 2008).

JingHong Farm is just nearby and the rubber liquid gathered in the day can be delivered and sold to the Farm in the same day. Farmers get cash income which is the second reason for the

rapid development of rubber planting. The production of tropical fruits such as longan and litchi faces much more marketing risks.

China initiated a logging quota management system in 1999. Farmers must get an approval by the local forest authority and pay a certain amount of money for afforestation, even if they cut trees from their own timber forest. In 2003, China abolished the tax on special forest products which includes rubber. It means that farmers now can gather rubber freely without paying any kinds of taxes or fees. Therefore, farmers are more enthusiastic to plant rubber trees than before.

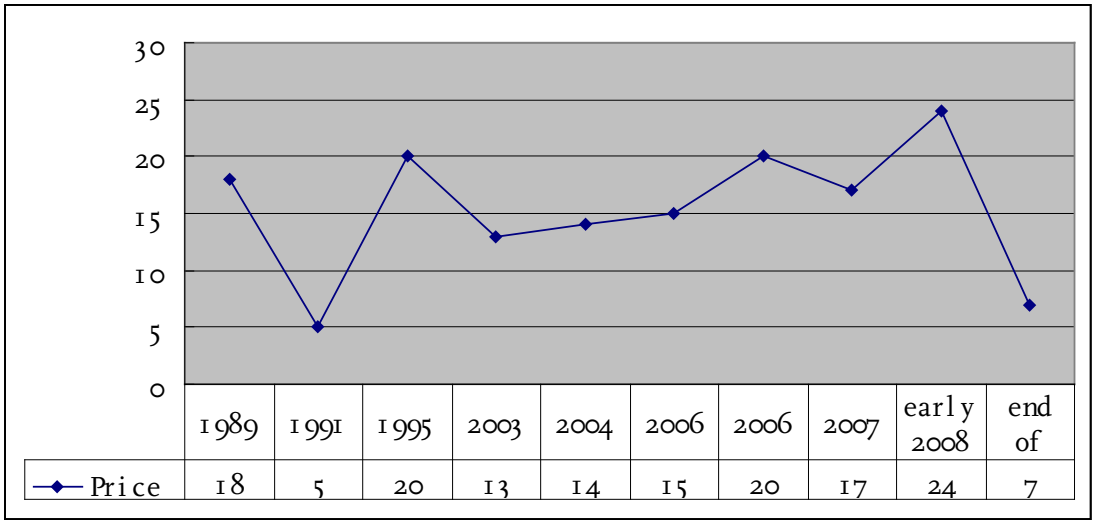
Considering the above factors, a simple agricultural production mode was formed in villages of low altitude in the natural reserve: *"getting grain from hybrid rice, earning money from rubber, and having other goods traded with money"* (farmer).

Table 9: Comparison of rubber and other tree crops

Name	**Average profit (yuan/mu*year)**	**Know-how**	**Market**	**Marketing risk**	**Tax/fee**
Rubber	2,000-5,000	Established industry	Nearby	Lower	None
Timber forest	Not available	Not-established industry	Long distance	Higher	Afforestation Fund
Fruit trees	Not available	Not-established industry	Long distance	Higher	none
Source: key informant					

In recent years, rubber became the main source of income for the local households. One important risk is the dependency of prices on the international market. In 2007, local farmers expected increased prices in the near future. According to them, now it is time to renew rubber trees in South-East Asian area. This will reduce the supply of dry rubber. So they think they will not suffer the market risk these years. However, this situation has changed in the end of 2008 due to global financial crisis. From the end of 2008 the price of dry rubber declined rapidly to one-third (figure 2).

Figure 2: Dry rubber prices in NNNR (in yuan/kg)



Source: key informant

4.3 Environment and biodiversity

Rubber is a non-native plant to Xishuangbanna. Its natural habitat is the Amazonian rainforests. If compared to the humid tropics and alluvial plains in the Amazon basin and South-east-Asia, Xishuangbanna's rubber plantations are mostly located in subtropical mountainous regions with a relatively low temperature and prevalent poor soil fertility. If rubber is grown in such a marginal biophysical environment, higher labor input is needed, e.g. for weeding, for terracing of the soil erosion control and for soil fertility management (XU 2006).

Yunnan Province is estimated as the northern latitude limit for rubber cultivation. The decision to introduce the plant species to this marginal climatic zone back in the 1950s was based on the Government's interest to achieve self-sufficiency in latex production (XU 2006).

The increase of rubber planting in NNNR induced negative impacts on the environment. Most of the rotation land was transferred. This is recognised by the farmers: Some talk about landslides during the raining season which takes place much more frequently than in the past. Water in the rivers become less and less; some water source was polluted. In village 2 they got water from the river near the village. Now they must construct a pipe-water system to catch water from the peak of the mountains.

Next to the landslides, the most dramatic change in the recent years reported by the farmers is the change in the water household of the area. A drop of the groundwater level is perceived as well as the missing of winter mist or fog. An explanation for this incident can be found in QIU 2009: during the winter time, this dense fog of evaporated water was trapped beneath the rainforest canopy. Since the rubber trees have been taken over more and more of the area, the

winter fog is becoming less. Rubber trees are known as huge water consumers, even considered by the locals as so-called *"water pumps: the trees suck up the water"*.

Erosion is another problem: compared to the rain forest, more water seems to be lost from the spaces in between since there are no plants which can hold the water back or store it, causing more surface water run-off during the rainy season. As a result, the water content of the soil will be reduced and in consequence, less water can evaporate. And further, a drop down of the stream flows and dwells and rivers are likely to dry out (QIU 2009). Another environmental consequence of the shift from rainforest to rubber plantations is the negative influence on carbon dynamics and climatic changes in the area (QIU 2009). However, these issues have never been mentioned in our interviews with local farmers. But according to data of meteorological stations in Xishuangbanna it seems that the region received less rainfalls, has been getting warmer and experienced more severe droughts since the 1960s (QIU 2009).

4.4 Livelihood

Live within a household also changed (see table 10). According to interviews with local villagers, rubber plantation and management is labour intensive. They have to do some tending work such as fertilizing, branches cutting and weeding and so on. After the rubber tree can be tapped they have to tap the rubber juice every early morning from April to October. Households which planted on large scale had to hire waged workers to help them to tend the rubbers.

Table 10: Livelihood changes

	Before rubber plantation	**After rubber plantation**
Agricultural products	various	Rice and maize
Labour need	self-hired labour	Labour intensive (night!), waged labour
Main income source	Agricultural products Off-farm work	Rubber latex
House	Traditional wooden houses built by locals	New style, concrete, built by external craftsmen
Consumables	Few	TV set, washing machine, fridge, motorcycle etc.
Plough power	Buffalo	Tractor
Livelihood character	Subsidence	Market oriented

Due to the fact that rubber farmers have more purchasing power, traders from JingHong and MengHai are attracted and they might occur frequently in the villages to sell vegetables, meat, clothes etc. This is also a major reason why most farmers in rubber planting villages gave up

pig farming; it is just much easier for them to buy meat from such traders. Moreover, farmers are able to buy tractors to cultivate their fields and as a result, buffaloes lose their importance to the villagers. This tendency will become more prevalent when rubber plantations have either displaced the former grazing land for buffaloes and cattle or the area for corn planting, which is needed to feed the animals. Also local households could improve daily live and buy commodities such as TV, washing machine, fridge, motorcycle. Instead of the traditional style houses with wood and grass new concrete ones could be built, often by external craftsmen. This shows a transition from subsistence to a market oriented agriculture.

4.5 A new phenomenon: Land renting

Renting land for rubber plantation became very popular in both villages, especially in village2 with its large-area slopes. Different forms of contracts have been concluded regarding to the period and the ways of sharing the profits (table 11). About 19 households contracted their land to others and get renting income. The renters come from different neighbour villages, other provinces or counties.

Table 11: Different forms of land renting in village 2 (examples)

Renter from	**Size (mu)**	**Benefit sharing**	**Contract period**	**Starting time**
Other county	20	Lessee invests in rubber planting for 6 years; later land will be shared	26 years after first tapping	2003
Village 1	47.7	17000 yuan	25	2004
Jinghong county	17	25000	25	2004
NNNR administrative bureau	20	15000	30	2003
Food and Oil Company	15	32580	26	2003
JingHong farm	8	4000	40	2003
Source: key informant				

5 Concluding remarks

Rubber introduction was strongly supported by the Government. However, the adoption took several years of trial and comparison. Farmers considered a range of factors: driving forces such as the regular income and as a result the immense higher personal welfare; but also the higher risk due to monoculture and changing prices. Villagers are aware of the environmental conditions including changes in soil fertility, the tremendous change of the landscapes, and also ecologic problems. Insofar development of the land use structure was in both surveyed villages a quite complex process. Decisions were rational and clearly towards rubber.

Meanwhile, rubber is the main source of cash income. It has not only influenced agricultural activities and the seasonal calendar of the farms; but also everyday lives and behaviour of the people with a complete change of their daily routines.

Rubber has become the main driver of economic development in the NNNR. Future scenarios for innovations which may help to conserve the status-quo of biodiversity have to consider this. Alternatives might not be found, at least not easily or without massive compensation. The question might not be "rubber or not?" but "how to improve the rubber production system towards a conservation of biodiversity?"

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