Farming system changes in South-West China: Impacts of rubber cultivation

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Abstract: *The Nabanhe National Natural Reserve (NNNR) is located in the Xishuangbanna Dai Autonomous Prefecture of Yunnan Province, China. The region is one of the biodiversity hotspots of the world with highly diverse nature, societies and cultures, as well as agriculture. In the past decades the land-tenure reformation and the formal governmental agricultural extension have been the main drivers for the introduction of new crops and varieties such as "rubber" and hybrid paddy rice. This went along with new technologies such as fertilizer and pesticide. As a consequence, the farming system shifted from a subsistence slash-and-burn system to an intensive, market oriented one.Rapid economic development was coupled with fundamental social changes in families and villages (individual behaviour, social relationships, ceremonies, communication working conditions), and a decline in the biodiversity of the natural tropical rain forest and agriculture. The role of agriculture for farmers changed from ensuring food security towards income generation and consumption. The pathway of development might be similar to the one followed in other regions. The main distinction is in the speed.*

Keywords: *Farming System, Livelihood, rubber cultivation, South-West China*

Introduction

China is experiencing high-speed social transition and development. Agricultural development is considered to be one of the key elements. Since the People's Republic of China was founded in 1949, agricultural issues always have been put in the priority position in macro and micro development policy systems and practices. The agricultural development strategy, which had the core content of cultivation and promotion of new varieties, adoption and diffusion of new technology and confirmation of the land property system, has had a positive impact on poverty reduction, economic growth and social change in China. This trend can be observed everywhere in China and Xishuangbanna is no exception.

Xishuangbanna is located in the south-west of China and in the boundary area between China, Laos and Burma. It is famous for its biodiversity and regarded as a global environmental hotspot. In the past, swidden agriculture was the dominant model in Xishuangbanna. However, with the reform of the land property system, the introduction of the rubber industry and hybrid products and the application of new technologies such as fertilizer and pesticide, swidden agriculture is beginning to be replaced by Rotated Irrigation Farming and a Plantation Farming Pattern. Rotated Irrigation Farming is characterized by one growing season or two growing seasons a year with higher intensified utilization. Plantation Farming Pattern is characterized by long term production. As a result dry rice, which is the main crop in the swidden farming system has been replaced by modern economic crops such as rubber. The planted area of rubber in rural communities has increased from 42ha in 1965 to 41449ha in 1998, and the percentage of the planted area of rubber in the whole Xishuangbanna region has increased from 0.5% to 45% (Guo Huijun, 2001). In the meantime, traditional major crops in swidden farming such as dry rice, dry land corn and beans have almost disappeared. The agricultural ecosystem in Xishuangbanna has changed from traditional biological diversity to a system with only rubber as the major crop, a complete change to the farming system.

The paper focuses on the agricultural farming system shift driven by rubber cultivation along with the other agricultural innovations including land-use institutions and varieties, and the impacts on rural

development in Xishuangbanna. The research has been carried out in the Nabanhe National Natural Reserve (NNNR). Since the first rubber trees were introduced in the beginning of the 1980s by the neighbouring state-owned farm, 21 villages out of 32 villages in the NNNR have planted rubber trees with a total planting area of 822 hectares by 2004. Rubber cultivation has become the dominant agricultural behaviour and a major source of income for many farming households in NNNR. Four natural villages were selected to do this research considering the ethnic groups, land resources and rubber cultivation, transportation conditions and number of households, namely Mandian, Pabin, Naban and Danuoyou. The detailed status of the four villages is showed in below table.

Table 1. Basic Status about Research Villages.

Village	Mandian	Pabin	Naban	Danuoyou
Altitude (M)	670	770	690	800
Ethnic	Dai	Hani	Dai	Lahu
Households (Number)	56	38	42	92
Size of Paddy field (Mu)	205	86	366	433
Main crop in paddy field	hybrid rice	hybrid rice	hybrid rice, mellon	hybrid rice
Size of rotation land (mu)	1500	1590	700	3000
Main plants	only rubber	only rubber	only rubber	rubber, tea, bamboo, hemp, maize
Size of rubber by HH	1935	694	989	945

Source: Key informants Review in village level.
Notes: the size of rubber in the table includes the land in village and the land rent in other villages.

Farming System Changing Induced by Rubber Cultivation

In the past the traditional swidden farming system was the dominant agricultural development model. Some characteristics of this traditional farming system are very unique. Firstly this farming system is a kind of self-efficient and subsistence agriculture, and it is suitable for a low population density. The system often requires as much as 2 hectares to feed one person due to the lengthy fallow period generally required (Zhang Ping, 1999). Secondly, the diversity of plants is quite high with the food crops. Thirdly, the objective of the farming system is to meet livelihood needs and not to be oriented by the market. Fourthly, the need for labor, funds and additional material is quite little and the harvest mainly depends on the natural conditions. Fifthly, the farming system has a strong linkage with the social and cultural environment, and it varies among different villages (Xu Jianchu, 2000). However nowadays the traditional farming system has been completely replaced by the new farming system. The farming system shift is definitely a result of the integration of the institutional, social and economic elements, such as the land tenure reform, the agricultural green revolution and the improvement in the development conditions. But in the NNNR, rubber as a totally new planting variety adopted by local farmers has induced important and direct changes in the local farming system.

Plant Structure

In the traditional farming system the food crops were mainly plants cultivated within the NNNR. Because of the lower yield the local farmers had to cultivate as much land as possible so that they could harvest enough food. The farmers cultivated local varieties, such as dry maize, peanut, beans, dry rice and broomcom for their food security on the rotational land which was located at the low waist of the mountains. They seldom explored the forest land which was located at the high waist of the mountains and only collected the firewood. The plant structure is showed below.

The adoption of rubber is surely not only driven by the plant structure. In the 1980s high-yield hybrid rice was introduced to the NNNR and most farmers could get enough food from planting hybrid rice in their paddies. To some extent, from the point of view of their priority livelihood strategy of food security, hybrid rice adoption liberated the rotational land. Local farmers did not need to cultivate food crops on it. At this time rubber became the alternative. So nowadays local farmers cultivate

rubber on the rotational land and even on part of the forest land. Rubber + Hybrid rice has become the main crop structure in the NNNR, and the local traditional varieties are disappearing.

Table 2. Agricultural production structure before rubber cultivation.

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
Forest land	Natural forest	Local	No calculated	Firewood

Source: key informant interview

Land-use Model

Before the rubber plantations, the rotation agricultural production model was very popular in the NNNR. A Rotation Agricultural Production model means that the arable land is cultivated for 2 or 3 years and then not cultivated for 4 to 12 years so that the land capacity can recover naturally. The rotation land-use model can maintain the soil's nutrition.

Table 3. Rotation Agricultural Production System in Pabin Village.

	Land piece 1	Land piece 2	Land piece 3	Land piece 4
1965-1968	Dry paddy	Desolation	Desolation	desolation
1968-1971	Dry Maize	Dry paddy	Desolation	desolation
1971-1974	desolation	Dry Maize	Dry paddy	desolation
1974-1977	desolation	desolation	Dry Maize	Dry paddy
1977-1980	Dry paddy	desolation	desolation	Dry Maize

（notes: the time is assumptive time）

Since rubber was introduced to the NNNR, local residents transferred the rotational land from agriculture to rubber planting. The rotation land-use model has also changed. Local farmers do not leave land desolate anymore. They cultivate and manage the land every year, and they can also reap the harvest every year. To preserve the land's nutritional value they have to use plenty of fertilizer.

Labour Inputs

Rubber is a kind of labor-intensive plant. In the past under rotational agricultural the harvest depended on the natural conditions. In general the villagers seeded on the sloping land or irrigated land and then seldom conducted any field management. The only thing they needed to do was to wait for the harvest season to come, so the agricultural production burden was not too heavy. The rubber plantations changed this situation. According to interviews with local villagers, the rubber planting and management are labour intensive. They have to conduct some tending work such as fertilizing, branch cutting and weeding and so on. Once the rubber tree can be tapped, they have to tap the rubber juice every early morning from April to October.

Table 4. Labor Inputs on the rubber, hybrid rice and hemp (unit: person day/mu).

		Preparing the land	Breeding and cultivation	Fertilizing	Dealing with Pesticides	Grass cutting	Harvest
Rubber	Month		**	April, May, August, November	End of February to March	May and September	April to November
	Labor input	4	--	10	2	6	5

Productive Inputs

In the past, organic manure was used to fertilize the land to maintain the soil nutrition. In the rotation land-use model organic manure and recovery are naturally sufficient. Since the rubber planting started, rubber grows every year and needs plenty of nutrition from the soil, and the soil cannot supply it without any external supplement. So as mentioned above fertilizers are necessary inputs for the soil's nutrition. Higher yields of rubber can be achieved with more fertilizer. Pesticides are also used by villagers in order to control the insects and sicknesses. During the growth of the young plants, the farmers will use fertilizer to enhance the growth of rubber. Compound fertilizer, urea and manure will be used as fertilizers. The kinds and amounts of fertilizer are different in the different growth stages of the rubber. Detailed information concerning fertilizer will be shown in the table below.

Table 5. The fertilizer used for rubber.

	Kinds	Amount	Fertilizing time	Source	Price
1-3 year tree	Urea	60 kg/ha	Twice a year April and November	Market	2 yuan/kg
3-8 year tree	Compound fertilizer	215 kg/ha	Once a year November	Market	3 yuan/kg
Above 8 year tree	Compound fertilizer	600 Kg/ha	Twice a year April and November	Market	3 yuan/kg
	Urea	450 kg/ha		Market	2 yuan/kg
	Manure	7500 kg/ha		Self-supplying	Free

Source: key informant interview

What's more, rubber trees are often attacked by white powder sickness (in Chinese: Baifenbing) and scale insects, so the farmers will spray special pesticide on the rubber tree. Nowadays local farmers use more and more fertilizers and pesticides in agricultural production.

Table 6. The pesticide usage for rubber.

Sickness and insect	Phenomenon	Pesticide	Amount	Spaying time
Whiter powder sickness	The whiter dots on leaves	Sulfur Powder or Triadimefon	37.5kg/ha	The end of Feb and the beginning of March
Scale insects	The leaves will turn to black	Rogor	Some	Immediately

Source: key informant interview

In summary the swidden farming system has been turned into an intensive farming system through labour, fertilizer and pesticide input. In comparison to the traditional system the intensive farming system has different characteristics. Firstly the farming system is made to seek higher output and match complicated livelihood needs. Secondly a single plant replaces the diversity of the previous plants and cash crops are the priority for consideration. Thirdly the objective of the farming system is oriented by livelihood and the market. Fourthly the need for labour, funds and additional material is necessary and the harvest mainly depends on the technical and input conditional.

Impacts of the change in the Farming System

Impacts on the livelihood

As mentioned above the economic profits are the key motivations for farmers to adopt the innovations. Without any doubt rubber had become the main source of cash income in Mandian, Naban and Pabin villages and it can also be estimated to be the main source of cash income in Danuoyou village. On average the cash income per mu of rubber in the harvesting stage is about 2000 yuan per year. The farmer's income obviously increases and daily life also changes.

Due to the fact that rubber farmers will have more purchasing power, traders from JingHong and MengHai are attracted and they might turn up 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. Furthermore the local households have invested to improve their daily lives. Fixed consumables like TV sets, washing machines, fridges and motorcycles have also become necessary commodities for them. In table 7, we can find that in Panbin and Naban almost every household have motorcycle, cell phone, TV set. They have also hanged their houses from the traditional style with wood and grass to the modern style with concrete. Nowadays they seldom build their houses themselves and they prefer to invite external professionals to do it. From the consumption pattern we can find that the local households are experiencing a transition from self-sufficiency to market dependence.

Table 7. The status of fixed consumption in targeting villages (Unit: Number).

Village	Motorcycle	Telephone	Cell phone	TV	Refrige	Household
Naban	45	35	43	42	30	42
Pabin	34	24	40	38	15	38
Danuoyou	45	12	25	60	20	92

Source: local statistical data

Market dependence also means higher market risk. Selling rubber for income has become the main source of income for local households. The market fluctuations are the biggest risk for rubber planting. The price of rubber will fluctuate with the international market. The local farmers told me that the rubber trees were being renewed in Southeast Asia. The supply of original dry rubber in the international rubber market had reduced making the price rise in the coming future, so they thought they would not suffer any market risks in the coming years. However, this situation has changed in the end of 2008 due to the global financial crisis. From the end of 2008 the price of dry rubber declined fast. The market risk has become the main risk for local farmers' livelihood development.

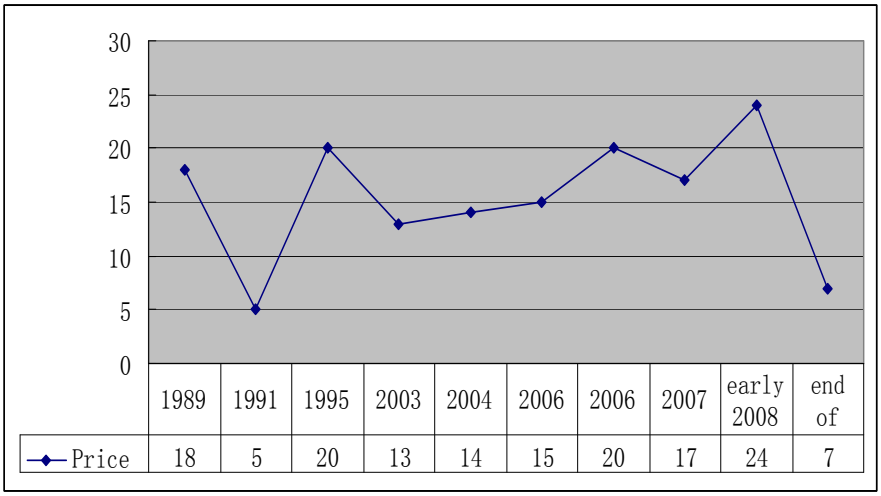

Figure 1. The changing curve of the dry rubber price in the NNNR (Unit: yuan/kg)

Source: key informant interview

A New social phenomenon-- land renting and hiring labour

With the high economic profit even outsiders from the village can hope to share in the benefits of the rubber plantation. Renting land for rubber planting has become very popular in the research villages. Because of its large scale of sloping land about 19 households contracted their land to others and earned the resulting rent in Pabin, and about 40 households rented land to others in Danuoyou. The renters signed the formal renting contract with the holders of the land-use right with the

approval of the village committee. According to the detailed information in the contracts kept in the committee office of Pabin village, the characteristics of the land renting can be summarized. Firstly, the identities of the land renters are diverse. The land renters included the local officials, formal workers in local sectors, farmers in villages, neighbouring villages and from outside of Jinghong county, workers in state-owned farms, businessmen and so on. Secondly, two kinds of mechanisms of benefit sharing were adopted by renters and holders. One way is that renters pay the total renting fee to the holder in one go, and then get to keep all the profits during the duration of the contract . The other way is that the renters and holders share the profits of the output without a renting fee. Thirdly, the duration of land renting is usually between 25 and 30 years, which matches the growth age of rubber and the legal duration of the land-use right. Fourthly the size of the land rented was limited and ranged from several mu to 50 mu, because of the investment capacity of renters and the size of the holders' contracting land. The interviews with some land holders showed that lack of funds and labour were the dominant reasons to rent land to others. To some extent if bio-diversity and environmental sustainability are not considered, the land-transfer permission promoted land-use efficiency in the NNNR.

As discussed in previous parts, rubber cultivation is a labour-extensive production. Some households who plant a large scale of rubber have to hire some waged workers. The households who have planted rubber on a large scale of land and the renters who contracted the land for rubber in the NNNR, need to hire some waged workers to help them to tend the rubber. Most of the waged workers come from other villages, in which there are not many land resources, and outside of the NNNR, from other poor counties in Yunnan province, Hunan province and Guizhou Province. Hybrid rice and hemp also need more field management input.

Impacts on social changes

What's more the adoption of innovation also induced a harsh social change in the NNNR. Firstly the traditional religious ceremonies are affected by the rubber plantations. For example, Dai people are commonly Hinayana Buddhists, but they also worship nature in the form of keeping "holy hills" with holy forests on it. It has been reported that sometimes the only "protected" and undisturbed vegetation in Dai villages could be found on such holy hills (Xu Jianchu, 2006). However, this situation has changed over the years since the villagers have been cutting more and more of the holy trees in favour of planting rubber trees instead.

Secondly the social differences have increased. Rubber cultivation needs much investment because of fertilizers, pesticide and seedling input. The different households in the village cannot afford the same costs. The richer can pay more and can cultivate more rubber, thus getting even more and becoming much richer. The poor cannot pay as much as the richer villagers. In the land renting contracts, most land holders who rent the land do so because of lack of investment. The speed in adopting rubber cultivation is also a key factor which impacts upon the benefits. The ones who adopted rubber planting earlier have got more economic benefits. For example Mandian village is now the richest because it was the earliest to plant rubber, and Danuoyou village is poorest because it was the latest to plant it. As a result the economic inequality increased.

Thirdly the diameter of social activities has expanded. In traditional times the villagers enjoyed self-sufficient lives and they did not need to have exchanges with outsiders. The main social networks were at the community level, based on blood, relatives and geographical relationships. But now the situation has changed. Rubber is absolutely an external variety for local farmers and their indigenous knowledge system cannot support its cultivation. They have to connect with outsiders like the research sector, the government and the market sector in order to get new technology and information.

Impacts on the environment

If compared to the humid tropics and alluvial plains in the Amazon Basin and SE-Asia, Xishuangbanna's rubber plantations are mostly located in subtropical mountainous regions, in which a relatively low temperature can be found and poor soil fertility is prevalent. If rubber is grown in such a marginal biophysical environment, more labor inputs are needed, for example for weeding, terracing of the soil, erosion control and soil fertility management (Xu Jianchu, 2006).The increase of rubber planting in the NNNR induced negative impacts on the environment. With the huge economic profit in the NNNR most of the rotational land was transferred from forests, dry maize, dry paddies, fruit and tea to rubber. So the biodiversity in the NNNR decreased because of the mono-agriculture replacing multi-agriculture. The size of the natural rain forest, the varieties of plants and the species of wild animals declined fast. In addition the use of fertilizer and pesticide also increases the risk of agricultural pollution.

The most dramatic change in recent years reported by the farmers is the change in the water resources of households in the area, especially the drop of the groundwater level and the reduction of the winter mist or fog. The local climate records show that the average fog days in winter were reduced from 115, 128 and 159 in the 1970s to 30, 97 and 98 in 2005 respectively in Jinghong, Menghai and Mengla (Zhoulei, 2008). Rubber trees are known as huge water consumers, and they are even considered by the locals to be so-called "water pumps": the trees suck up the water. Since the rubber plantations are not as densely cultivated as a natural rain forest, more water is 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 as a consequence, less water can evaporate. And further, there is a reduction of the stream flows, and dwells and rivers are likely to dry out (Qiu J, 2009). Some villagers talked about the landslides during the rainy season taking place much more frequently than in the past, and also claim that the water in the rivers has become less and less. Some water sources have also been polluted. For example in Pabin the people used to get water from the river near the village, but now they must construct a pipe-water system to get water from the peak of the mountains.

Conclusion

Under the drive of economic development, the local government took measures to introduce some new planting varieties such as rubber for cash income in the 1980s via the formal and informal agricultural extension system. The new varieties adoption in the NNNR changed the farming system, land relations, household economy and social life as well as some institutions.

Before rubber was introduced to the NNNR local farmers cultivated dry maize and rice on the sloping land and the cultivation model was slashing and burning. They never used fertilizers, pesticide and herbicide. Their harvest depended on the weather. Now they plant rubber to substitute the local maize and rice. In the NNNR it is now very difficult to find sloping land with the local traditional cultivation varieties. Rubber plays a very important role for local development. Firstly, rubber is the main driver of economic development in the NNNR and has become the main cash income source. Secondly, the introduction of rubber has resulted in a complete change in the daily routine of the people and the seasonal calendar of the farmers. These changes have not only influenced their agricultural activities, but also their everyday lives and behaviors. Thirdly, the landscape, including various environmental conditions, has changed tremendously. The development of the NNNR confronts the challenge of how to balance the relationship between environmental balance, biodiversity and livelihood development.

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