Situational Analysis Report: Xishuangbanna Autonomous Dai Prefecture Yunnan, China

CGIAR RESEARCH PROGRAM ON Integrated Systems for the Humid Tropics

World Agroforestry Centre Working Paper

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Photos: James Hammond, Zhuangfang Yi, Benjamin Custer, Timothy McLellan and Jiawen Zhao.

About the authors

James Hammond works on integrative approaches to solve environmental problems. He holds a bachelor's degree in anthropology and a master of science in environmental sustainability. He is currently a PhD candidate developing new approaches towards collaborative design of agricultural development innovations. His current research focus is on Xishuangbanna using participatory and descriptive research methods to better understand the context in which innovations may be adopted; and also in Guatemala using a similar set of methods to approach a different set of problems.

Zhuangfang Yi is a member of the Xishuangbanna ethnic minority. She obtained her PhD studying market-based incentive schemes for the promotion of eco-friendly rubber in Xishuangbanna. As a research fellow at ICRAF, Dr Yi has published several peer-reviewed journal articles, reports and a book chapter in varying research fields, including environmental science, ecology and eco-health. As a consultant of the Green Rubber Leadership Group, she has also helped the Xishuangbanna government to develop their 12th 5-year biodiversity planning (2010-1015). Dr Yi is the first female Dai minority to hold a PhD degree.

Timothy McLellan is a research assistant at the World Agroforestry Centre's East and Central Asia Office. Tim holds a bachelor's degree in law and Chinese from The School of Oriental and African Studies, a master's degree in law and anthropology from the London School of Economics, and is currently a PhD candidate in anthropology at Cornell University. As a member of ICRAF East and Central Asia's soil biology group, Tim is conducting research into mushroom harvesting and forest resource use across Northern Thailand, and Yunnan, including in Xishuangbanna.

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Keywords

Xishuangbanna, China, farming systems, rubber, tea, banana, land use, R4D, rural development.

Acknowledgment

This report was conducted as part of the CGIAR Research Program on Integrated Systems for the Humid Tropics (Humidtropics). Xishuangbanna is one of the sites in which the Program will operate. This is a scoping study to better understand the context in which the Program will work.

Humidtropics is a CGIAR Research Program led by IITA. It seeks to transform the lives of the rural poor in tropical America, Asia and Africa, and uses integrated systems research and unique partnership platforms for impact on poverty and ecosystems integrity. Research organizations involved in core partnership with Humidtropics are AVRDC, Bioversity International, CIAT, CIP, FARA, icipe, ICRAF, IITA, ILRI, IWMI, and WUR. http://humidtropics.cgiar.org.

CGIAR is a global agricultural research partnership for a food secure future. Its science is carried out by the 15 research centres who are members of the CGIAR Consortium in collaboration with hundreds of partner organizations. http://www.cgiar.org.

Abstract

This report summarizes the situation of rural development, agriculture and environment as it is perceived by expert opinion and literature evidence, as of 2014/2015. It is written as part of the CGIAR Research Program on Integrated Systems for the Humid Tropics (Humidtropics; http://humidtropics.cgiar.org/), which takes an integrated systems approach to transform the lives of the rural poor, in the humid tropical parts of the world.

Xishuangbanna, Yunnan, southwest China, is a small area of land (20,000 km^2) which historically had extremely high cultural and biological diversity, and is one of only two places in China which are considered to have a tropical climate. The region is renowned for producing high quality tea, but it is the rubber boom that has caused the greatest impacts on the landscape and economy of Xishuangbanna. Rubber has been planted since 1955, but during the late 1990s rubber prices boomed and small holder farmers rapidly planted increasing amounts of rubber. Now almost all natural forests of the lowlands (altitude 500-700m) and more than half of the mid-elevation land (700-900m) is planted with rubber. Land at higher elevations still supports mostly forest cover, tea and other farming systems, but rubber has encroached in recent years, despite expert doubts about the yield potential.

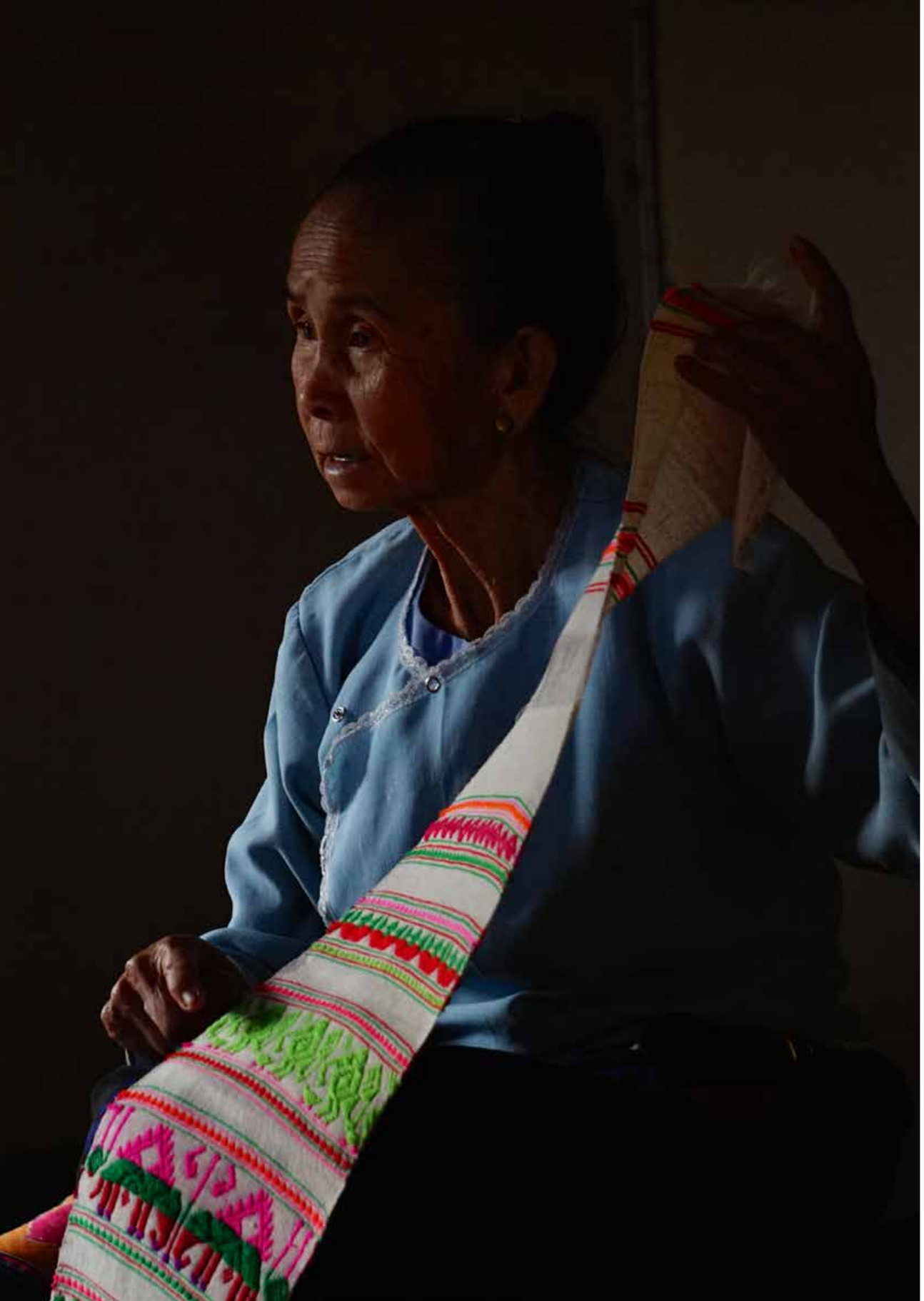
The environmental impacts have been high, although not well quantified by academic literature. Habitat loss and biodiversity loss are obvious, and there are numerous reports of reduced water availability, increasing water pollution, soil hardening in some of the older plantations, and generally declining soil fertility (probably due to erosion and excessive agrochemical use). The economic impacts have also been great, with those farmers who manage successful rubber plantations making unprecedented profits for this region.

In recent years (since 2012) the price of rubber has crashed to about 50% of its peak value. This has led many farmers to question whether or not they should continue with rubber as their main crop; although for now most farmers have chosen to wait and see if prices rise again. The other major popular cash crop is banana, which requires greater upfront investment, offers greater profits and causes even greater environmental impacts.

The institutional context is in some ways very strong, but there are some crucial gaps which hamper progress. There are some excellent agricultural research facilities and groups operating in the region, and the government departments are well funded. There is also a well-functioning market system for major crops and companies can access most areas. The governmental style of leadership has moved on from ‘command and control’ towards individual decision making by every small holder. However, the communication between small holders and ‘experts’ is still unidirectional and sporadic. There is a vital disconnect between those with the knowledge and power to implement changes and those who manage the land through their small holdings.

Generally, the living conditions and quality of life are better than average for rural people of the Mekong region. The average income for a rural person in Xishuangbanna is approximately $1,100 usd per year. However, there is great variation between the wealthiest areas ($3,000 per person per year) and the poorest areas ($600 per person per year). The people living at the high elevations tend to be poorer and less educated, and in some cases practice more mixed and traditional farming systems.

The main challenges faced in Xishuangbanna at present are how to convince the large number of small holders to manage their rubber plantations for reduced environmental impact; how to cope with the rubber price crash; and how to aid the development of those peoples living in the higher elevations without further compromising ecosystem services.



Contents

Executive Summary of the Xishuangbanna Situational Analysis Report

The objective of this situational analysis report is to identify the most pressing issues on which the CGIAR Research Program "Integrated Systems for the Humid Tropics" in Xishuangbanna should begin to work. Using the below entry themes as starting points, a research for development (R4D) platform has prioritized and further developed some themes. This is the summary of findings from the full situational analysis report.

Entry Themes

Rubber and other Plantations

1. Rubber is fast expanding into high altitude areas where profits are low and the impact on ecosystem services (water catchments, soil erosion, forest loss) may be high. How can we simultaneously improve living standards, and protect biodiversity? How can we slow rubber expansion into new high altitude areas, and reduce the impact of existing plantations?

2. Low and mid-elevation rubber is already well established and gives high profits. What mechanisms could incentivize and encourage more sustainable management of rubber for ecosystem service benefits (such as clean water and biodiversity)?

3. Expansion of new plantation crops such as banana or coffee can lead to unregulated forest loss and damage to ecosystem services.

Unequal Economic Benefits

4. Those who own lowland rubber plantations are wealthier and have more opportunities than those who live further up the valley sides or on the hill tops. This has come at the expense of much loss of forest. However, those who live higher up and have mostly kept forests which sustain services such as naturally regulated water flow throughout the year, and biodiversity preservation. How can this balance be made more equitable, so that the up-landers receive fair reward for maintaining ecosystem services?

5. Some ethnic groups seem to be considerably poorer than others: we identified the Bulang and the Aini as groups who may benefit particularly from assistance schemes. These groups may also be able to advise on traditional integrated agricultural methods.

6. There are some problems which have come with the economic benefits of rubber to the lowland peoples – most notably lack of interest in youth education and the risks that a rubber price crash would leave few options for alternative incomes.

Alternatives to Plantation Expansions

7. Using crops and tree species which are high value, contribute to more diverse agricultural systems and benefit ecosystems. Intercropping techniques and new varieties can draw on traditional knowledge and the new niche crops investigated by the Bio-Industrial Office and Tropical Crops Research Institute.

8. Developing eco-compensation schemes. What is the potential of payment for ecosystem services to incentivise changes in land management? Payments could be for carbon sequestration, water catchment management, biodiversity protection, and reducing chemical pollution

9. Tourism is a major element of the economy in Xishuangbanna. Can eco-tourism be developed to spread benefits amongst land managers (such as small holders, nature reserves or forest managers) in order to encourage sustainable management?

10. Enhance capacity for local processing of crops into value added products – for example roasting coffee before sale.

Constraints

11. Knowledge transfer mechanisms from experts to farmers are weak. Can we improve knowledge transfer systems using the government extension services (who have widespread coverage) or partnerships with contract farming companies (who have expertise but not geographic coverage)?

Blind Spots for Further Investigation

1. Lack of verified information and official data on water pollution.

2. Lack of high quality data on the overuse of fertilisers and pesticides

3. Illegal wildlife trade – mainly for meat and medicine. Wildlife is both hunted locally and imported from neighbouring countries (Laos, Myanmar).

4. The timber trade from Myanmar and Laos is reported to be a route for illegally or unsustainably logged timber to enter the Chinese market. As deforestation increases in Laos and Myanmar, there are reports of large wildlife (tigers, elephants) being driven into Xishuangbanna.

5. This report lacks detailed information on livelihoods, ethnicity or agricultural practices in Menghai. We drew many of our findings from a household survey which did not cover Menghai County.

6. Border trade and interactions with neighbouring countries.

Introduction to Xishuangbanna

The Autonomous Dai Prefecture of Xishuangbanna is a little piece of tropical South East Asia in China. It is mainly populated by ethnic minorities, the architecture is reminiscent of northern Thailand or Laos, the climate is monsoon tropical, and palm trees line the city streets. Xishuangbanna is at the northern extremity of the tropical latitudes, and therefore is not as consistently warm as many other tropical places.

It is situated in the extreme south west of Yunnan Province, shares borders with Myanmar, Laos and Vietnam, and the Mekong River runs through it to Thailand. The land is mostly steep and mountainous, with flat valleys at lower altitude covering approximately 20% of the land area.

The prefecture is divided into three counties: Jinghong County, Mengla County and Menghai County. The prefecture's capital is Jinghong City.

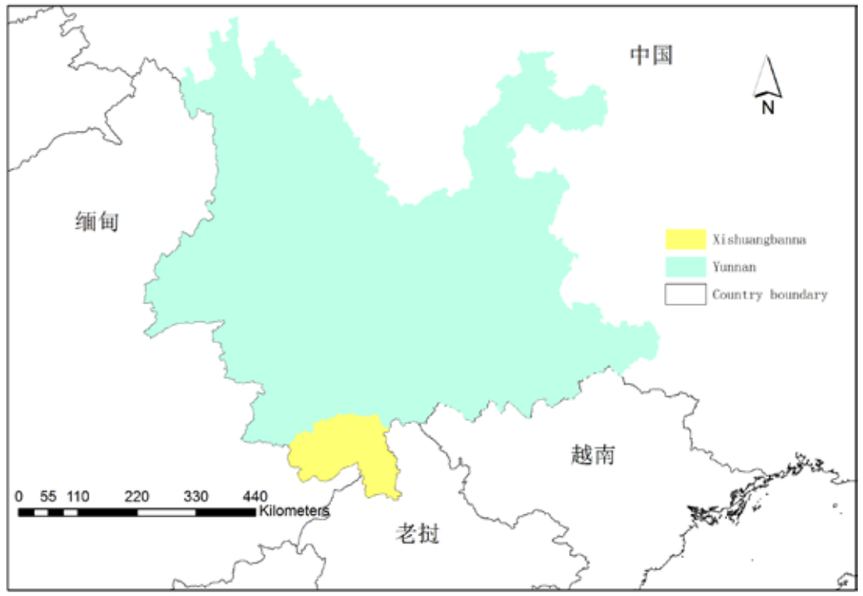


Figure I. Location of Xishuangbanna in Yunnan, and location of Yunnan in China (top right).

Development Overview

- Xishuangbanna is a mountainous region, and **elevation has a major stratification effect** on many factors, including: land use, income and livelihoods, ethnicity, and natural resources (forest, water, biodiversity).

- There is a great **cultural diversity**, with more than 8 major ethnic groups, and many more less populous ethnic groups and subgroups.

- **Traditionally, intercropping of many local varieties was common,** and agriculture was diverse and within a crop-forest landscape. Today, that type of practice is much less common and mono-crops are the major land use in low and mid-elevation areas. Nevertheless, most households still raise a variety of crops in addition to their primary cash crop. From analysis of survey data it appears that the **Bulang people maintain the most diverse agricultural practices today**.

- **Jinghong and Mengla counties contain most of the lowland rubber plantations**; Jinghong has more tea at higher elevation, and Mengla has more forest and nature reserves. Menghai County is different: the valleys are higher and the climate does not permit rubber, instead the major crops are rice, vegetables and sugar cane. **Menghai is more forested** than the other counties. We have more detailed information on Jinghong and Mengla counties due to a 1000 household survey conducted in 2012

- **Infrastructure is well developed** in all counties: more than 95% of villages have a road, running piped water and electricity. Access to affordable health care is reported to be very high, and the average life expectancy for the prefecture is 71 years. There is a cultural awareness of nutrition; there is little distinction between medicinal plants and food. One of the typical female roles is to provide the family with good nutrition.

- Education is not so good; depending on the location **20-40% of household heads are illiterate**. Education on average is improving and with the younger generations illiteracy is not common (less than 5% on average). However, amongst the most marginalized ethnic groups household head illiteracy is as high as 80%, and 30% of households have no literate family member. (In our 2012 survey, those recoded as being of 'Other' ethnicity had the poorest literacy. Based on the location in which the data was collected, this group is most likely the Aini minority).

- The vast majority of **women are less well educated** than their male counterparts, although amongst most educated (college and university) females make up a greater proportion than males.

- There are **problems with youth education**: many lowland youth (particularly Dai and Hani) drop out of education after primary school. This is reported to be for two reasons: 1) the Chinese state education system does not accommodate minority languages and cultures; and 2) income from rubber is so high that education seems unnecessary. There are attendant youth problems such as excessive alcohol consumption, drug use and gambling.

- More than **90% of households are engaged with either rubber or tea**, with rubber dominating low and mid elevations, and tea dominating the high elevations. Broken down by ethnicity, Dai, Hani and Bulang are heavily engaged with rubber; and Yi, Han and 'Other' are engaged with tea.

- Although 90% of surveyed **Bulang** households grow rubber, and 93% of the '**Other**' ethnicity grow tea, the **profits of both groups are very low**. This suggests that these groups may be especially receptive to productivity or income enhancing interventions.

- The Dai and Hani are the wealthiest ethnicities, followed by the Han and Yi. The Bulang and 'Other' are the poorest – **over 50% of the Bulang and 'Other' are below the province-defined poverty line.** The medium and high elevations are less wealthy and contain more poverty than the valley floor regions.

- Most households are also engaged in numerous non-cash crop agricultural activities such as rice, vegetables, fruit, livestock and maize. Some households are engaged in timber, forest products, aquaculture, mushrooms and other activities. This shows that **diversified agriculture is still common in Xishuangbanna**, even though it is not the main source of income.

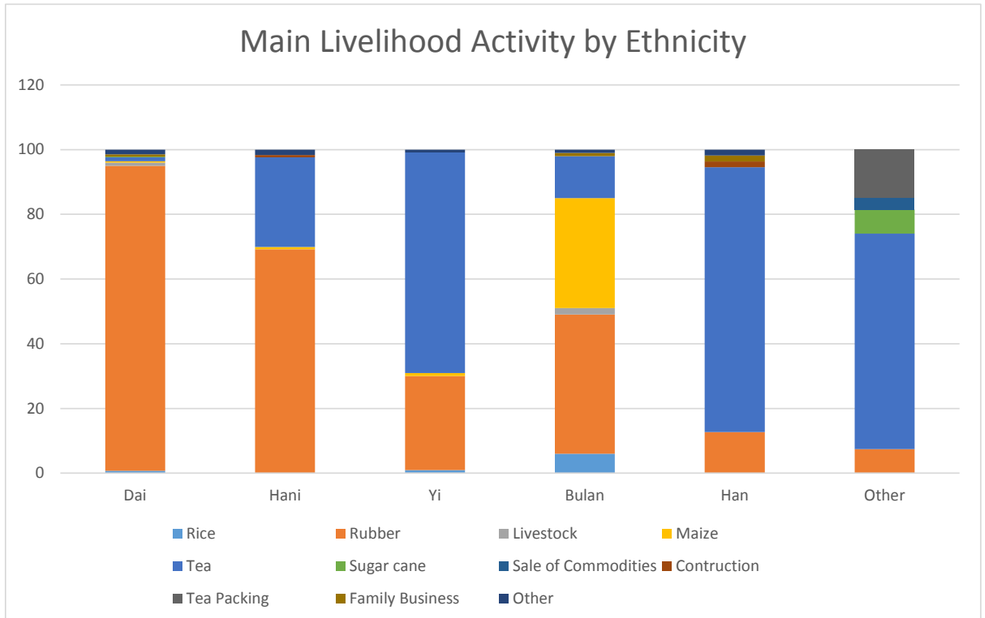


Figure II. Main livelihoods activity by ethnicity as reported in household survey. Source: Mekong futures project 2010.

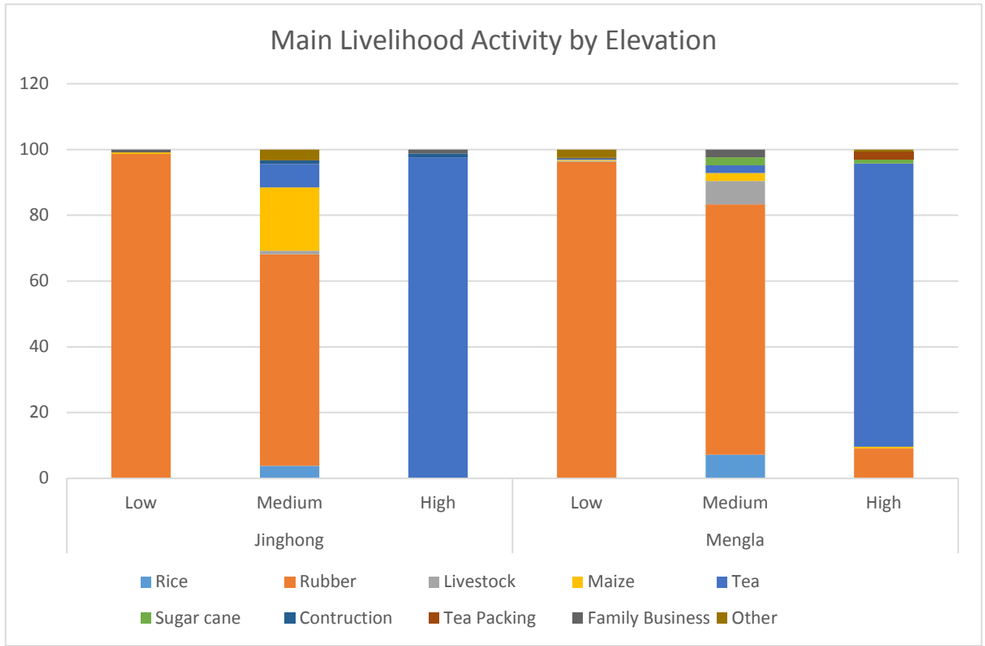


Figure III. Main livelihoods activity by elevation as reported in household survey. Source: Mekong futures project 2010.

- Generally **less than 10% of households work in wage or salary jobs** (including farm labour). The exception is the 'Other' minority, of whom 21% work in farm labour and 21% in tea packing, and who are not well paid. The more profitable jobs are in restaurants and tourism. A small proportion of the 'Other' minority make good money from trading agricultural produce.

Agricultural Production Systems

- The vast majority of **agricultural land is managed by smallholder farmers**. Small holders typically have about 3ha of agricultural land and a similar sized piece of forest land. There are also state managed forest lands, village managed community forest lands, and state managed nature reserves.

- **Rubber plantations dominate Xishuangbanna** in terms of land use and economy. Between 2000 and 2010 there was a **rapid expansion of rubber plantations**. Twenty one percent of all the land in Xishuangbanna is rubber plantation. The lowland valleys of Jinghong and Mengla counties are completely filled with rubber, the mid elevation valley slopes are mainly planted with rubber, and **high elevation rubber plantations have been established in recent years**. The greatest amount of high altitude rubber expansion has occurred in Menghai County.

- Profits from rubber far outstrip other activities (between 2 and 10 times more). Low elevation rubber is the most profitable, mid elevation rubber is less profitable and evidence shows that **high elevation rubber is not profitable**. However, many small holders are establishing high elevation rubber and will not discover the actual yields for seven years after establishment: this is a slow learning cycle and by the time these very low or negative profits become common knowledge, a large amount of high elevation land may already have been converted to rubber.

- **Tea plantations are very important economically**, second only to rubber. They do not take up a large land area however, and are only planted above 900 m. Intercropping of tea is practiced by a significant minority, and works well with many tree species, including timber and rubber.

- The **largest land use by area is still forest**, with 50% of Xishuangbanna covered by forest. Most of this remaining forest is in the upland regions, with lowland forest having been displaced by agriculture. The upland forests are less biodiverse than lowland forests, but provide important water filtering and slow-release services.

- Land use and terrain in Menghai is very different to Jinghong and Mengla counties. The flat valleys of Menghai are at a higher elevation where rubber does not grow well (700-900 m). The landscape in the valleys of Menghai is still well forested, and also supports considerable agricultural production. **A greater proportion of forest has survived in Menghai** than in Jinghong or Mengla.

- **Banana plantations are a recent driver of forest loss**. They have been established in lowland areas in the last 5-7 years, and in upland areas in the past 1-2 years. Expansion is often into illegally cleared forest land.

- Other common commodities exported from Xishuangbanna are sugar cane, coffee, bamboo, timber, and coffee. Locally consumed commodities are rice and vegetables (mainly grown in Menghai), meat, fish and fruit.

- **Mixed farming systems are common,** even though households tend to rely heavily on one or two major cash crops, they usually also raise some staple crops and livestock. Also of interest are a **vast array of indigenous rice species** (over 70), as well as **traditional integrated agricultural systems** such as Hani rice-rattan agroforestry or Dai home gardens.

- The Xishuangbanna Bio-Industrial Crops Office has outlined **plans for niche high value crops**, many of which can be intercropped with forest or other agricultural systems. These are: medicinal plants, orchid, macademia nuts, sacha inchi nuts (*Plukenetia volubilis)*, agar wood, *Vernicia montana*, moringa (drumstick tree). They also advocate expansion of the land area of coffee, fast growing timber, bamboo, hemp and cassava for ethanol; and promote value added products from rubber and tea, such as rubber seed oil and chemical derivatives from tea processing.

- **Agricultural technology is well developed and widely available.** Sixty to seventy percent of households own a small hand-held tractor to use on their farms, although this is lower in the poorest areas. Modern cultivars such as rubber varieties suited to local conditions were developed and were subsidised. Fertilizer and pesticide use has increased steadily over the past 25 years. **Overfertilisation is a common concern.**

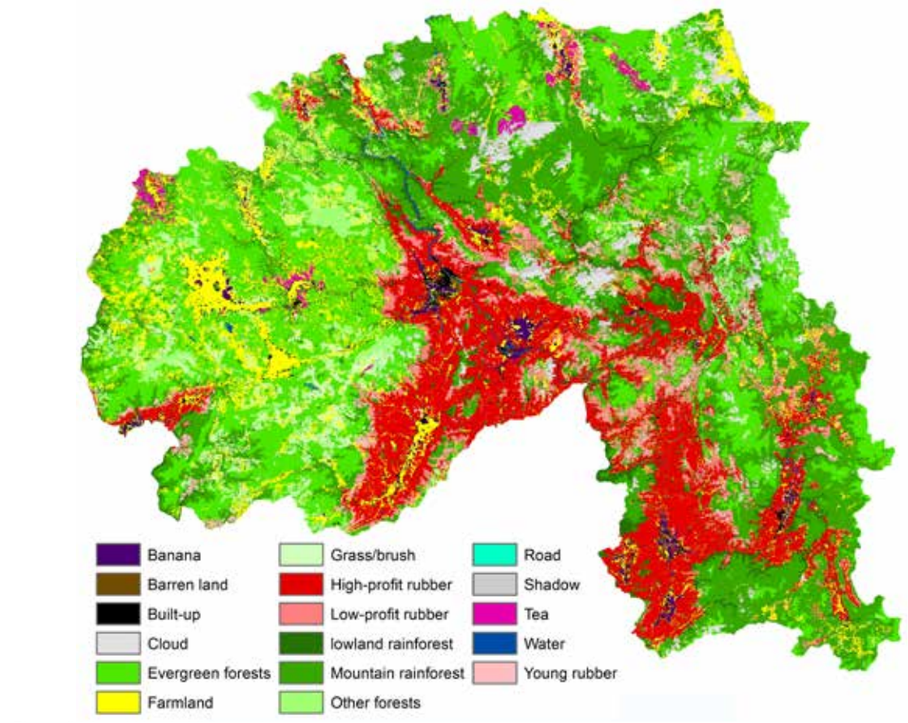


Figure IV. Land Use in Xishuangbanna.

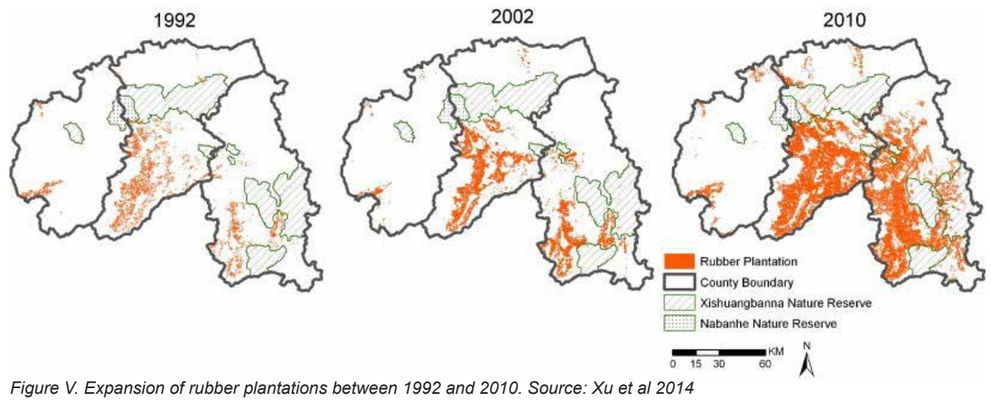


Figure V. Expansion of rubber plantations between 1992 and 2010. Source: Xu et al 2014

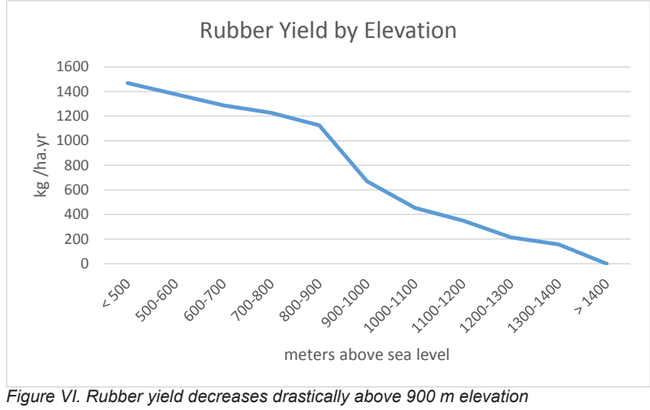


Figure VI. Rubber yield decreases drastically above 900 m elevation

Institutions and Markets

- There are two well organised routes by which land use planning and management are disseminated to land managers: the **government system and the market system**. There are also well established and capable research organisations which provide guidance to both government and market institutions.

- There are **four main classes of land management**. Small holders are generally free to make their own decisions about land management. Community forest land is managed by village leaders. Nature reserves are under the authority of the Xishuangbanna Environmental Protection Office. State Forests are under the authority of the Xishuangbanna Forestry Office.

- The **government system is hierarchically organised** from Province level down to individual villages, with plans made at prefectural level and passed down all the way to village leaders. This works well for instructions and rules, but not well for complex ideas and training. There is also weak enforcement of rules, which means that illegal village-level land use practices (e.g. clearing of forest) may not be reported back to higher levels.

- The **market system has greater influence over farmers**, who respond either to price signals, or to requests and training from the (large scale) buyers of their produce. Newer products are introduced to farmers by companies via a contract farming system.

- For the local government, there is a tension between rapid economic development from rubber and other cash crops and the protection of natural resources. A key stakeholder is the governmental **Bio-Industrial Crops Office, who work with both research and business** organisations in an attempt to balance the demands of economy and environment.

- There is a **state extension service**, which manages Agricultural Technology Stations at the township level. However Station staff are few in number, poorly trained, and can usually only provide advice on the major cash crops. Issues such as over-fertilisation have yet to be resolved, and are not well reported. Recently mass communication by text message has been adopted by the extension services.

- There is **good market penetration** and access in Xishuangbanna, and there are **four main types of value chains** operating in the area. For the main cash crops (rubber, tea, sugar cane) there is small holder production with self-transport to the processing factory of the producer's choice. Banana is informally contracted by outside entrepreneurs who pay upfront costs, sometimes encourage illegal land clearing, and return later to collect produce in large trucks, for direct export. Contract farming systems are in place for emerging niche and high value crop. Produce for local markets (such as rice, vegetables, meat) is either sold directly by farmers to consumers or passes from farmers to individual markets traders to consumers.

- Considerable efforts are being made to **develop environmentally-friendly rubber and tea plantations**. Each has a demonstration area of over 5000 ha, and there are research-government-business coalitions developing techniques. However, questions of landscape level implementation remain unaddressed.

- There is a **disconnection in the knowledge transfer process**: high quality knowledge, techniques and strategy are developed at higher levels, but the mechanisms by which these are passed down to small holders are neither reliable nor quick. The extension services have limited capability and the contract farming companies have a localised effect, only targeting farmers in small areas.

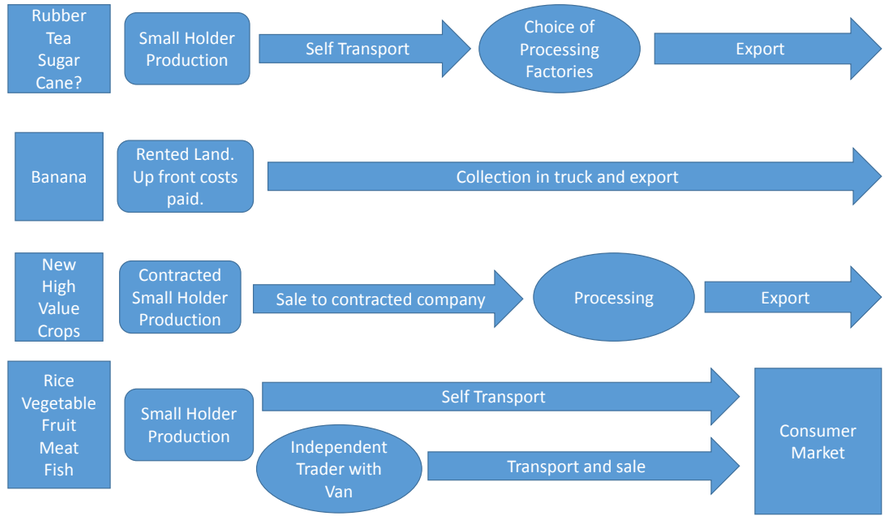


Figure VII. The Four major types of value chains in Xishuangbanna.

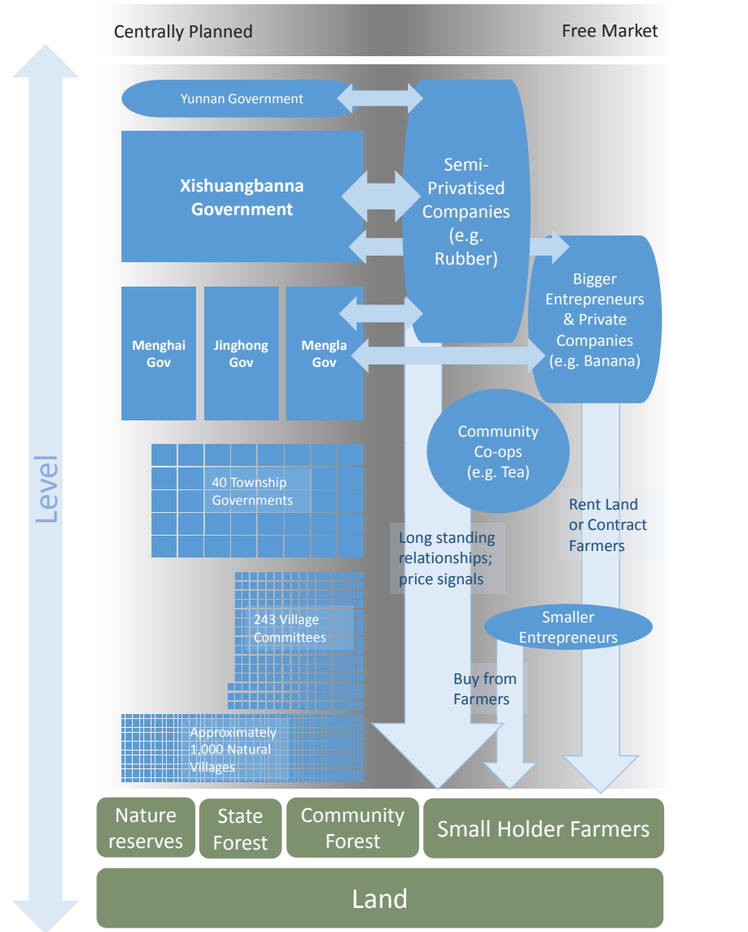


Figure VIII. The Organisation of Government and Market forces which Influence Land Managers

- A law was passed at provincial level (Yunnan level) which **gave powers to the Xishuang-banna government to develop and manage their own eco-compensation programs**. This could be a key part of an incentive scheme to encourage changes in land management on a large scale.

Natural Resources and Environment

- **Biodiversity is the major unique natural asset** of Xishuangbanna, and is in decline. It is the most biodiverse part of China: Xishuangbanna covers only 0.2% of China's land area, but harbors nearly 10% of fish species, 15% of amphibians and reptiles, 16% of plants, 22% of mammals, 36% of birds, found in China. There are also charismatic animals such as elephants and gibbons.

- Xishuangbanna was **originally heavily forested**. Studies of satellite imagery suggest that forest cover in Xishuangbanna shrank from 69% to less than 50% of the landscape; and the important tropical seasonal rainforest shrank from 10.9% to 3.6%. There has also been significant increase in forest fragmentation.

- **Water availability and pollution** are reported to be issues of major concern, but official figures are hard to find. Most local water sources are no longer suitable for drinking.

- The tropical forest landscape contains **large carbon stocks** in the forms of biomass and soil carbon. Carbon stocks are estimated to be in decline due to land conversion.

- Land conversion to **rubber is cited as the major driver** of natural resource decline: clearing of forest drives loss of habitat, and impacts biodiversity (the most biodiverse areas are also the best rubber areas); rubber has high water and initially high fertilizer requirements. However, other crops also drive these processes. Banana in particular is also cited as an emerging risk to ecosystem services.

- **Nature reserves cover 12% of the land area.** A recent (completed in 2011) initiative designed and established connectivity corridors between all nature reserves in the prefecture, although there are questions about the ongoing governance of these corridors.

- There is a well-established tourist industry which showcases both the cultural and bio-diversity. However, **sustainable and equitable tourism is not common in Xishuangbanna** and most profits benefit neither the general population nor conservationist causes.

- A project valued ecosystem services in two study areas covering only 9% of the prefecture land area, and estimated that ecosystem service value at 1.2 billion USD per year. Another study found that carbon prices of 10 USD per ton would be sufficient to incentivize much of the high and mid elevation rubber plantations towards ecological management. Payments for watershed management are another option. **Payments for eco-system services** could provide the additional incentive for more environmentally sound land management.

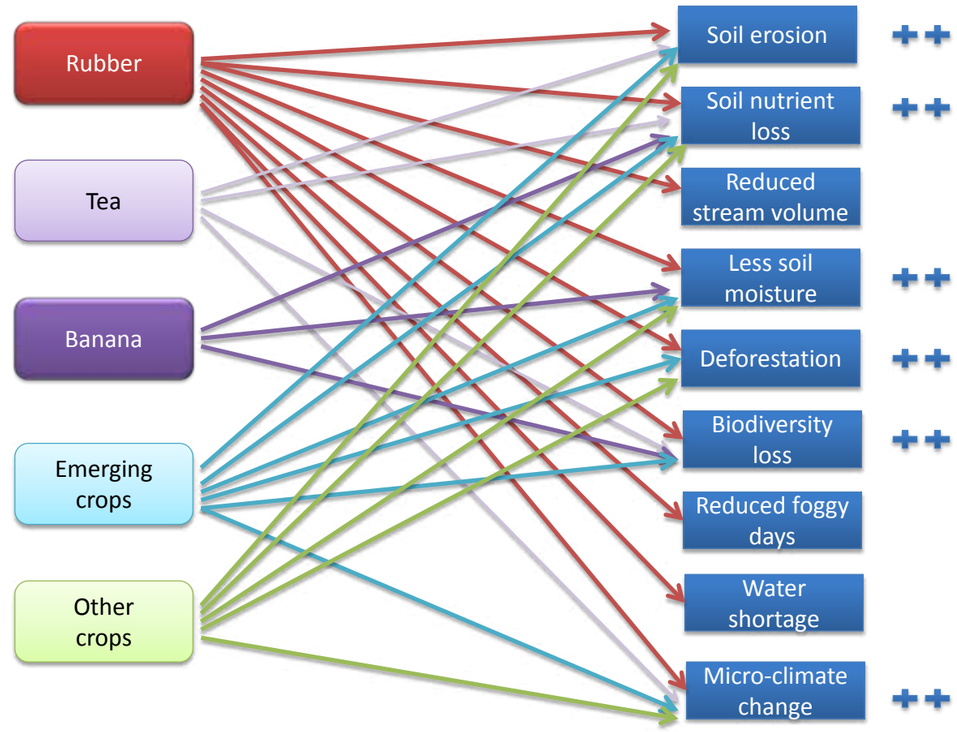


Figure IX. The main agricultural land uses and the environmental impacts they cause.

Introduction

The purpose of this report

This report was conducted as part of Humidtropics[1]. Xishuangbanna is one of the sites in which the Program will operate. This is a scoping study to better understand the context in which the Program will work.

The purpose of this report is to give an overview of the state of social development, agriculture, environment, and institutional organisation. The report is intended to be used as a starting point for planning research for development activities to be undertaken in the target area.

The authors hope that the report can be used by others as a basis for understanding the region and developing integrated, successful development projects.

Location of Xishuangbanna

This situational analysis focuses on a border region in China's Yunnan Province, called Xishuangbanna (pronounced "see-shwang-baa-na"). It is officially classed as an autonomous prefecture (one level below province). Due to the high proportion of non-Han Chinese ethnic groups, the prefecture has 'autonomous' status, meaning it can enjoy a higher degree of decision making power than the normal prefecture. See Figure 1.

1 See: http://humidtropics.cgiar.org/

Xishuangbanna shares borders with Myanmar and Laos, is very close to Vietnamese borders and the Mekong river connects Xishuangbanna to Thailand (see Figure 1). The architecture, local food, religious practices and languages are similar to those in Laos or Northern Thai culture.

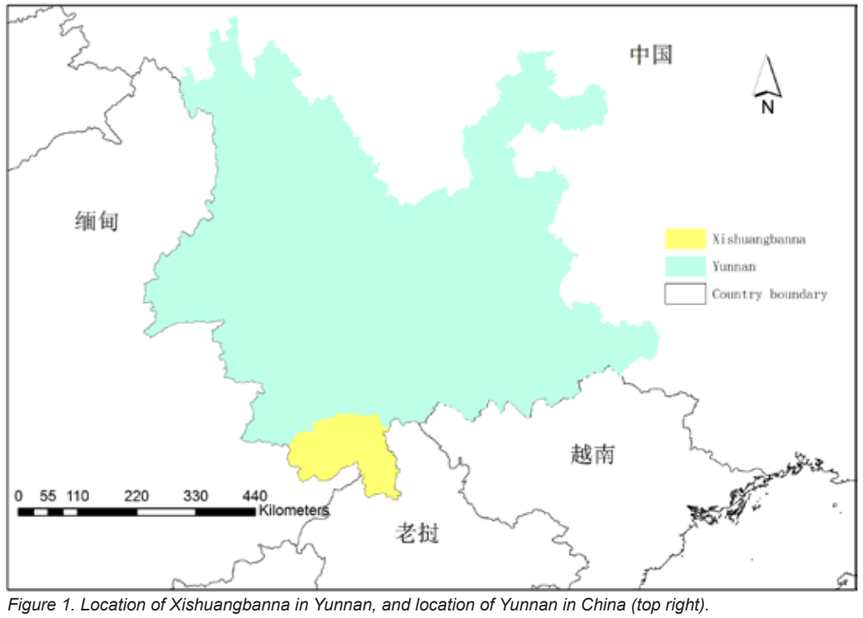


Figure 1. Location of Xishuangbanna in Yunnan, and location of Yunnan in China (top right).

Methodology and Data Sources

This situational analysis report is based on four types of data: literature review, expert interviews, Landsat remote sensing data, and an unpublished household survey.

The literature review drew from academic sources, searched on web of knowledge and google scholar for the key word 'Xishuangbanna'. From Chinese governmental data, the Yunnan and Xishuangbanna Statistical Yearbooks were used (2013 editions). Reports from international research projects were used, and reports (in Chinese language) from government offices were used.

Expert interviews were conducted with research staff in Kunming and in Xishuangbanna research organisations; and with government officers at the Xishuangbanna prefecture level.

Remote sensing data was analysed and land cover maps developed, building on those published elsewhere by one of the authors (e.g. Yi et al. 2014).

A currently unpublished household survey was conducted in the region in 2010, and has been used in this report to inform the socio-economic and livelihood sections of the Development Overview chapter. A total of 1000 households were surveyed from two of the three counties within Xishuangbanna. Whilst the household survey data is very useful, it should be remembered that Menghai County is not represented by that dataset. This survey was conducted by ICRAF East and Central Asia as part of the "Mekong Futures" project, funded by CSIRO, and it is anticipated that this dataset will be made available on the ICRAF data portal (http://thedata.harvard.edu/dvn/dv/icraf) before the end of 2015.

Chapter 1: Development Overview

Introduction to Xishuangbanna

Xishuangbanna is a prefecture in Yunnan province, southwest China. It is the only piece of tropical forest inside China's borders, and the only place where elephants still live in their natural habitat in China. It is well known in China for these two reasons.

Xishuangbanna is divided into three counties: Jinghong County, Mengla County and Menghai County. Jinghong City, in Jinghong County, is the capital of the prefecture and the seat of the local government. The prefecture is mountainous and historically well forested, which made travel difficult. Infrastructure, however, is now well developed. Generally the higher elevations are less well connected, less developed, less wealthy and contain more un-degraded forest habitat.

Jinghong and Mengla counties share a similar distribution of terrain. The lowlands (500-700 m) are in the Southern parts of Jinghong and Mengla counties, and mainly planted with rubber monoculture. The medium elevation land is also mainly planted with rubber. Land above 900 m is traditionally planted with tea; although this is changing more towards rubber, coffee or banana. A substantial portion of these counties is protected as national parks, and there are biodiversity corridor projects attempting to connect protected landscapes.

Menghai province has a different terrain and agricultural profile: there are less lowlands and the main cash crops are sugar cane and hemp. Menghai also produces much of the rice and vegetables which are consumed in Xishuangbanna.

Table 1 and Figure 2 show the land distribution by elevation and by county.

Location	land area km²	km² low elevation (500-700 m)	km² at medium elevation (700-900 m)	km² at high elevation (900-1200 m)	km² at very high elevation (above 1200 m)
Xishuangbanna	19,000	1,956	6,773	5,987	4,493
Jinghong	6,900	997	1,523	2,884	1,634
Menghai	5,300	96	3,513	346	1,416
Mengla	6,800	863	1,737	2,757	1,443

Table 1. Land Area by County and Elevation class

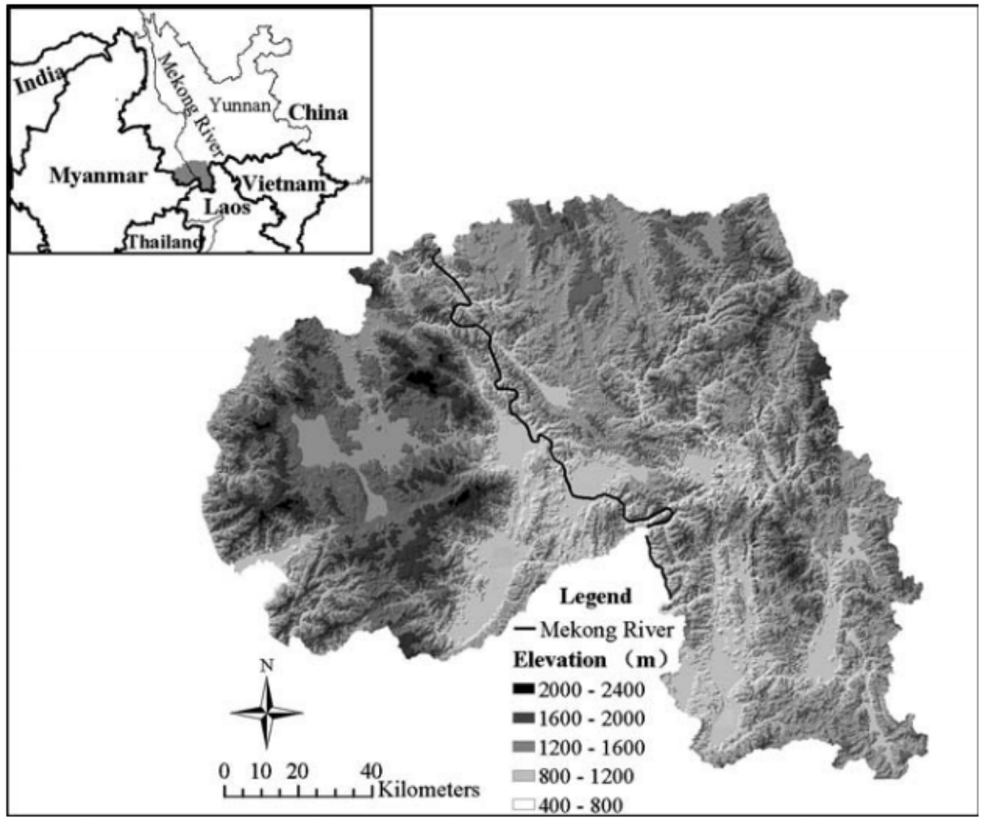


Figure 2. The location and topography of Xishuangbanna Autonomous Prefecture, in the southern part of Yunnan province. Source: Li et al 2007a.

Climate

Xishuangbanna is a tropical region. For most of the year it is hot and moist, and during the monsoon season it rains heavily. There are four bio-climatic zones: warm temperate and moderately moist (high elevations); hot and moderately moist; extremely hot and moderately moist; and extremely hot and moist (low elevations).

The average temperature in Xishuangbanna is 20-22.5 °C, with an average high temperature of 25-27 °C occurring in May-June. Average precipitation is 1200-1800 mm per year and the wet season lasts from May to October during which 90% of the rain falls. See Figure 3.

Climate change projections suggest that Xishuangbanna's climate will become hotter, and wetter, and the extremely hot and moderately moist and extremely hot and moist zones are projected to expand from 34% to almost 75% by 2050. This would dramatically increase the area of Xishuangbanna suitable for rubber (Zomer et al. 2014).

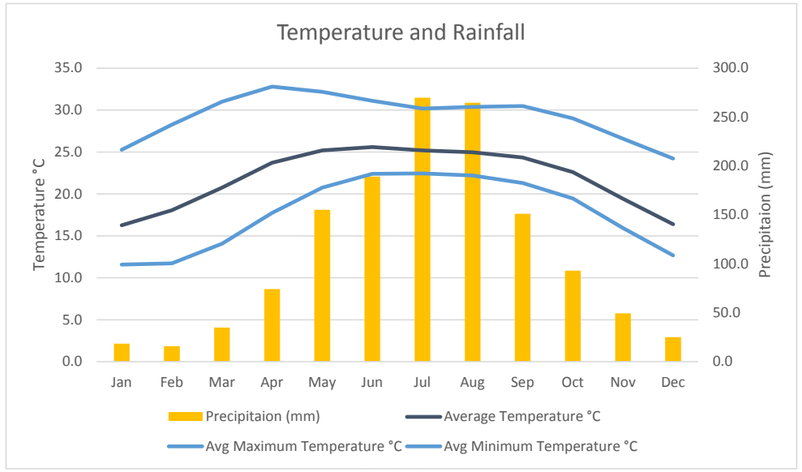


Figure 3: Temperature and Rainfall average 1953-2014. Source: Xishuangbanna Meteorological Bureau.

Infrastructure

Infrastructure is well developed in much of Xishuangbanna. According to government yearbooks (2009) almost all houses have access to piped water, paved roads and electricity (see Table 2). There is also a well-developed market economy for local products and nationally and internationally exported products.

Location	Villages with tap water	Villages with paved road	Villages with telephone
Xishuangbanna	98.6	99.1	97.3
Jinghong	97.6	97.6	92.9
Menghai	98.8	100.0	100.0
Mengla	100.0	100.0	100.0

Table 2: Percentage of villages with access to basic infrastructure. Source Xishuangbanna Statistical Yearbook 2009

Population and Ethnic Groups

Over one million people live in Xishuangbanna, of whom 70% live in rural areas and generate income primarily from agriculture. Households have on average 4.3 people, although low elevation households tend to be larger: the lowland household average is 4.5, midland 4.2 and highland 4.1 persons. The average range of household size is 3-5 members. There is a slight skew towards males in the population.

Location	Total Population	Population Density (per km²)	Average household size	M:F ratio	% Agricultural Population	% Non-Agricultural Population
Xishuangbanna	1,149,000	58.4	4.2	1.1	70.0	30.0
Jinghong	527,200	76.4	4.3	1.1	61.9	38.1
Menghai	336,300	63.5	4.2	1.1	83.9	16.1
Mengla	285,500	42.0	4.1	1.1	68.6	31.4

Table 3: Population Data for Xishuangbanna. Source: Yunnan Statistical Yearbooks 2013.

Within China, Xishuangbanna is one of the richest regions both culturally and biologically. The population of approximately 1.1 million encompasses 13 distinct ethnic minorities whose traditional land-use systems play a crucial role in maintaining the region's outstanding biodiversity (Xu et al., 2009). The Dai people are the most populous group in Xishuangbanna, followed by the Han, and the Hani. These three groups combined constitute 71% of Xishuangbanna's population, with the remaining 29% consisting primarily of Yi, Lahu, Bulang, Aini (a sub-group of Hani), Yao and Jinuo peoples. In the Mekong Futures data, on which much of the analysis in this report is based, the Lahu, Yao and Jinuo are combined into one ethnic category labelled 'Other'. This category frequently is the least prosperous, suggesting that these 'other' ethnic groups are more marginalized. Below is a brief overview of some of Xishuangbanna's larger ethnic groups.

Location	% Dai	% Han	% Hani	% Yi	% Lahu	% Bulang	% Yao	% Jinuo
Xishuangbanna	27.9	24.3	19.0	5.9	5.4	4.2	2.0	2.0
Jinghong	34.7	29.8	17.6	4.7	0.3	2.1	0.5	0.6
Menghai	38.7	12.6	20.9	2.1	13.1	10.8	0.0	0.0
Mengla	20.7	29.8	24.3	9.9	1.0	1.0	6.7	0.5

Table 4. Percentage of ethnic group in Xishuangbanna, by county. Source: Xishuangbanna Statistical Yearbook 2012

County	Elevation	% Dai	% Hani	% Yi	% Bulan	% Han	% Other	Total in survey
Jinghong	Low	63.6	26.4		9.1	0.5	0.5	220
	Medium		45.1	10.4	44.0		0.5	182
	High		95.2			4.8		84
Mengla	Low	73.4	23.8	0.6		2.2		320
	Medium	100.0						42
	High	3.0	1.8	53.6		25.9	15.1	166
Total in Survey		422	299	110	100	55	27	1014

Table 5. Percentage of ethnic group at each elevation, in Jinghong and Mengla. Source: Mekong Futures Survey 2010.

The Dai

The Dai of Xishuangbanna (Tai Lue) have close historical and contemporary connections with similar lowland groups in Laos, Burma and Northern Thailand (Cohen 2000; Davis 2003). Prior to the 1980s, Dai peoples primarily cultivated semi-aquatic rice and winter vegetables for local consumption. Due to their tradition of sedentary agriculture, feudal political system, and rich tradition of written language, contemporary and Imperial Chinese governments have sometimes considered the Dai to be more "advanced" than other non-Han, ethnic minorities.

The Han

The Han are the largest of China's ethnic groups, constituting more than 90% of China's population. Though some Han households have lived in Xishuangbanna for many generations, many – especially in Jinghong City – are recent migrants. Whereas in 1950 Xishuangbanna's Han population numbered just 5,000 Han, the Han population is now just under 300,000, almost a third of Xishuangbanna's total population (McCarthy 2009).

The Hani

The Hani (Akha) occupy very similar regions to the Dai. Like the Dai, they are present not only in Yunnan's Xishuangbanna, but also across the border in Burma, Thailand and Laos. According to local

customary laws, the lands cultivated by Hani peoples have often belonged to neighbouring Dai elites. Hani farmers were therefore expected to pay tax to Dai headmen in the form of goods such as rattan or wild game (Xu 2005). Even today, Dai paddy fields in Xishuangbanna often rely on the labour of upland Hani peoples (Coward 2006). Like the Dai, Hani livelihoods are today heavily dominated by rubber production.

The Bulang

The Bulang have long been known for cultivating tea. The Bulang, like other upland tea farming communities, traditionally cultivated tea beneath the canopy of primary forests. Traditional Bulang agroforestry systems, like those of many upland groups, are highly complex, incorporate a vast variety of crops, and are closely tied to elaborate ritual cycles (Yin 2001).

Traditional Land Management

Historically, the indigenous peoples of Xishuangbanna nurtured and sustained diverse landscapes through diverse agricultural crops and practices. Many studies have focused on how these different groups evolved enduring land-use systems from paddy rice to shifting cultivation and ancient tea agroforestry (Liu et al. 2002; Pei 1985; Xu et al. 2009). Xishuangbanna peoples also have long traditions of managing forest margins in agroforestry systems that integrate secondary successional vegetation with a diversity of native ecosystems. The religions of Dai and Hani ethnic groups, for example, have shaped the management of 'holy hills' – sacred forests in which ancestor spirits dwell. These various agro-ecosystems have served as valuable wildlife habitat as well as provided for ecological functions including gene flow, nutrient cycling and hydrological processes.

Many of these traditional agricultural and ecological practices have given way to modern cash crops and monocrops. This transformation of the spiritual landscape has deeply affected ethnic minority cultures (Reuse 2010; Sturgeon 2013). As well as their intrinsic value and their potential to provide ecosystem services; traditional cultural, ecological, and agricultural practices have the potential to generate income through ethno- and eco-tourism.

Gender and Youth

Women play a very important role on family livelihood and nutrition improvement across ethnicities and landscape in Xishuangbanna. Women are ordinarily less well educated than men, and very rarely take up off-farm employment. This pattern does, however, change beyond high school level education. Of the minority educated beyond high school, women make up a greater proportion. (See Table 6.) Female headed households are uncommon. Out of 1014 surveyed households (in the Mekong Futures Survey), only 41 reported to be headed by a female. Since rubber monoculture and tea cultivation became the major income sources, women have provided most of the labour force for tapping rubber latex, and picking tea. Taking care of elderly and young family members, and farm work are the primary daily responsibilities of most women in Xishuangbanna. Women are therefore the key decision makers with regards to livelihood and nutrition improvement for their families.

Village boys traditionally became monks and received a Buddhist education. However, with household income increasing from rubber and tea markets, Han-Chinese school has become the dominant education pathway for village children. Linguistic and cultural barriers between ethnic children and Han Chinese teachers, however, reduce the enthusiasm of many students. Improvements in household income and the promise of future income from rubber have, moreover, dampened motivation for higher education. These factors have contributed to the emergence of high dropout rates in schools, excessive alcohol and narcotics consumption, and gambling. These are the major social issues for youth in Xishuangbanna.

Education

Xishuangbanna operates nine years of compulsory education for all children. However, in practice this is not always achieved. According to the government statistics, between 80 and 100% of under-sixteens have some education. This implies an improving trend in education levels across the general population. Of the adult population, about 40% have only primary education, and 25% have junior high school. There are more illiterate people than there are senior high school graduates.

Elevation	Gender	Illiterate	Primary	Basic Secondary	High school	College	University
Low	M	18.7	44.1	29.4	5.9	1.3	0.5
	F	27.1	41.1	23.4	5.5	2.0	0.8
Medium	M	20.5	50.2	24.9	3.6	0.8	0.0
	F	33.9	36.3	22.4	5.4	1.7	0.2
High	M	15.0	34.6	37.3	10.2	2.7	0.2
	F	25.2	30.6	30.6	8.4	4.2	1.0

Table 6. Percentage of the population who have achieved a highest education level, disaggregated by gender. Source: Mekong Futures Survey 2010 (for this table only, n=4384)

A comparison of the educational achievement of the household head and the most highly educated household member suggests that the highest educational achievement within the household is usually one level up from the household head's (Tables 8 and 9). This again implies an improving trend in education at all elevations.

	% with any education	primary school	junior high school	senior high school	% illiterate < 16 year olds	% illiterate adults	% illiterate female	% illiterate male
Xishuangbanna[1]		43	25	7	0	11	17	9
Jinghong[22]	100	37	28	9		10	16	9
Menghai[3]	81				6	9	15	8
Mengla[4]		41	25	7		13	22	11

Table 7. Education rates amongst the general population of Xishuangbanna. Sources: Government data (see footnotes).

Even so, a considerable proportion of household heads are illiterate. This should be considered when developing extension or training materials. The highest illiteracy rates are found in the low and medium elevations in Mengla. The lowest average educational achievements are also found at the medium and low elevations of Mengla.

Education achievement by ethnic groups can also be analysed. The 'Other' category is by far the least educated, with a household head illiteracy of 81 percent. Although rapid improvements have been made, 30 percent of 'Other' ethnicity households still lack a literate family member. The Bulang group also show a low educational profile compared to other groups.

The Dai people have a surprisingly low education rate when compared to the Han, Yi and Hani peoples. This corresponds to anecdotal evidence that a high proportion of Dai people leave education early to focus on rubber farming, which is relatively lucrative.

When household head education level and highest education level in the household is compared, again the trend is of improvement. It appears that the next generation achieves one level higher than the previous. However, the rate of college or university education is still low.

		Illiterate	Primary	Basic Secondary	High school	College
Jinghong	Low	23	62	13	1	1
	Medium	24	57	16	2	1
	High	14	52	24	7	2
Mengla	Low	30	52	17	1	1
	Medium	40	57		2	
	High	19	38	36	7	1
All Locations		25	53	19	3	1

Table 8. Percentage of households with household head's highest educational achievement, by elevation and county. Source: Mekong Futures Survey (2010).

		Illiterate	Primary	Basic Secondary	High school	College	University
Jinghong	Low		16	62	15	5	3
	Medium	1	30	49	15	4	
	High		13	61	19	7	
Mengla	Low	1	23	46	19	8	3
	Medium	5	48	33	10	2	2
	High	5	10	43	27	11	3
All locations		2	21	50	18	7	2

Table 9. Percentage of households with a member's highest educational achievement, by elevation and county. Source: Mekong Futures Survey (2010).

	Illiterate	Primary	Basic Secondary	High school	College
Dai	28	61	9	1	1
Hani	26	45	23	4	1
Yi	4	50	39	6	1
Bulang	23	63	13	1	
Han	13	42	38	5	2
Other	81	7	11		
All Groups	25	53	19	3	1

Table 10. Percentage of households with household head's highest educational achievement, by ethnicity. Source: Mekong Futures Survey (2010).

	Illiterate	Primary	Basic Secondary	High school	College	University
Dai	1	25	49	15	7	2
Hani	0	12	56	23	7	2
Yi		11	49	28	9	3
Bulang	2	43	51	3	1	
Han		5	44	35	15	2
Other	30	26	33	4	7	
All Groups	2	21	50	18	7	2

Table 11. Percentage of households with a member's highest educational achievement, by ethnicity. Source: Mekong Futures Survey (2010).

Health

Information on health and healthcare was difficult to gather. According to the Yunnan statistical yearbook (Yunnan Statistics Bureau 2013), 98.9% of villages have access to medical care. Interviews with locals described that most villages have a volunteer who is trained in health care, but for more serious issues a person should travel to a town to visit a doctor or a city to visit a hospital. The state subsidises much of the cost of basic healthcare. Life expectancy average for Xishuangbanna is 70.6 years (Li 2007). (Source: http://www.xsbn.gov.cn/legalbill/quarterly/contentslist/200709/5703.html).

	Life expectancy	Hospital	Local medical institutions	Professional public health agencies	Other health agencies	Medical personnel	% villages with access to medical care	Health agencies
Location								
Xishuangbanna	70.59	29	737	15	1	7,780	98.90%	782
Jinghong		19	332	8	1	4,556		360
Menghai		3	190	3		1,277		196
Mengla		7	215	4		1,947		226

Table 12. Health and healthcare indicators. Source: Xishuangbanna Statistical Yearbook 2012

Livelihoods

In the Mekong Futures Survey, households were asked to identify their main livelihood activity, their most important livelihood activity and their most stable. There was little difference in response between the questions. It should be noted that although one primary livelihood was identified, households are often engaged in multiple activities.

The main livelihoods are dominated by rubber at low and medium elevations, and tea at the higher elevation. At the medium elevation, a minority of farmers identified themselves as primarily maize or rice farmers. See Figure 4.

The main livelihood can also be broken down by ethnic group (see Figure 5), with rubber or tea completely dominant as the main livelihood activity for all ethnic groups. The main activity of the ethnic groups can be related to the locations where they commonly live. The Dai, who mainly live in the lowlands, predominantly are rubber farmers. The Yi, who live mostly in the highlands, with a smaller number in the midlands, are mainly tea farmers, and some are rubber farmers.

The Bulang are of particular interest because their main livelihood activities are more diverse, comprising rubber, maize, tea and rice farmers. The Other category of ethnicity includes many rubber farmers, but also tea packers and traders of commodities.

Income

Government statistics calculate income per capita. Below 2500 RMB per year per person, the government offers food subsidies. We therefore take 2500 RMB per year per person as the poverty line. According to the government statistics, ten percent of people are below the poverty line.

The average income of rural people is considerably less than urban people, and even in rural areas a large proportion of income is derived from non-agricultural sources. The poorest county of Xishuangbanna is Menghai.

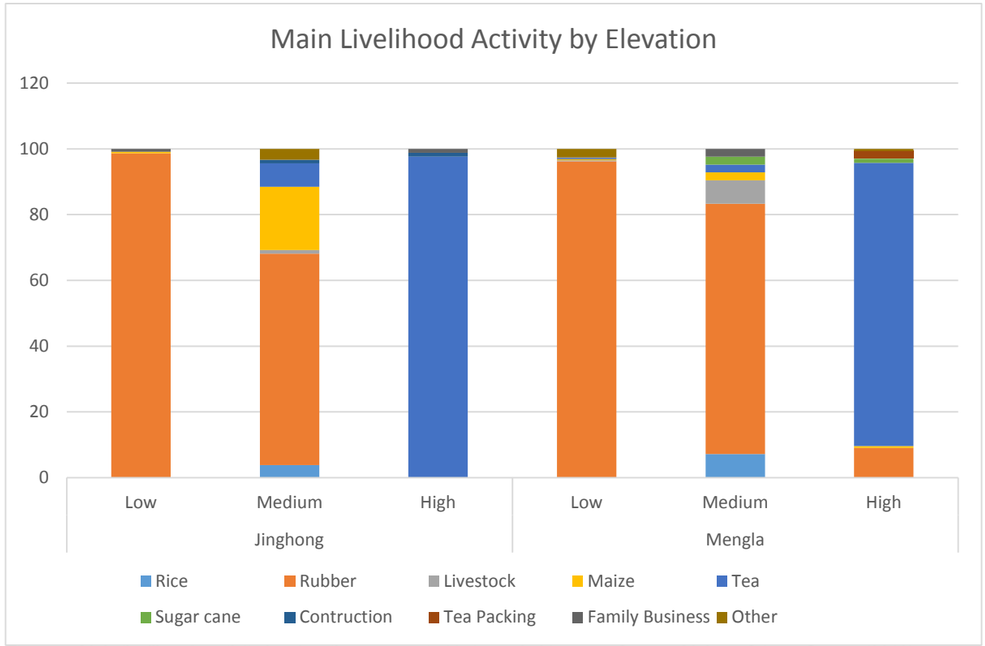


Figure 4. Main livelihoods activity by elevation as reported in household survey. Source: Mekong futures Survey (2010).

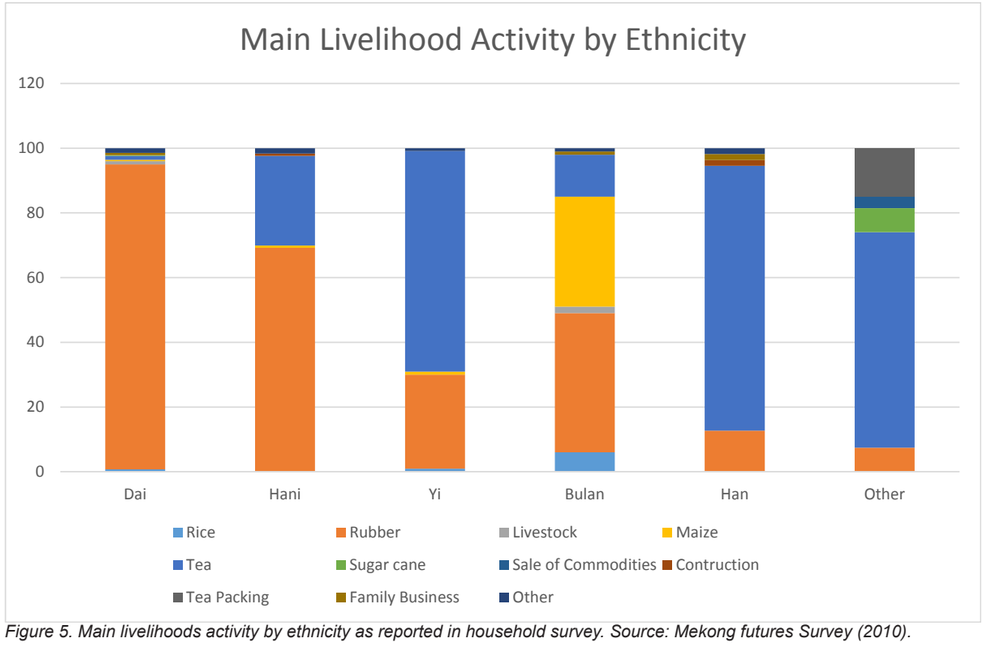


Figure 5. Main livelihoods activity by ethnicity as reported in household survey. Source: Mekong futures Survey (2010).

More detailed information can be gained from the Mekong Futures household survey (see Tables 14 and 15). It is clear that incomes in the lowlands are higher than in medium or high elevation. Incomes from agriculture are higher in the low elevations, and incomes from-non-agriculture sources are slightly higher. The percentage of people below the poverty line is considerably higher in medium and high elevations compared to the low elevations.

Income from agriculture in the Jinghong County highlands – an area which is mainly populated by Hani people who primarily grow tea – is much lower than in other regions. But it seems that the people in the Jinghong highlands make up for the shortfall with higher than average non-agricultural income.

Although the average income is fairly high in the Jinghong medium elevation lands, the proportion of people living below the poverty line is the highest of all locations surveyed. This implies a large range of incomes in that area. Household debts are common and average about 20-30% of annual income.

When the income data is divided by ethnicity, it is clear to see that the Bulang and Other categories are the least wealthy. They have the lowest incomes, and much higher proportion of households below the poverty line (more than 50%). They also have the lowest household debts, which may reflect a lack of access to capital.

	Average Annual Income per person	Average Income per Rural person	Average Net Income per person from Agriculture	% below 2500 RMB per person
Xishuangbanna	20,309	12,185	4,879	10
Jinghong	23,770	8,153	6,720	
Menghai	19,323	5,084	3,991	
Mengla	19,323	7,101	3,467	

Table 13. Average annual income in RMB. Source: Yunnan Statistical Yearbook 2013, Xishuangbanna Statistical Yearbook 2012.

		Annual Household Income	Annual Agricultural Income	Annual Non-Agricultural income	Household Debts	% below 2500 RMB per person
Jinghong	Low	68,807	55,102	13,704	19,101	6
	Medium	42,805	35,914	6,892	13,478	30
	High	28,003	15,301	12,703	23,876	20
Mengla	Low	86,300	74,136	12,163	19,511	4
	Medium	37,468	30,030	7,438	10,537	19
	High	36,840	31,559	5,281	6,766	17
All Locations		59,749	49,475	10,274	16,232	13

Table 14. Average Income, debts and poverty line by elevation and county. Source: Mekong Futures 2010.

	Annual Household Income	Annual Agricultural Income	Annual Non-Agricultural Income	Debts	% below 2500 RMB per person
Dai	77,813	65,020	12,793	17,674	6
Hani	63,979	51,913	12,067	22,559	9
Yi	36,844	32,518	4,326	9,213	11
Bulang	13,470	11,636	1,834	3,650	53
Han	49,237	39,719	9,518	13,927	7
Other	18,225	10,072	8,153	4,357	56
All Groups	59,749	49,475	10,274	16,232	13

Table 15. Average Income, debts and poverty line by ethnicity. Source: Mekong Futures Survey 2010.

Assets

The Mekong Futures survey data also covers household assets. The lowlands again appear to be the wealthiest, in terms of car ownership and computer ownership, as well as the average number of household appliances owned. The Jinghong mid-elevation and Mengla highlands appear to be the least wealthy in terms of household appliances, computers and cars. The Jinghong highlands have a relatively high ownership of vans and computers, which may relate to the higher-than average incomes from non-agriculture sources.

Almost all households own a motorcycle and a television.

Asset ownership by ethnicity again shows that the Bulang and Other categories are the least wealthy. The Dai, Hani and Han are the wealthiest.

		Motorbike	Car	Van or Truck	TV	Computer	Average Number of Household Appliances
Jinghong	Low	99	27	6	100	10	5.4
	Medium	92	11	1	95	1	3.9
	High	90	6	10	99	10	4.2
Mengla	Low	99	33	8	99	17	5.5
	Medium	100	19	7	100	7	5.3
	High	89	8	7	98	5	4.5
All Locations		96	21	6	98	9	4.9

Table 16. Percentage of households who own an asset, and the average number of household electrical appliances owned, by elevation and county. Source: Mekong Futures Survey 2010.

	Motorbike	Car	Van or Truck	TV	Computer	Average Number of Household Appliances
Dai	100	34	8	100	14	5.6
Hani	95	17	5	99	9	4.8
Yi	93	10	5	97	4	4.4
Bulang	87	3	1	92	1	3.2
Han	96	11	9	100	9	5.4
Other	70	0	11	93	4	3.0
All Groups	96	21	6	98	9	4.9

Table 17. Percentage of households who own an asset, and the average number of household electrical appliances owned, by ethnicity. Source: Mekong Futures Survey 2010.

The Diversity of Livelihood Activities, and the Net Income Generated

Although rubber and tea are the primary livelihoods of most people in Xishuangbanna, households are engaged in a number of livelihood activities, both agricultural and non-agricultural. Tables 18 and 19 show the percentage of households engaged in agricultural activities and the net income they report, disaggregated by elevation. Tables 20 and 21 show the percentage of households engaged in each non-agricultural activity, and the net income, also disaggregated by elevation. The same information disaggregated by ethnicity is presented in tables 22, 23, 24, and 25.

At low and medium altitude, almost all households grow rubber trees (92-99%). At high altitude, 98-100% of households grow tea. In Mengla, at medium and high altitudes it appears that many farmers grow both rubber and tea. Intercropping of rubber and tea may therefore be most common in this area.

The majority (approximately 50-80%) of households also grow rice, maize and raise livestock. Approximately 20% of households grow vegetables and annual fruit, and approximately 10% of households keep fruit trees. Households at high elevation in Jinghong and medium elevation in Mengla appear to be engaged in the widest array of activities, which again suggests intercropping.

Major profits are reported from rubber, fruit trees and tea. The major rubber production areas are low and mid elevations in Jinghong and Mengla, where reported profits are 24-69,000 RMB per year, with the higher values achieved in the lower elevations. Major fruit tree areas (primarily banana) are present at low elevations, where profits range from 27-44,000 RMB per year. Tea grows better at high elevations, reported profits are 13-30,000 RMB per year, but for most other crops higher profits are achieved at lower elevations. This reflects better climatic conditions, and maybe better market access.

Smaller profits are reported from horticulture, livestock and maize. Presumably most less profitable produce is used and consumed within the household; rice is the most obvious example of this.

There are some less popular activities which can turn a greater than average profit – two examples are gathering forest products (honey and precious woods) and aquaculture. These may be potential niches with opportunity for expansion. Mushroom cultivation and gathering also seem under-exploited.

Non-agricultural income generating activities are less commonly practiced than agricultural activities. The most common non-agricultural sources of income are government subsidies, renting out land, and pensions. These are all relatively low earning. Family businesses (for example restaurants) are common in all but the poorest areas (Jinghong mid-elevation and Mengla high elevation). Generally between five and ten percent of households are involved in employment type activities such as labouring on farms, rubber tapping, tea packing, construction, or government work.

The profits reported from non-agricultural activities are not as high as from the top agricultural commodities, but can still be relatively good. Family businesses, tourism related activities and manufacturing generate profits of approximately 10-30,000 RMB per year in most locations. Construction work generates 10-15,000 RMB per year, and is common in most locations. Farm labour, plantation work and similar labouring jobs are generally less well paid, earning approximately 5,000 RMB per year; except in the low elevations of Mengla where wages are much higher (approximately 30,000 RMB per year).

With the exception of employment in government jobs and family businesses, there is little opportunity for gainful non-agricultural work in mid-elevation Mengla relative to other locations. A small proportion of households in high elevation Mengla report a substantial annual income (35,000 RMB) from buying and selling agricultural produce. This may imply a greater opportunity for improved marketing chains between the highlands and more affluent lowlands. Tea packing is especially low earning (5,000 RMB per year). This is noteworthy because 15% of the 'Other' ethnic group consider it as their main livelihood activity.

Disaggregating the agricultural and non-agricultural activities by ethnicity shows similar general findings: the majority (50-90%) of households are engaged in rubber, tea, rice, maize and livestock, and a minority of households (10-20) grow vegetables. In terms of non-agricultural activities, subsidies, rent and pension are the most common, and relatively low profit. Family businesses, government employment, tourism and construction work are practised by all ethnicities. Of those surveyed, only the Dai and the Hani operate shops.

The profits generated by different ethnic groups provides useful information as to how their livelihoods are constructed. The Dai and Hani earn the most from rubber (58-59,000 RMB per year); the Dai also earn the major profits from fruit trees (41,000 RMB per year), and lesser profits from vegetables (6,000 RMB per year). The Han and the Yi earn the greatest profits from tea (39,000 RMB and 31,000 RMB per year, respectively). An interesting outlier are the Hani who earn 29,000 RMB per year per household from forest products, possibly from macadamia nuts and honey. The Bulang earn the most from vegetable production, although this sum is relatively modest (7,500 RMB per year).

An interesting contrast can be drawn between the two least wealthy groups, the Bulang and the 'Other' category. The Bulang are involved in the most diverse set of agricultural activities, including the highest proportion of rice farmers, and the lowest proportion of households involved in non-agricultural activities. The 'Other' category have the lowest proportion of rice farmers; and the least diverse range of activities, focusing almost entirely on cash crops; and the greatest proportion of households engaged in non-agriculture activities, most of which are low income. It appears that the Bulang group exhibit some characteristics of self-reliant agriculture, whereas the 'Other' group appear to be very focused on the cash economy, a focus which has delivered them very poor returns.

Conclusions

The population in Xishuangbanna can be categorised by three factors: their ethnicity, urban or rural, and elevation. Urban people and those living in the lowland valleys are generally wealthier, better educated and have greater access to opportunities.

Regarding ethnic groups, the Dai and the Han are generally the wealthiest and best educated. The Yi and Hani have good education but incomes are not as high, they tend to live at higher elevations where rubber is not so profitable and tend to grow a more diverse range of crops than the Dai. The Bulang have a much more diverse cropping system, which appears to be closer to the traditional subsistence mixed farming systems which were commonplace before the widespread monocropping of cash crops. Other ethnicities (such as Yao) report low incomes and low paid wage labour with little agricultural production. The Bulang and Other ethnicities show low levels of education and literacy.

The average income of a rural individual in Xishuangbanna is 2,000 USD per year (12,000 RMB). Education is widely available, infrastructure and market penetration and development is good, health care is widely available and affordable. The conditions in the lowlands are generally good, however the conditions higher up the mountains are less good, but, in general, are not desperate.

However, according to information from an unpublished household survey (Mekong Futures 2010), there are hotspots of poverty. For example, more than half of the Bulang households in the mid-elevation region of Jinghong County, and more than half of the households of the Other ethnicity category in the high elevations of Mengla are below the locally defined poverty line (income less than 400 USD per person per year); and amongst the Other ethnicity category 81% of household heads were illiterate.

It is therefore noted that hotspots of poverty do exist, and should be identified as potentially important locations to conduct further Humidtropics projects and work.

		Rice	Horticulture	Fruit Tree	Rubber	Aqua-culture	Livestock	Fishing	Aquatic Species	Forest Products	Handi-crafts	Mush-rooms	Maize	Tea	Forestry
Jinghong	Low	60	18	3	99	3	55	5	0				49		0
	Med	54	7	9	92	1	70	2		3	1	1	74	27	1
	High	85	17	13	12		64						60	98	5
Mengla	Low	56	18	7	99	0	42	2	4	1	0		42	16	
	Med	83	40		98		45	5					64	50	
	High	54	7	1	44	1	57		1				62	100	1
All Locations		60	15	6	82	1	54	2	1	1	0	0	55	36	1

Table 18. Percentage of households who report growing each crop, by ethnicity. Source: Mekong Futures Survey 2010.

		Rice	Horti-culture	Fruit Tree	Rubber	Aqua-culture	Live-stock	Fishing	Aquatic Species	Forest Products	Handi-crafts	Mush-rooms	Maize	Tea	Forestry
Jinghong	Low	1,174	**7,314**	**27,667**	**47,863**	500	5,210	815	500				3,016		
	Med	-109	2,227	2,397	**32,884**	-1,575	2,682	100		**13,578**	-1000	0	2,135	2,227	-150
	High	-460	471	4,609	-4,193		3,484						-203	**13,345**	-25
Mengla	Low	-451	3,835	**44,067**	**68,820**	**6,000**	4,354	2,083	317	4,345	300		408	1,587	
	Med	484	3,525		**24,407**		3,705	-550					1,270	3,671	
	High	-336	-9		2,602	-375	829		1,200				-102	**29,979**	
All Locations		53	3,991	22,256	47,086	548	3,437	945	393	11,899	-350		1,218	17,002	-50

Table 19. Average net Income reported in RMB per year, per household, from each agricultural activity. Numbers in bold earn more than the average agricultural activity. Source: Mekong Futures Survey 2010.

		Farm labour	Work on Plantation	Sale Agri-cultural Goods	Manu-facturing	Con-struction	Mining	Tourism	Govern-ment	Rubber Tapping	Tea Packing	Family Business	Remittance	Shops	Pension	Rent	Subsidies	Land Com-pensation
Jinghong	L	5	2		2	1	0	2	9			12		3	19	55	78	6
	M	4	3		1	6		5	8			3	2	2	20	27	70	2
	H	8	1		1	10	2	6	6			17		7	37	13	88	5
Mengla	L	0	1		1	2		1	8	1		10	2	1	14	59	59	5
	M	2							5			12			14	26	69	10
	H	7	1	1	1	3		5	10		4	5	2	1	16	13	83	1
All Locations		4	1	0	1	3	0	3	8	0	1	9	1	2	18	40	72	4

Table 20 Percentage of households who report taking part in non-agricultural activities, by county and elevation. Source: Mekong Futures Survey 2010.

		Farm labour	Work on Plantation	Sale Agri-cultural Goods	Manu-facturing	Con-struction	Mining	Tourism	Govern-ment	Rubber Tapping	Tea Packing	Family Business	Remittance	Shops	Pension	Rent	Subsidies	Land Com-pensation
Jinghong	L	3,016	10,550		**34,875**	**12,667**	1,400	**20,940**	5,388			**32,896**	233	11,943	858	7,435	730	**38,357**
	M	4,329	5,614		6,000	9,412		**12,489**	3,574			**13,040**	**27,333**	567	892	11,240	1,314	4,203
	H	4,159	4,000		**20,000**	**13,848**	**31,000**	**19,480**	6,740			**28,786**		9,933	2,368	7,092	1,191	1,675
Mengla	L	**30,000**	**31,250**		**19,000**	7,840		**31,800**	5,785	10,000		**20,650**	1,000	**17,125**	3,457	9,760	995	**23,562**
	M	3,000							**18,000**			**28,700**	1,000		500	7,588	812	4,975
	H	5,491	2,000	**35,000**	**24,000**	**16,300**		8,738	6,907		4,257	**21,156**	5,600	**33,600**	935	5,641	724	5,000
All Locations		4,846	13,418	35,000	24,650	11,657	21,133	15,448	5,856	10,000	4,257	25,578	13,229	11,762	1,767	8,915	949	22,796

Table 21. Average net Income reported in RMB per year, per household, from each non-agricultural activity, elevation and county. Numbers in bold earn more than the average activity. Source: Mekong Futures Survey 2010.

	Rice	Horticulture	Fruit Tree	Rubber	Aquaculture	Livestock	Fishing	Aquatic Species	Forest Products	Handicrafts	Mushrooms	Maize	Tea	Forestry
Dai	60	20	6	98	1	41	4	3	0	0		45	12	
Hani	50	14	4	74	1	64	1		1			54	37	2
Yi	64	11		55		71	1	2	3	1	1	70	81	2
Bulang	91	9	16	90		69	1					87	45	1
Han	60	5	4	45	2	45						45	89	
Other	21			57		50						54	93	
All Groups	60	15	6	82	1	54	2	1	1	0	0	55	36	1

Table 22. Percentage of Households who report growing each crop, by ethnicity. Source: Mekong Futures Survey 2010.

	Rice	Horticulture	Fruit Tree	Rubber	Aquaculture	Livestock	Fishing	Aquatic Species	Forest Products	Handicrafts	Mushrooms	Maize	Tea	Forestry
Dai	268	**5,870**	**41,465**	**59,034**	500	2,977	1,156	358	3,690	300		1,967	4,355	
Hani	-341	639	**8,517**	**58,374**	950	**5,903**	150		**29,300**			166	**10,288**	-320
Yi	-269	700		**11,271**		1,350	0	600	1,667	-1,000	0	-63	**31,092**	600
Bulang	408	**7,550**	2,397	5,640		1,476	-100					3,358	2,447	0
Han	-20	167	4,250	**9,722**	-375	876						-266	**39,118**	
Other	-480			**7,205**		992						-194	5,106	
All Groups	53	3,991	22,256	47,086	548	3,437	945	393	11,899	-350	0	1,218	17,002	-50

Table 23. Average net Income reported in RMB per year, per household, from each agricultural activity. Numbers in bold earn more than the average agricultural activity. Source: Mekong Futures Survey 2010.

	Farm labour	Work on Plantation	Sale Agri-cultural Goods	Manu-facturing	Cons-truction	Mining	Tourism	Govern-ment	Rubber Tapping	Tea Packing	Family Business	Remittance	Shops	Pension	Rent	Subsidies	Land Com-pensation
Dai	3	1		1	1	0	1	8	0		12	1	2	17	56	68	6
Hani	4	3		1	5	1	4	9			8	2	5	25	43	69	4
Yi	6	1			1		6	9			5			19	19	85	1
Bulang					4		1	7			2	2		9	9	77	
Han	5			4	7		4	11		2	9	2		13	16	80	
Other	21		4		11		7	4		21	4	7		21	4	86	4
All Groups	4	1	0	1	3	0	3	8	0	1	9	1	2	18	40	73	4

Table 24 Percentage of Households who report taking part in non-agricultural activities, by ethnicity. Source: Mekong Futures Survey 2010.

	Farm labour	Work on Plantation	Sale Agri-cultural Goods	Manu-facturing	Cons-truction	Mining	Tourism	Govern-ment	Rubber Tapping	Tea Packing	Family Business	Remittance	Shops	Pension	Rent	Subsidies	Land Com-pensation
Dai	3,417	**30,300**		**32,250**	**12,000**	1,400	**23,300**	5,618	10,000		**22,314**	2,333	**12,329**	2,044	9,243	812	**32,865**
Hani	4,456	7,807		**13,000**	**12,541**	**31,000**	**19,346**	5,464			**32,033**	**27,333**	**11,479**	1,653	9,434	1,359	3,398
Yi	2,891	2,000			**50,000**		7,071	6,666			**15,540**			829	4,886	870	5,000
Bulang					4,215		9,600	1,051			**31,500**	1,000		646	3,797	565	
Han	**12,333**			**13,500**	10,250		9,300	**13,024**		300	**36,200**	1,000		5,243	7,362	793	
Other	6,783		**35,000**		5,500		**12,800**	7,200		4,917	**25,550**	5,600		867	8,000	933	1,500
All Groups	4,846	13,418	35,000	24,650	11,657	21,133	15,448	5,856	10,000	4,257	25,578	13,228	11,762	1,767	8,915	949	22,796

Table 25. Average net Income reported in RMB per year, per household, from each non-agricultural activity by ethnicity. Numbers in bold earn more than the average activity. Source: Mekong Futures Survey 2010.

Chapter 2: Agricultural Production Systems

Agricultural production of major and niche commodities

The major agricultural commodities of Xishuangbanna are rubber, tea, rice, maize, banana, sugar cane, bamboo, vegetables, pigs, chickens, cow, coffee, fish and timber.

High value commodities, which are emerging and not widely grown are: orchids, macademia nuts, agar wood (which is sold for its scent), medicinal plants (such as *Amom villosum*), honey, walnuts, moringa (also known as drumstick tree), sancha inchi (which is pressed for oil).

Native crop varieties of interest are the vast array of rice species (over 70) traditionally grown but now generally abandoned (Xu et al. 2014; Yin 2001).

The spatial distribution of land use is shown in Figure 6, and the proportions of land cover by land use are shown in Figure 7. Approximately 55% of the land is forested, 21% covered by rubber plantation, and 11% farmed for other crops. The lowlands of Jinghong and Menghai counties are mostly filled with rubber, with some banana. Around the edges of the main rubber areas are low profit rubber plantations, on higher elevation land where the rubber trees do not yield so well. The cultivated lands in Mengla are mainly planted with sugarcane, rice, vegetables, and hemp although recent interviews with local leaders state that increasingly bananas are planted. Tea and coffee are grown in the higher elevations, especially in Jinghong.

Various initiatives are underway to introduce niche crops into Xishuangbanna. These include research for development projects on macadamia cultivation in Jingha County run by the Xishuangbanna Tropical Crops Institute and the Xishuangbanna Bio-Industrial Crops Office. The Xishuangbanna Bio-Industrial Crops Office have further research for development projects on, among other things, moringa (Jinghong), dendrobium nobile (Jinghong, and Mengman), rattan (Puwen). Additional macademia, as well as orchid, programs are being carried out in Menghai. Xishuangbanna Tianyun Linzhong Herbal Medicine Growers Ltd. are developing medicinal herb cultivation in Jinuo Shan and Dadugang. Inchi cultivation and processing is being developed by the Yunnan Forestry Investment Co. in Puwen. And the Yunnan Institute of Insect Resources has a research for development project on high value timber in Jinghong. In addition, numerous stakeholders from science, government and business are pursuing high-value niche markets for ancient, organic, and/or environmentally-friendly tea.

Land use can also be analysed by elevation. The different land uses by elevation are presented in Figure 7. The major pattern is that rubber has displaced all other land uses from the lowlands, causing indirect land use change at the elevations above 900 m. Below 900 m, the area of rubber plantations already exceeds that of forests. New rubber plantations are mainly located above the altitude of 900 m, which is the limit for high yielding, high profit rubber in Xishuangbanna. This shows that rubber plantations are expanding into new higher elevation areas where the financial returns are expected to be lower; converting natural or secondary forest land and undermining ecosystem services. Farmland for other non-rubber crops has also generally been pushed up to higher elevations. Banana land is located below 900 m, although there are recent observations and reports of banana plantations in recently converted forest land above 900 m.

The biggest proportion of forest is located above 900 m. The forest type above 1000 m in Xishuangbanna includes mountain rainforest, evergreen broadleaves forest and deciduous forests, which support less biodiversity than lowland rainforest.

Crop[5]	Land Area (km²)			Total production (tons)		
	2010	2011	2012	2010	2011	2012
Rubber	2,713	2,873	2,896	255,300	283,045	292,044
Sugarcane	134	133	139	900,800	971,769	881,335
Vegetables	126	128	141	122,800	126,181	137,974
Fruit (including banana)	159	228	268	428,600	551,853	698,474
Aquaculture (tilapia)	60	58	59	22,000	27,304	34,219
Tea	487	504	521	27,800	30,932	36,180
Macadamia nut	9	8	10	600	1,349	1,064
Hemp	18	15	8	1,700	1,458	762
Bamboo (m³)				300,000	307,446	332,044
Coffee	33	43	52	30,200	6,655	16,097
Amomum villosum (medicinal herb)	66	72	68	700	1,030	607
Pigs (head)	509,900	509,095	507,481	22,900	24,149	26,174
Cattle (head)	103,800	90,668	78,397	4,300	4,266	4,060
Poultry (head)	3,632,200	3,862,800	3,980,000	4,100	4,372	4,824

Table 26. Land area and production of major and minor commodities in 2010-2012. Not all commodities are included in the source data. Source: Xishuangbanna Statistical Yearbooks.

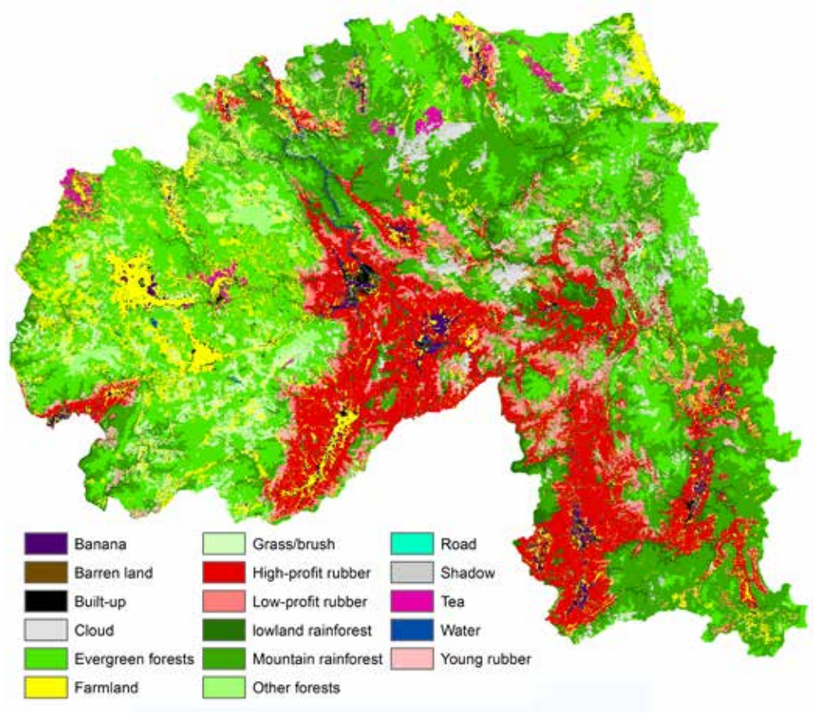


Figure 6. Land use map of Xishuangbanna.

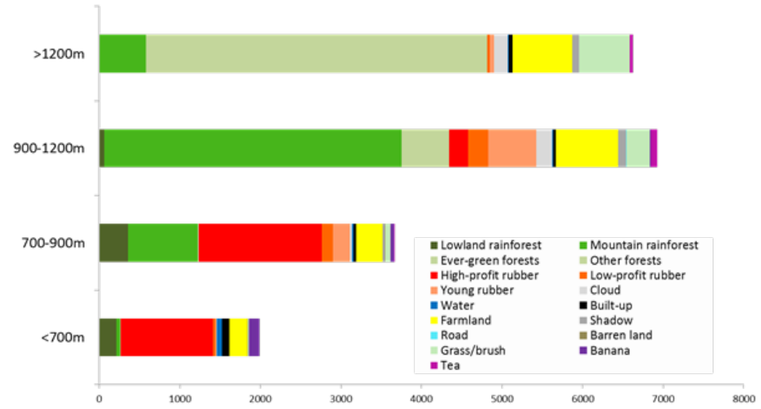


Figure 7. Land use by elevation, for all of Xishuangbanna.

Land Use by County: Jinghong

Land use below 900 m is dominated by rubber. Farmland and banana are the other main agricultural land uses. There is little forest left below 700 m. Between 900-1200 m forest is the largest land use category, but the second largest is low-profit rubber, and also new rubber plantations which have not yet reached maturity. There is a greater amount of farmland between 900-1200 m than at other elevations. The tea plantations are mainly above 900 m, and a small amount of banana is now above 900 m. Above 1200 m the major land use is evergreen forest, with some farmland, tea plantation and even some low-profit rubber.

Potential issues for investigation are the spread of banana plantations to higher altitudes, and the possibility of intercropping tea and rubber.

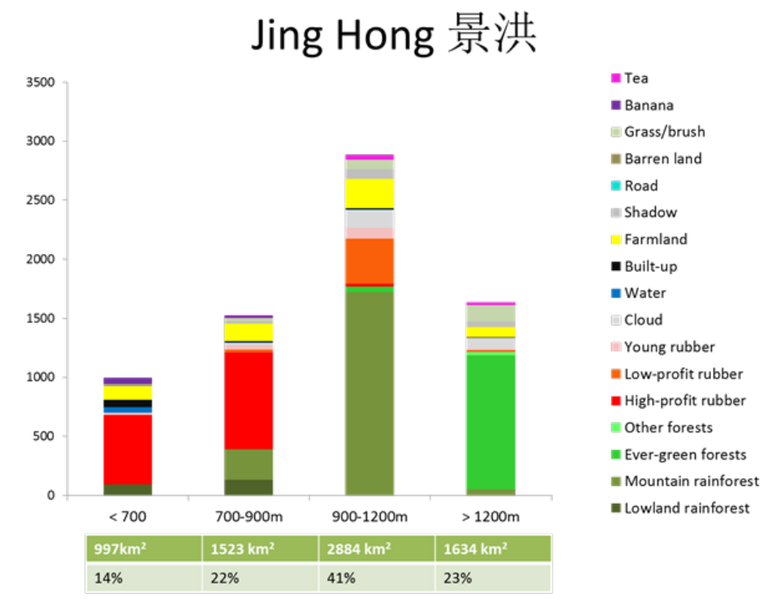


Figure 8. Land use (km²) by elevation for Jinghong County. Also land area in each elevation class, as km² and a percentage of the total.

Land Use by County: Mengla

Land use in Mengla County is similar to Jinghong, although there are more new immature rubber plantations in Mengla. High-profit rubber dominates the landscape below 900 m, and low-profit rubber is the largest agricultural land use between 900-1200 m. Mountain forest is the largest land use between 900-1200 m and evergreen forest the largest above 1200 m. Banana plantations are relatively large compared to other counties below 700 m, but have not (yet) spread to higher elevations. There are few tea plantations in Mengla. The amount of farmland is consistent between low, medium and high elevations (<1200 m); but there is relatively little cultivated land above 1200 m, except for some low profit rubber.

Potential issues for investigation are the spread of banana to higher altitudes, and the performance of rubber above 1200 m – if it is acceptable then that land use might increase.

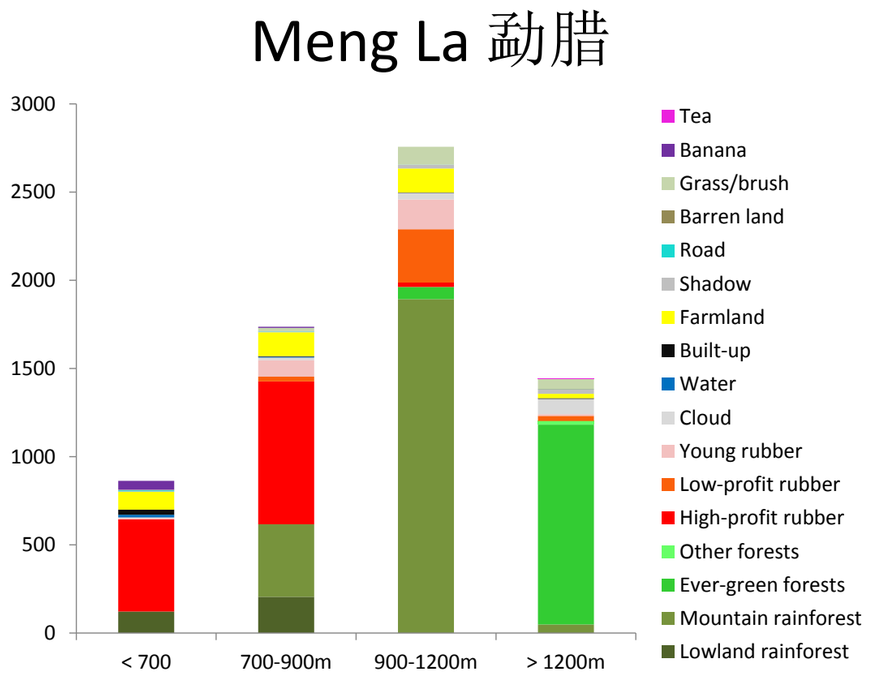


Figure 9. Land use (km2) by elevation for Mengla County. Also land area in each elevation class, as km2 and a percentage of the total.

Land Use by County: Menghai

Land use in Menghai is very different to Jinghong and Mengla counties. The terrain is different: there are few lowland areas (<700 m); the majority of the land is in the medium or very high elevation categories (700-900 m or above 1200 m).

Menghai is described by local experts as an example of "Green GDP", as most of the income is from diverse farming of local varieties of crops for food consumption. The income from Menghai County

reportedly overtook the income from Mengla County in 2013, providing some evidence that a diverse farming system based on local varieties can compete with mono-culture cash crop land use. It was also reported that there a more small businesses which upgrade local produce to higher value products in Menghai than in other counties. Of course, the geographic conditions must be taken into account, but Menghai may provide a useful example.

According to our spatial analysis, there are few rubber plantations in Menghai, the majority of the cultivated landscape is mixed farmland – primarily sugar cane, hemp, rice and vegetables. There is a larger amount of farmland above 1200 m in Menghai compared to the other counties. There are also banana plantations at 900-1200 m and above. The performance of these plantations and the management practices should be monitored as they may provide an example for banana expansion in other counties. The small rubber plantations in Menghai are at the 900-1200 m elevation bracket, and are high profit. The reason for high profit rubber at that elevation should be investigated. Menghai is also the location for orchid and macademia nut production projects which are emerging examples of integrated farming systems into the forest landscapes.

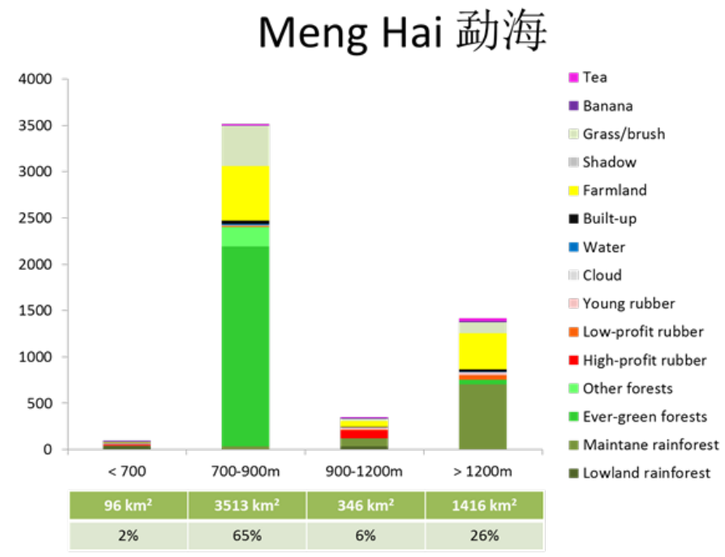


Figure 10. Land use (km²) by elevation for Menghai County. Also land area in each elevation class, as km² and a percentage of the total.

Market Prices for Commodities

Table 27 shows the value of the major agricultural commodities in Xishuangbanna, based on provincial level government data. Rubber is not mentioned explicitly but is the major component of 'Forest Products'. This obfuscation is due to disagreements between different levels of government about how much money rubber should be allowed to generate. The gross value of 'Forest Products' is one order of magnitude higher than any other crop.

In terms of livestock production, pigs are the most valuable, followed by fish, buffalo and cow, then poultry and others. Some indigenous breeds are raised including, black chickens and "South Yunnan Short Ear Pigs" (Riedel et al. 2014). Livestock is not a major component of cash incomes for most households, but is an important component never the less – most families raise some livestock (see Tables 28 in Chapter 1). Suggestions have been made to improve pig productivity: through better feed management and a breeding program (Riedel et al. 2014).

	Forest Products (rubber and tea)	Rice and Other Grain	Maize	Fruits and Nuts	Live-stock	Horti-culture	Sugar Cane	Timber and Bamboo	Medi-cinal Plants	Forest Trees	Beans and Peas	Oil Crop	Tubers
Xishuangbanna	3,320	894	651	572	525	273	180	63	54	48	17	16	9
Jinghong	1,707	230	220	236	192	98	0	31	12	40	3	6	0
Menghai	113	491	283	74	196	112	162	25	11	8	10	7	7
Mengla	1,499	173	148	262	138	63	17	7	31	0	4	3	2

Table 27. Total Value of Crops Produced in million RMB per year, Xishuangbanna statistical yearbook, 2009.

	Pigs	Fishery	Buffalo and Cow	Poultry	Others
Xishuangbanna	207.5	162.23	82.93	33.71	1.06
Jinghong	84.06	63.93	22.27	17.74	0.24
Menghai	65.04	69.78	53.4	8.9	0.81
Mengla	58.4	28.52	7.26	7.07	0.01

Table 28. Total Value of Livestock Produced in million RMB per year, Xishuangbanna statistical yearbook, 2009.

From the Mekong Futures household survey data (2010), the most profitable farming options are: rubber, banana, and tea. Other fruit trees, vegetable productions and livestock production are above average in terms of profit, for some locations and ethnic groups. Other forest products have the potential for high profit, although in most circumstances that is not achieved. See Tables 19 and 23 for more detail on profits at the household level.

Farming Systems

The vast majority of agricultural land is managed by smallholder farmers. Non-agricultural land, is under management of the state, in state forests or national parks. Each village also has a patch of community forest land which is under management by the village committee (a governance level for a small number of villages, typically around five).

State managed collective farms are uncommon in Xishuangbanna. State rubber farms were broken up between 2007 and 2012 because local farmers felt that they could earn more income as managers of their own small plots of land rather than by receiving a wage for working on the state farm.

The land tenure system in China allocated a plot of agricultural land and a plot of forest land to each rural household, typically between 2 and 4 hectares (30-60 mu) in Xishuangbanna (see Table 29). The households can then manage their land how they wish, with restrictions in place regarding the conversion of land to other uses. Sale of land is not permitted, although renting is. It is common for farmers to rent land to one another, or to external agents who may use the land for a particular commodity.

Household forest land cannot be legally converted into agricultural land, and some restrictions are in place regarding logging. Community forest land is managed by the village committee and in practice should be used communally but is sometimes leased to investors for personal gain. State managed forest land should also not be converted to agricultural uses, but in some areas law enforcement may be too weak to prevent land conversion. According to expert interviews, banana plantations are the major driver of forest land conversion at the time of writing.

		Elevation Average	Dai	Hani	Yi	Bulan	Han	Other
Jinghong	Low	31	22	48		43	6	16
	Medium	45		49	40	43		19
	High	56		56			73	
Mengla	Low	58	53	69	62		96	
	Medium	92	92					
	High	68	106	69	78		68	24
Ethnicity Average		53	47	56	71	43	71	23

Table 29. Average farm size in mu at different elevations and for different ethnicities. Source Mekong Futures 2010.

Farming Technologies

Farming technology, such as modern varieties, agricultural inputs and machinery are widely available in Xishuangbanna. Rubber varieties especially suited to the higher elevation and low minimum temperatures of Xishuangbanna were developed by the Xishuangbanna Tropical Crops research Institute, and locally subsidised. According to the Xishuangbanna Statistical yearbooks, fertiliser and pesticide use has increased steadily during the last 25 years. Inputs are subsidised by the government and affordable for most farmers. Although statistics are not available at farm level, eutrophication and pollution of water is a commonly reported problem by experts interviewed and excessive agricultural inputs were commonly identified as the cause.

According to the Mekong Futures household survey (2010), 60-70% of households own a small hand-held tractor to use on their farms. The only areas where this is lower are the medium elevations of Jinghong and the higher elevations of Mengla (which were found to be the poorest areas in the Development Overview chapter).

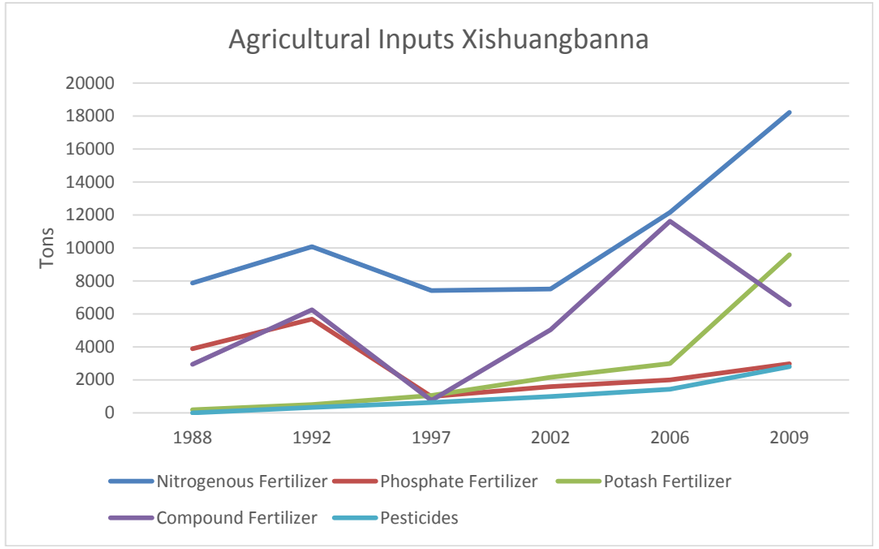


Figure 11. Increasing Agricultural Inputs in Xishuangbanna between 1988 and 2009. Source: Xishuangbanna Statistical Yearbooks.

		Tractor	Hand Tractor	Rice Harvester	Pump	Milling Equipment
Jinghong	Low	19	70	4	16	29
	Medium	14	43	2	3	7
	High	13	64	2	1	19
Mengla	Low	28	60	3	15	15
	Medium	33	69	2	7	31
	High	16	21	1	5	22
All Locations		21	53	3	10	19

Table 30. Percentage of smallholders who own farming technology. Source Mekong Futures (2010).

Rubber Farming

The expansion of rubber plantations into higher (and steeper) ground is the biggest land use trend at present in Xishuangbanna. The average yield data for rubber at different elevations is presented in Figure 12. Above 900 m elevation there is a marked drop in rubber yield, and plantations are no longer profitable (Yi et al. 2014).

Although monocropping is the norm for rubber plantations in Xishuangbanna, there are numerous possibilities for inter-cropping. The most common in Xishuangbanna is the planting of pineapple with young rubber. This brings increased economic returns (Ahmad 2001; Rajasekharan & Veeraputhran 2002), but comes at an increased environmental impacts due to soil erosion and excessive agro-chemical use.

Other potential intercropping systems include rubber-cacao, rubber with *flemingia macrophylla merr* (a plant used in Chinese medicine); rubber with *rauvolfia verticillata* (a hypotensive herb) and teak; young rubber-corn; young rubber-chilli; and young rubber with various vegetables. Many of these intercropping systems have been trialled and demonstrated at the Xishuangbanna Tropical Botanical Garden for over two decades, but have not become widely adopted. Generally, these systems can offer increased income, with either no environmental benefit or a negative environmental impact. For example, the benefits of cacao agro-forestry systems are debated (Yi 2014; Ruf 2011), but the fact remains that these systems have not caught on locally.

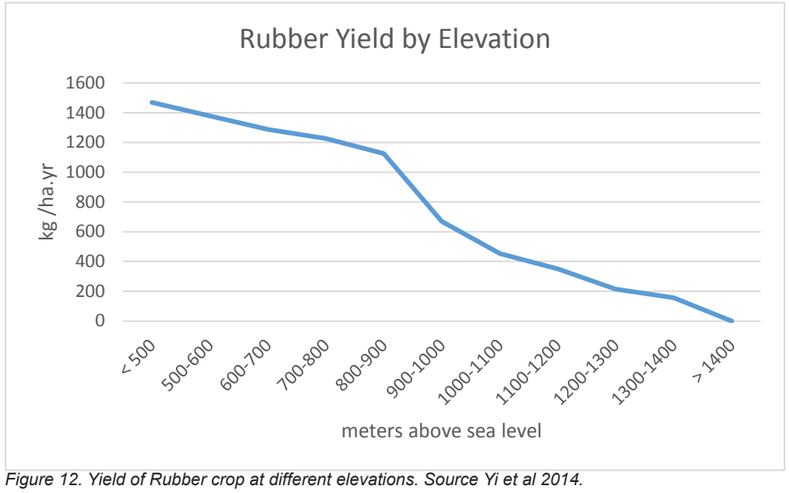


Figure 12. Yield of Rubber crop at different elevations. Source Yi et al 2014.

A further, more complex and environmentally beneficial intercropping system is an "analogue forest": a man-made rainforest which uses rubber trees and other indigenous tree species to establish forest-like productive land use. There are 3 main layers in this agroforestry system: the canopy layer has 67 tree species; the shrub layer under the tree canopy has 29 species; and grass/herb layer has about 16 species. The rubber analogue forest concept is based on high value, long-term tropical timber and functionally diverse; it provides a range of products and also prevents the loss of the biodiversity and minimizes anthropogenic climate change impacts (Yi 2014). Despite a long term demonstration analogue forest at Xishuangbanna Tropical Botanical Gardens, the economics of the concept are not well understood.

Tea Gardens

Tea has traditionally been grown in the northern part of Xishuangbanna for centuries. Just north of Xishuangbanna is a region called Pu'er which is world renowned for tea production. In fact, much of the tea sold as Pu'er is grown in northern Xishuangbanna, and then sold through Pu'er.

Xishunagbanna is famous for the "Six Tea Mountains" on which ancient (300-800 year old) tea forests exist. The tea from these ancient plantations commands a high price at up to ten times the value of standard tea, and high levels of respect amongst tea connoisseurs. These tea mountains are the subject of much local pride and a draw for tourism.

Although much of the tea produced in Xishuangbanna is cultivated on mono-crop terraces, tea can be intercropped well with forest, rubber or other trees. Compared to either tea terraces or rubber monoculture, rubber-tea systems generate higher economic returns under specific circumstances, and have become popular within a rather specific elevation band in Mengla County (around 800 m elevation). They can also provide numerous ecological benefits, including a reduction in soil erosion by 42% compared to rubber monoculture and 23.8% compared to tea terraces, and increases soil organic matter (Yi 2014). Such systems are already being employed in Nabanhe National Nature Reserve, as well as a recently developed tea-walnut systems (Leshem et al. 2010).

Banana Farming

Bananas have a 4 year rotation, and one patch of ground can usually support three rotations. They have a high fertiliser requirement, and often chicken manure is used to supply the needed potassium. This generates bad smells and attracts insects, so plantations are often unpopular with locals. Banana has a relatively high start-up cost which prevents many small holders from establishing plantations. A recently published study on banana farming in Xishuangbanna confirmed interviewee reports (Zhang et al. 2014)

Although banana is cultivated as a mono-crop in Xishuangbanna, studies elsewhere in the humid tropics suggest potential economic and ecological benefits for inter-cropping banana with, among other things, rubber (Rodrigo, C. M. Stirling, et al. 2005; Rodrigo, Clare Maeve Stirling, et al. 2005) or coffee (Van Asten et al. 2011).

Observed Trends

The expansion of rubber plantation was mapped from satellite imagery by Xu et al (2014), and is shown in Figure 13. It is clear that most of the expansion has taken place since 2002, and that it is primarily located in the lowlands of Jinghong and Mengla counties. The map also shows nature reserves in Xishuangbanna – rubber plantations go right up to the borders of the nature reserves, and in the south east on Menghai inside the nature reserves.

Xu et al (2014) concluded that "biodiversity has been reduced, habitat fragmentation has increased, carbon sequestration in natural forests has been reduced, and hydrological systems altered" by rubber plantations. They also found that while incomes have risen, food insecurity has also increased.

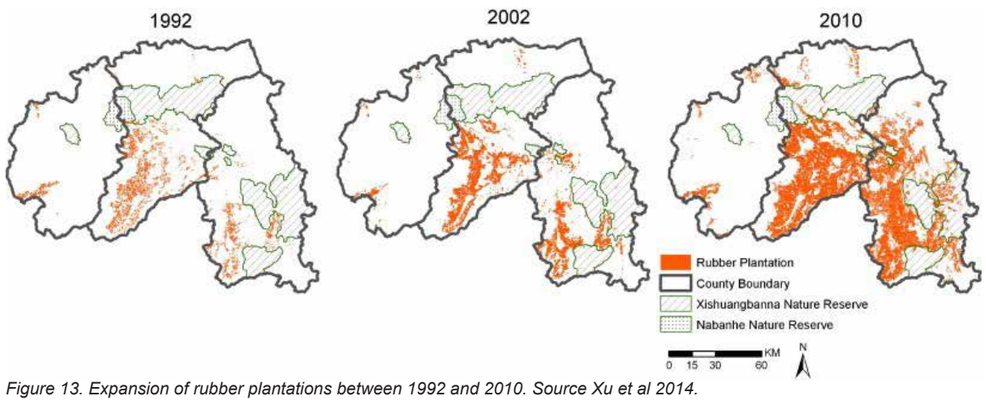


Figure 13. Expansion of rubber plantations between 1992 and 2010. Source Xu et al 2014.

Longer term observations of rubber and tea can be gained from the Xishuangbanna Statistical Yearbooks (Figures 14 and 15). Since 1983 the area of land under rubber and tea cultivation has steadily increased. The area of land planted with rubber increased from 50,000 ha to 250,000. The rate of planting has also increased since 2002 – since the price of rubber boomed. This can be seen in Figure 14 as the proportion of new immature rubber plantations has increased compared to mature rubber plantations; implying an increase in new planting. If the rubber productivity reported for 1992 is to be believed, then yields were exceptionally high compared to the land area of mature rubber land.

Land planted with tea has also increased by a factor of five since 1983, although the total land take is much less than rubber (from 10,000 ha in 1983 to 50,000 in 2009). The ratio of output to land area has stayed roughly consistent implying no major increases in productivity.

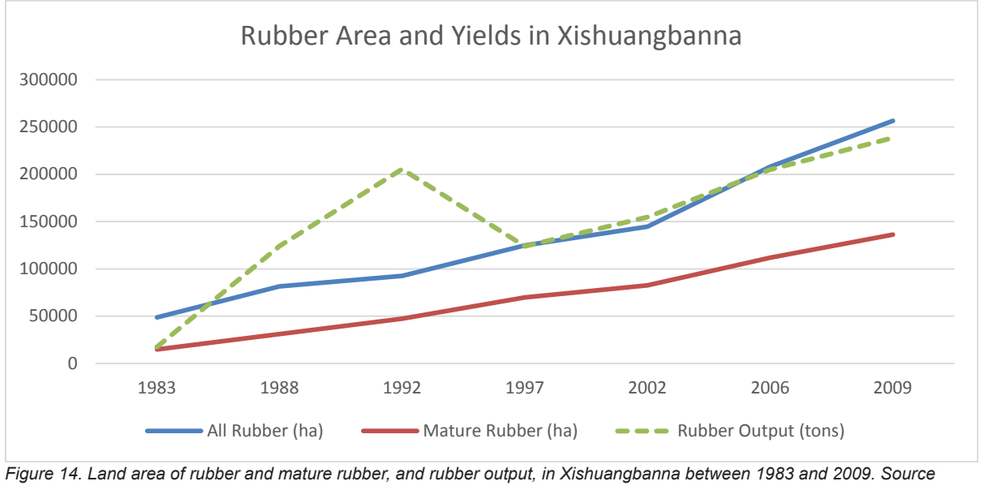


Figure 14. Land area of rubber and mature rubber, and rubber output, in Xishuangbanna between 1983 and 2009. Source Xishuangbanna Statistical Yearbooks.

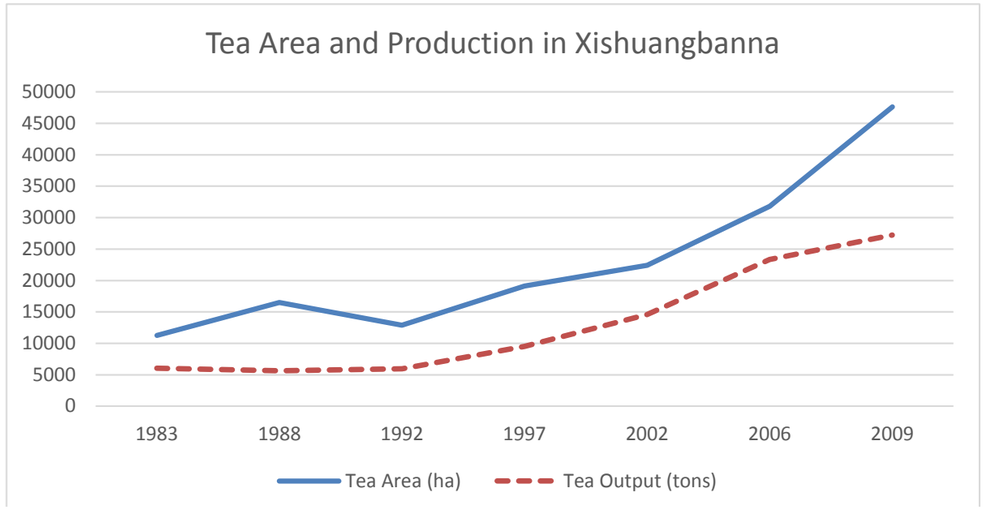


Figure 15. Land area of tea and tea output, in Xishuangbanna between 1983 and 2009. Source Xishuangbanna Statistical Yearbooks.

Future Scenarios and Alternative Agriculture Plans

Yi et al (2014) generated potential future land use scenarios and maps for Xishuangbanna, by the year 2035. The scenarios were 'Business as Usual' (scenario A), 'Maximum Economic Outputs' (scenario B), and Environmental Stewardship (scenario C). The land use maps are presented in Figure 16.

Under the business as usual scenario rubber and other crop expansion continued at the same rate as at present, with rubber plantations up to 1200 m. Under the maximum economic outputs scenario all potential land that could support a rubber crop was converted to rubber, mostly low profit high-altitude rubber, up to 1400 m. Under the environmental stewardship scenario forest land was protected, biodiversity corridors installed and low profit rubber converted back to forest.

Yi et al's (2014) study found that the impacts on carbon stored in the landscape and biodiversity would be very high for the maximum economic output scenario.

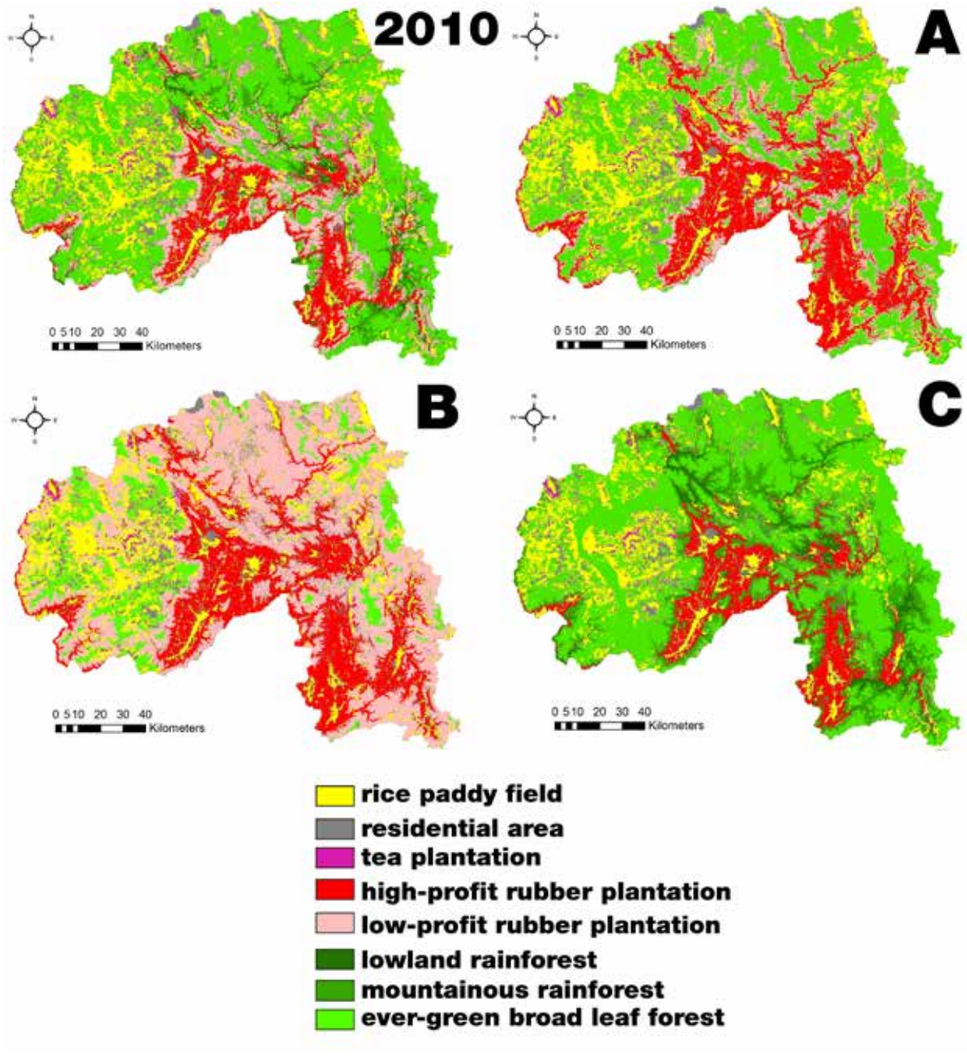


Figure 16. Scenarios for future land use, in 2035 for Xishuangbanna. Scenario A is Business as Usual, Scenario B is maximum economic outputs, and Scenario C is environmental stewardship. The land use map from 2010 is also shown for comparison. Source (Yi et al 2014).

The Xishuangbanna Bio-Industrial Crops Bureau are the prefectural government department who have responsibility for developing and planning economic crops. They have strong links to both the agricultural sector and the market sector. Table 31 is taken from their 5th 12 year plan, and Figure 17 derived from Table 31.

It shows that a modest increase relative to total area is planned for rubber area, a small modest increase for banana, and no increase planned for tea. The major plans for crop increases are the niche high value crops, many of which can be intercropped with forest or agriculture systems. Those are: *Vernicia montana*, medicinal plants, orchid, macademia nuts, and sacha inchi (*Plukenetia volubilis)*. There is also a focus on tree and forest crops such as bamboo, fast growing hardwood timber and agar wood. Other economic crops which are traditionally monocropped are hemp, seedlings and flowers, coffee and cassava. Other fruit and vegetable production is also planned to be increased.

The projected financial incomes from crops by 2020 are however incongruous with land area trends – most crops are projected to double in total value of output and it is unclear if this is expected to be achieved through improvements in yields or increased land area.

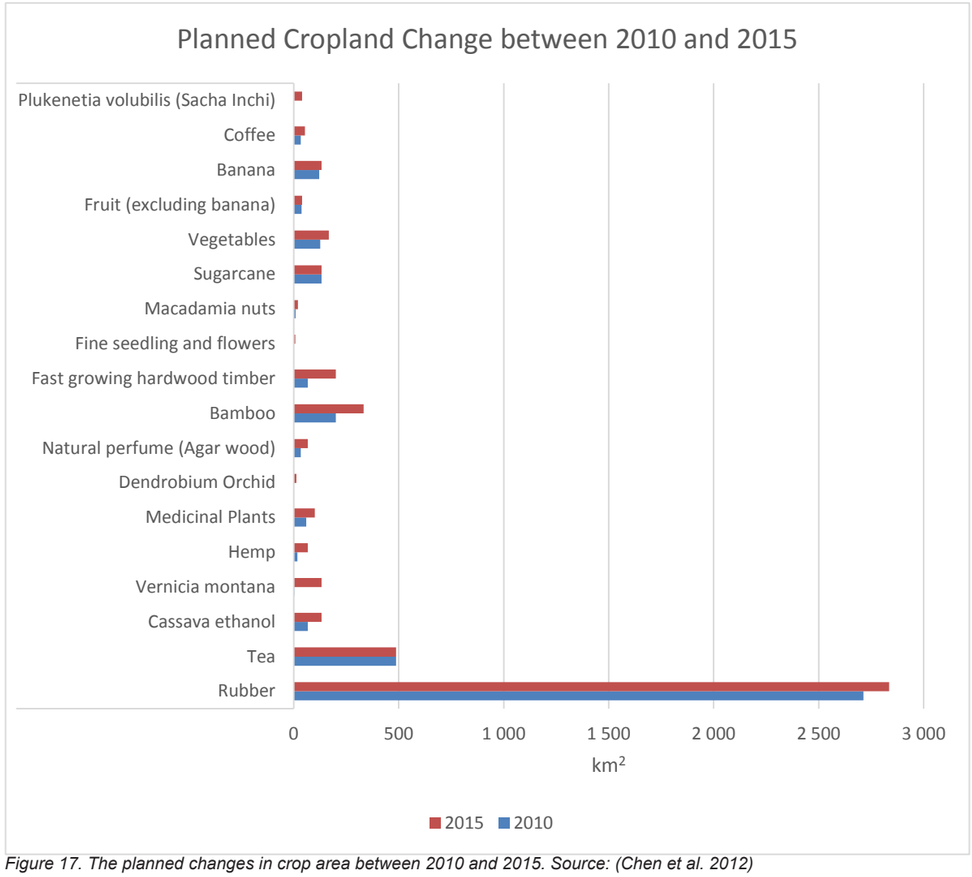


Figure 17. The planned changes in crop area between 2010 and 2015. Source: (Chen et al. 2012)

Crop	Area (km²)		Market Value (million RMB)	
	2010	2015	2015	2020
Rubber	2,713	2,836	12,540	25,230
Tea	487	487	1,990	3,990
Cassava ethanol	67	133	550	1,100
Vernicia montana	3	133	150	310
Hemp	18	67	510	1,030
Medicinal Plants	60	100	1,790	3,590
Dendrobium Orchid	1	13	2,300	4,620
Natural perfume (Agar wood)	33	67	640	1,280
Bamboo	200	333	360	720
Fast growing hardwood timber	67	200	450	900
Fine seedling and flowers	0	7	320	640
Macadamia nuts	9	20	320	640
Sugarcane	133	133	510	1,030
Vegetables	126	167	770	1,540
Fruit (excluding banana)	37	40	260	510
Banana	121	133	910	1,820
Coffee	33	53	740	1,490
Plukenetia volubilis (Sacha Inchi)	1	40	1,150	2,310
Special breeds program (households)	0	50	130	260
Poultry (head)	3,632,200	4,000,000	360	720
Pig (head)	509,900	600,000	1,910	3,850
Cattle (head)	103,800	150,000	770	1,540
Tilapia	60	67	700	1,410

Table 31. The planned land use and projected income for commodities of interest, in 2015 and 2020. Source Xishuangbanna Bio Industrial Crops Bureau 5th 12 Year Plan.

Conclusions

Rubber is the major crop which dominates agricultural production systems. Other major crops include tea, banana, rice, vegetable and sugar cane. There is in particular a risk of land conversion to banana crop in lowland community forests and highland state forests.

Agriculture can be divided according to elevation: in the low elevations rubber is the major crop, covering nearly all available land area. In Mid elevations, rubber is also the dominant crop, followed by forested land and other farmed land. At higher elevations, forest is the major land use type. The main productive land use at higher elevations are tea plantations.

There are a number of high value niche crops which are under investigation by private and state organisations. Promising crops include: sacha inchi, moringa, orchid, medicinal plants, agar wood, and macadamia nuts. These crops are usually trialled privately, and then farmers in certain location are contracted to produce these new cash crops, with full training and equipment provided by the company.

Traditional land use practices were highly diversified and integrated between crops and trees, but these practices have been mostly abandoned in favour of high value monocrops. Some intercropping with rubber is practiced, although the motivation is economic and often the environmental impact is higher than it would have been without the intercropping. Such combinations are young rubber with pineapple, maize, cacao or *flamengia macrophyllia*; and older rubber with tea. A more environmentally beneficial option which is under investigation is the combination of rubber with other trees.

Jinghong and Mengla counties are dominated by rubber; however Menghai County has a more diverse land use profile and may provide examples of good economic, environmental and agricultural practices.

Chapter 3: Markets and Institutions

Markets

Value Chains

The main agricultural products are shown in Table 32. The commodities are usually sold to a company who processes them locally before export. Emerging high value products are generally farmed under a contract system. In this system, a company provides materials and training to farmers, and guarantees to buy the produce after harvest. Locally consumed products are sold much more informally, often the farmer will take the produce to market themselves and sell them directly, or entrepreneurs with their own vehicle will drive around buying produce to take to market. The most common value chains are shown in Figure 18, and a brief summary for the main products is given below.

Major Cash Commodities	Minor Cash Commodities	Produce for Local Consumption	Emerging High Value Commodities
Rubber		Rice	Macademia Nuts
			Moringa (Drumstick Tree)
Tea	Sugar Cane	Vegetables	
Banana	Maize	Fruit	Agar Wood
	Hemp	Pigs	Sacha Inchi
	Coffee	Chicken	Orchids
	Bamboo	Cow/Buffalo	Amom Villosum
	Timber	Walnuts	Medicinal Plants
		Fish	

Table 32. The major and minor cash commodities for export outside of Xishuangbanna, emerging high value products and the produce destined for local consumption.

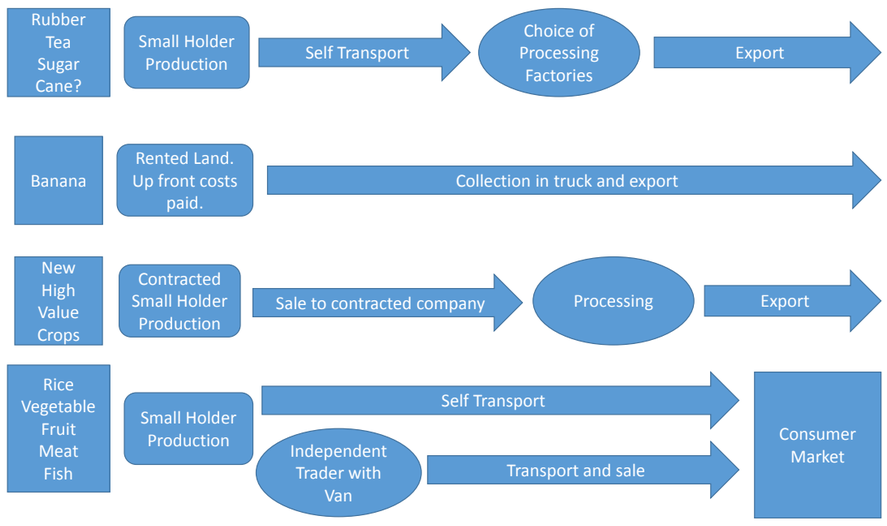


Figure 18. Indicative value chains for main types of commodities.

Rubber

Rubber is mainly grown on small holder properties. Small holders collect latex and mix it with an acid solution to form solids. These are collected for about one month and then self-transported to a local factory, where it is weighed and the small holder is paid accordingly. There are almost one hundred rubber processing factories in Xishuangbanna (see Figure 26 for the locations). They are generally owned by large companies who also deal with exporting the goods out of Xishuangbanna. According to expert interviews, it is common for small holders to drive to a second factory if the price is too low at the first; and it is common for small holders to share price information quickly via mobile phones

Global rubber prices rose sharply between 2000 and 2011. This was passed down all the way to small holders in Xishuangbanna who received increasing payment for their rubber at the factory gate. Figure 19 shows the price paid to small holder farmers at Mengxing State Farm (one of the major rubber plantations in Xishuangbanna). Prices rose sharply, from around 1000 USD per ton in 2,000 to 5,500 USD per ton 2011. Since 2011 there has been a price slump, which has also impacted upon small holders. As a result of the dip in prices, some smallholders have begun to rent out their plantations to others, while others have simply ceased tapping. Despite the price slump, research by the International Rubber Study Group suggests that there is still more demand than supply for rubber in China.

Local government officials reported that rubber is not taxed and therefore does not actually contribute directly to local government income.

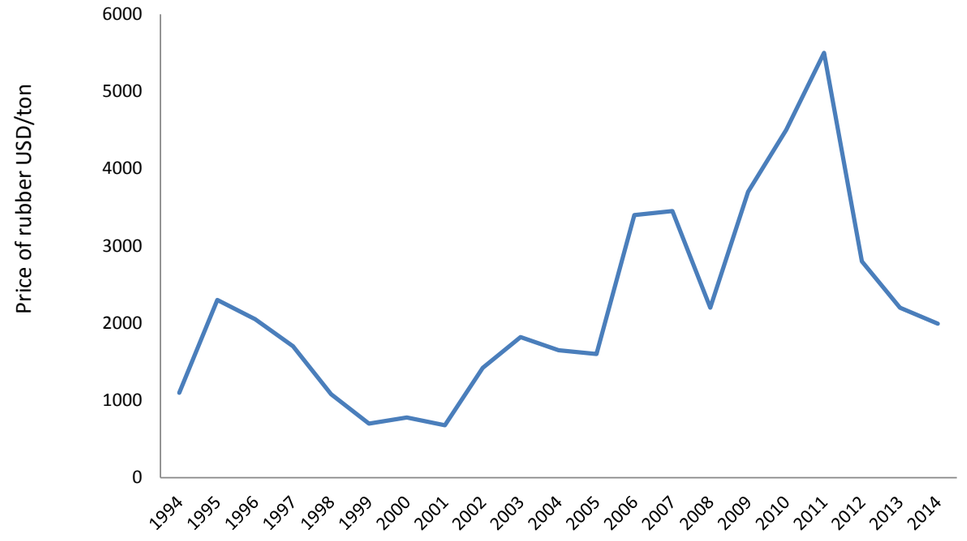


Figure 19. Price paid to small holders for their rubber, at Mengxing state farm (source International Rubber Study Group, n.d.).

Tea

Tea processing factories tend to be community owned, or family owned. Tea prices are dependent on quality, as well as on the reputation of the tea company, and of the area from which the tea originates. Interactions between tea companies and farmers are built on long standing relationships, and are usually place specific. Tea factories can exert significant influence over the methods farmers employ. If, for example a factory wants to obtain organic or ecological certification then that demand can filter down to the farmers.

The price of tea varies enormously depending on the quality and reputation. Figure 20 shows the wholesale price of 8 different teas sold by a single company – Da Yi Tea. While some tea is sold for as little as 200 RMB/kg, the most expensive is sold for 1400 RMB/kg. It is estimated that farmers receive 60-70% of the wholesale price.

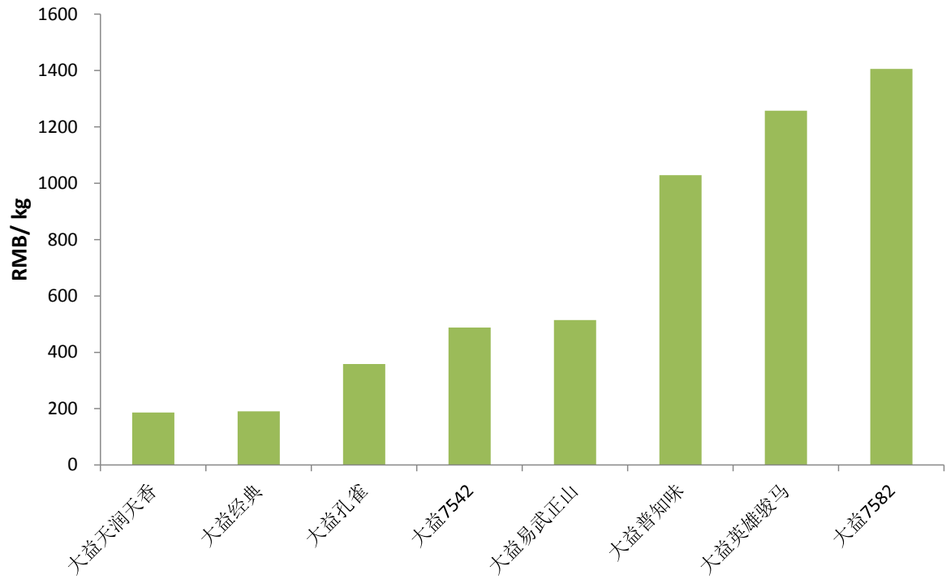


Figure 20. The Da Yi Tea Company's wholesale prices for different grades of tea.

Banana

The banana value chain is informally organised. Entrepreneurs rent land (small holder or community forest land) and contract farmers to raise the crops. There are also reports that entrepreneurs hire locals to clear patches of forested, sloping land to establish banana plantations. This is illegal but has not been challenged. The entrepreneurs who pay to establish the plantations are usually from outside Yunnan – Guangzhou is the most commonly cited location. Once bananas are ready for harvest, trucks arrive and transport the fruit out of Yunnan (again, typically to Guangzhou).

The crop is strongly affected by global and national price trends, as bananas are also imported into China and are grown in numerous other regions of China. The banana market price is, according to local sources, notoriously volatile.

New High Value Commodities

New, high value commodities have been introduced recently with the support of the Xishuangbanna Bio-Industrial Crops Office. Many of them can be intercropped with forest or rubber, and are intended to reduce the environmental impact of land use changes.

These crops are generally driven by a company who has a special interest in a particular crop. These companies often set up a demonstration area to showcase the benefit of their crops. Farmers are contracted to produce the new crop, full training and materials are given, and the company then buys back the crop. Often these products need to be processed in some way (e.g. oil extraction, or drying) before they are sold on as high value commodities such as beauty products, medicines, and health foods.

The farmer's sale price for orchids was reported to be 2-3,000 rmb (350-450 usd) per kilo of (dried) farmed orchids, and up to 8,000 rmb (1,200 usd) per kilo of wild orchids.

Locally Consumed Products

Products such as rice, vegetables, poultry, fish and pork which are produced and consumed inside Xishuangbanna are generally either sold to consumers in a local market by the farmer themselves; or an independent trader will visit small holders with a vehicle to buy the produce, before selling at a market to local consumers. These independent traders with vehicles are especially numerous in Menghai County where more vegetables and rice are grown.

Market Development

The Xishuangbanna Bio-Industrial Crops Office is a government department responsible for the interface between agriculture, environment and market. They work to develop major commodities such as tea and rubber, both in terms of marketing and improving the environmental impacts. They are also working to develop new high value products which can be integrated with other forest, rubber or tea systems.

In their 12th 5 year plan, the Bio-Industrial Crops Office published diagrams showing all potential products from the rubber and tea industries. The aim was to bring alternative products and markets to the attention of the major rubber and tea companies. These diagrams have been translated and are reproduced below as Figures 21 and 22.

The major undeveloped opportunities for rubber are: the use of rubber seed oil as a food or fuel; and rubber serum for high grade chemical uses.

Agricultural Inputs

Agricultural inputs and equipment are widespread in Xishuangbanna. There are many private shops which stock a wide range of chemical inputs and equipment which is affordable to most small holders. Fertilisers and pesticides are subsidised by the state contributing to their low prices and to the widespread problem of overuse.

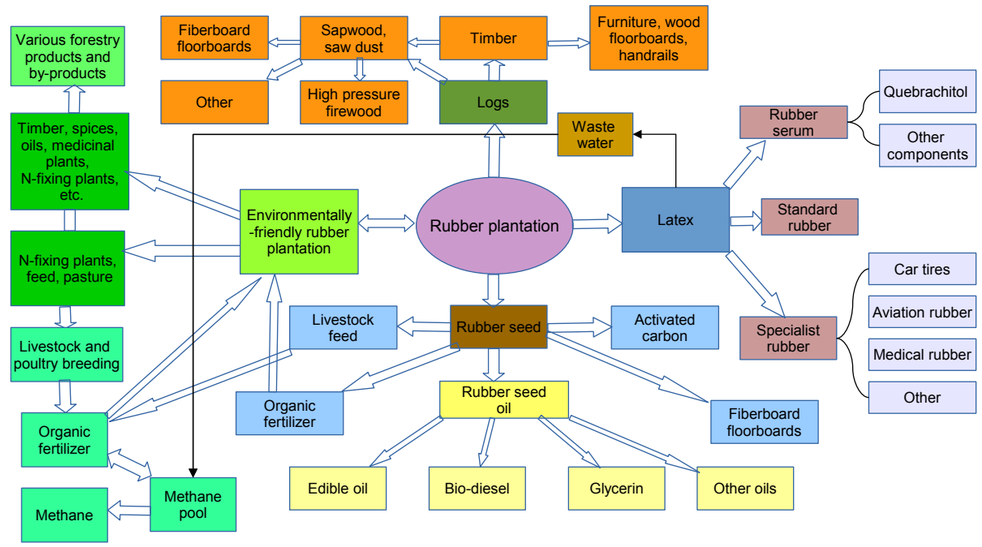


Figure 21. Potential rubber products and markets. Source: Chen et al, 2012.

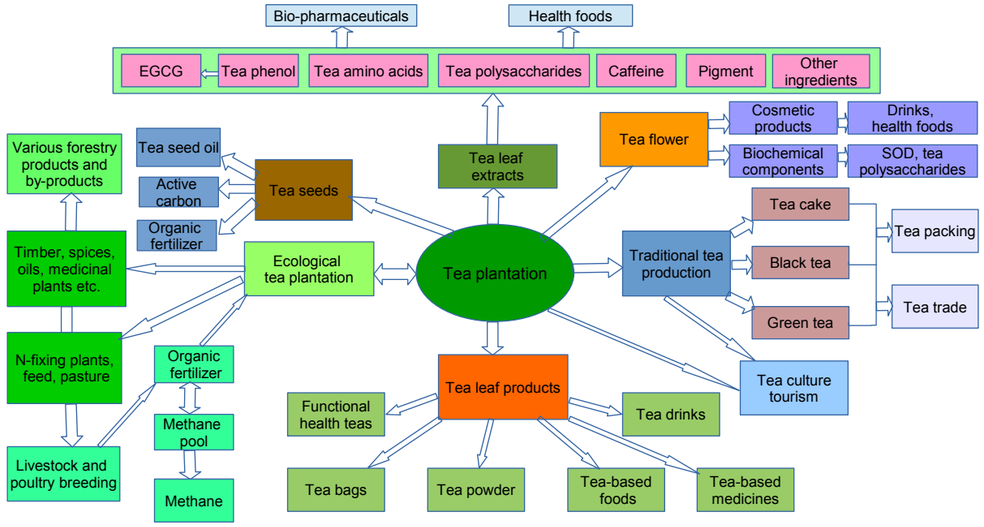


Figure 22. Potential tea products and markets. Source: Chen et al, 2012.

Import, Export and International Trade

Yunnan, and Xishuangbanna in particular, are situated at a junction point between many countries. To the southeast is Vietnam, to the south Laos, and to southwest Burma. The Mekong river flows between Laos and Burma to Thailand. There are border crossings to Vietnam, Laos and Burma. In addition there are highways which lead to Kunming, and then onto major Chinese transport hubs such as Guangzhou.

Figure 23 shows a map of the border crossings, the major markets, and trade routes. Table 33 shows the main commodities imported and exported along the trade routes.

	China	Vietnam	Laos	Thailand	Myanmar
Import from	Consumer Goods	Vegetables Rice Coffee Fruit	Timber Rubber Vegetables Illegal Wildlife Products Fruits Banana	Rice Fruit	Rubber Timber Illegal Drugs Illegal Wildlife Products[6]
Export to	Rubber Tea Sugar Banana Coffee Medicinal Plants Health Foods	Consumer Goods	Consumer Goods	Consumer Goods	Consumer Goods

Table 33. Main commodities imported and exported via trade routes in Xishuangbanna. Source: Expert Interviews with Bio Industrial Crops Office.

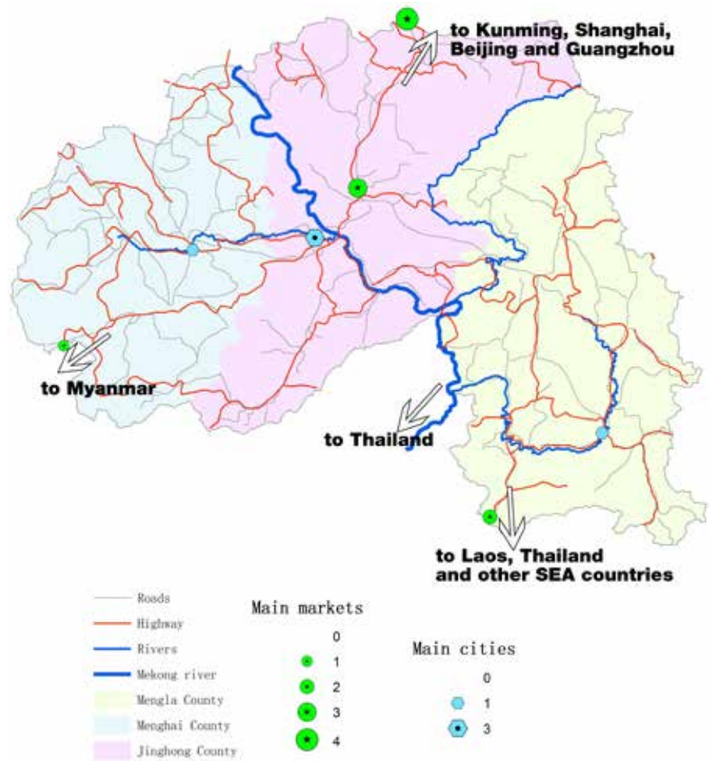


Figure 23. The Major trade routes in and out of Xishuangbanna.

Institutions

Land Tenure

The majority of land in Xishuangbanna is managed by small holders. Community forest land is managed by Village Committees; state forest land is managed by the Xishuangbanna Forestry Office; and nature reserves are managed by organisations appointed by the Xishuangbanna Environmental Protection Office.

Small holders do not 'own' land, but have the rights to use it, usually for a 99 year period, which is regularly renewed. Small holders usually have a piece (or pieces) of agricultural land and a piece of forestry land. There are restrictions on what can be done with the land, especially regarding timber and logging. The restrictions on clearing small holder forestry land may be one of the reasons that forest crops such as medicinal plants, forest tea, certain nuts and orchids are gaining in popularity.

Decision Making Power

When considering land management, there are two major tracks by which land managers are influenced. These are through the government system, and through the market system. These are illustrated in Figure 24.

The government system is essentially a centralised planning system, although a degree of decision making power is decentralised to each level. The market system is more complex, and contains different types of actors who may or may not interact. The market system is however highly developed and farmers are very responsive to signals from the market.

Farmers are in theory free to make their own decisions about what they grow, and a small minority of farmers experiment with new crops, techniques or livelihoods. In practice, however, market opportunities, price signals, and the availability of seedling, stock, equipment, and other inputs limit the range of sensible decisions available.

A recent study on land use decision making in two villages in Xishuangbanna found that villagers valued certain forest derived ecosystem services (fuel wood, timber, water regulation) as well as spiritual benefits, and decided collectively not to convert the old growth forests to rubber (Zhang et al. 2015). Such awareness of ecosystem services could be built upon when designing agricultural or land use interventions.

The Governmental System

Governmental plans are made at national and provincial level, and passed down to lower level government offices which have the job of implementation. Information for generating plans is collected by lower level government office, so in some respects the lower levels of the administration can exert influence over provincial and national level plans.

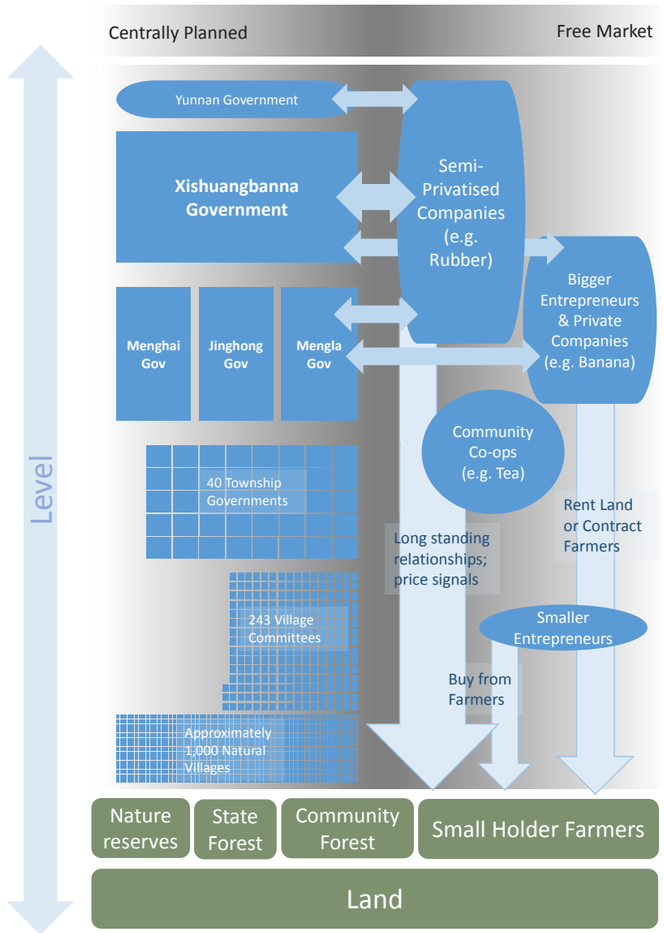


Figure 24. The two major tracks by which land managers are influenced.

Xishuangbanna is officially classified as an autonomous prefecture, which means it has a greater degree of decision making authority than a normal prefecture. This is in recognition of large number of ethnic minorities, particularly Dai (the official name is Xishuangbanna Dai Autonomous Prefecture). However, the Xishuangbanna prefectural government is still expected to obey plans formed at the provincial level.

The Xishuangbanna government is the most important decision making authority operating in the prefecture. Through various bureaus, decisions are made and communicated. The most relevant bureaus are: the Bio-Industrial Crops Office, the Agricultural Office, the Forestry Office, the Environmental Protection Office, and the Reform and Development Office.

The Bio-Industrial Crops Office works on cash crops and market development. They have strong links with semi-private and private companies, and strongly influence market conditions. The Forestry Office manage state-owned forestry land, and the Agricultural Office advise on agricultural policy and planning. One of the major roles of the Environmental Protection Office is the creation and management of nature reserves. The Reform and Development Office is concerned with improving living conditions and income for citizens.

Nature reserves and state forestry land are managed at the prefecture and county level, thus higher level decision makers have more control over these land types. Supervision of state forestry land is weak and illegal practices such as clearing for agriculture, poaching, or logging often go unchecked.

Community forests are managed at the village level by village leaders. Village leaders are bound by laws protecting the forests, and it is their duty to report anyone breaking these rules. There are, however, no adequate mechanisms for ensuring that village leaders fulfil these responsibilities, and many rent out community forest land for illegal purposes such as clearing for agriculture. This illegal activity is not usually reported to higher level government offices, meaning that action is rarely taken against illegal land conversion.

Small holder land is managed by small holders. Small holders are influenced by a number of actors: the government via village leaders, farming extension services, shops selling agricultural products, and, most importantly, by each other and by the agricultural companies who buy their products.

The Farming Extension Services

There is a farming extension service managed by the government, and which operates training and assistance centres at the township level. Farmers can visit these stations and get help fixing machines, instructions on how to use chemicals or agricultural inputs, and advice on managing major crops (usually rubber or tea). These stations also provide a selection of inputs which can be purchased, and sometimes team up with companies to offer farming equipment at discount prices.

These stations are not very well staffed, and the staff training is usually quite limited. Farmers often prefer to visit private shops to buy their agricultural inputs as, although the quality may not be as high, these shops offer a wider selection. The extension service has recently made an agreement with the major mobile phone operators that allows it to send news updates to all households via text message.

The government recognises that extension services are not the major knowledge transfer mechanism, and increasingly works with the medium to large companies who exert influence on farmers. New products are generally introduced by companies who contract farmers and provide them with the necessary training and materials. These relationships between farmers and private companies are often facilitated by the Bio-Industrial Crops Office. One drawback of this approach is that knowledge of new commodities and techniques is very localised: the knowledge is only passed to small holders in the location where the company operates.

The Market System

The major types of actors in the market system are large semi-privatised companies, private companies, community companies and small-scale entrepreneurs.

The semi-privatised companies have evolved from state owned companies that were originally set up to deal in major commodities. In Xishuangbanna these companies deal primarily with rubber, which requires considerable inputs, long payback times and complex processing. These types of companies have strong links with higher levels of prefectural and provincial government. After almost thirty years of operation these companies do not need to provide incentives or training to small holders; the market prices and potential profits are more than enough justification for most to convert land to rubber.

Private companies and bigger entrepreneurs act more independently of state organisations, but often still have links with prefectural or lower levels of government. These may be through the Bio-Industrial Crops Office or through personal contacts. Crops which are novel to the region or for which a new market emerges are usually brought in by these types of organisation: the biggest example is banana, but coffee has also gained ground in recent years. High value niche crops developed by these organisations include orchids, macademia, nut oils, and certain medicinal plants.

Private companies who want to introduce new crops generally use one of two systems. In the first, they rent land from farmers or village committees (who manage community forests), and hire the necessary labour. In the second system, they provide small holder farmers with the necessary training and equipment to cultivate the crop, and contract to buy the crop from the farmer once it is harvested.

Community companies mainly process tea, and have been established for longer periods of time. The reputation of these companies and the prices they are able to get for their tea is heavily dependent on their location. Interactions with farmers are built on long standing relationships, and are usually place specific.

Smaller entrepreneurs range from those with a large lorry, some money to invest and who intend to trade their goods outside the province (i.e. outside of Yunnan); to those who own a small van and trade locally, perhaps from one elevation to another or perhaps from one county to another. Generally, these actors will arrive and buy direct from the farmer, with little formal organisation or planning.

Research Organisations

Research capacity in China is generally high, and there are high level, well-funded research organisations based in Xishuangbanna, and based elsewhere but working in Xishuangbanna. The most active research organisations in Xishuangbanna are: Xishuangbanna Tropical Botanical Gardens; Xishuangbanna Tropical Crops Research Institute; The Kunming Institute of Botany; The Kunming Institute of Zoology; Yunnan University; Yunnan Agricultural University; Yunnan Environmental Resource Institute; The Tea Institute, Yunnan Academy of Agriculture; and the Yunnan Institute of Economics; and the Surumer Project (an International Research Project funded by GIZ and led by the University of Hohenheim).

Most research focuses on improving crop yields and economic production, as well as on balancing economic outputs with environmental protection. Major projects include friendly rubber trials and demonstrations, and environmentally-friendly tea plantations. Research into various high value crops and timber species which can be grown in combination with rubber form an important part of this research effort.

According to the stakeholder project survey conducted during a Humidtropics platform meeting in Jinghong (24th September 2014), participatory research methods are seldom employed and researchers in the area rarely build relationships with the farmers or communities to whom their research is intended to be relevant. The difficulties of building relationships between farmers and other stakeholders may furthermore be exacerbated by ethnic tensions. As discussed in chapter 1, Xishuangbanna is an ethnically diverse region in which Han Chinese are a minority. Han Chinese nevertheless dominate high level government and research positions, a fact which limits the credibility and legitimacy of their influence in the region.

Civil Society and NGOs

In China, foreign and local NGOs are highly restricted in their activities, and are subjected to close state supervision. Due to these reasons, there are not many NGOs operating in Xishuangbanna. The Worldwide Wildlife Fund (WWF) has a presence in Yunnan and conducts some research in Xishuangbanna. Flora and Fauna International and The Nature Conservancy conduct some biodiversity oriented work in Xishuangbanna, but do not have local offices. Chinese NGOs active in the region include the Wildlife Conservation Society, which encourages locals to act against poaching and illegal wildlife trade. Also active are the Hong Kong-based Kadoorie Farm and Botanical Garden which funds environmental education.

Though we are not aware of any currently operating projects in Xishuangbanna, there are also Kunming-based NGOs that operate across Yunnan. Green Watershed have operated numerous projects on, among other things, participatory water management, and corporate social responsibility. And The Environment and Biodiversity Legal Clinic has run programs in Yunnan to monitor water pollution.

Environmental NGOs operating outside of Xishuangbanna and Yunnan may also be important stakeholders insofar as they seek to raise environmental consciousness across China, and target consumers of products potentially produced in Xishuangbanna. The Friends of Nature, for example, seek to promote awareness of China's environmental problems, including by running winter environmental education camps for urban children at Xishuangbanna Tropical Botanical Gardens. Another national NGO, The Shanshui Conservation Center, campaigns to promote environmentally conscious consumer choice.

There is also very little space for cultural or self-representation groups, such as farmer unions or co-ops; or ethnic minority representation groups. Such groups can be perceived as socially radical and as such can be risky for members.

Recent Institutional and Policy Approaches to Agro-environmental challenges

Environmentally-friendly Rubber

There is a long history of rubber planning in Xishuangbanna. In the early 1960s a strategy report was published by Chinese agricultural scientists describing where in China rubber should and should not be planted, including much detail on Xishuangbanna[2]. They identified three tiers of productivity zones, and a strategy to avoid excessive detrimental impacts on ecosystem services such as water and soil. Part of this strategy included not planting rubber at high altitudes, leaving mountain tops forested to avoid soil erosion and to aid water flow, and carefully managing plantations near to water courses. The strategy advocated environmentally sensitive management of 20% of the projected rubber plantations in Xishuangbanna. Unfortunately, during the transitions from centralised planning to free market economy and the rubber price boom, much of this wisdom was forgotten.

In 2009, the Leadership group for Environmentally-friendly Rubber was established. Core stakeholders were research scientists from Xishuangbanna Tropical Botanical Gardens and government staff from the Xishuangbanna Bio-Industrial Crops Office. Strategies were developed on how rubber should be managed in Xishuangbanna, drawing upon the 1960s strategy as well as on new ideas for intercropping high value species and watershed management. In 2010 the Bio-Industrial Crops Office published their 12th Five Year Plan which was strongly supportive of environmentally-friendly rubber and new high value intercropping opportunities (Chen et al. 2012). Two key details of this plan were that rubber should not be allowed over 800 m elevation, with existing plantations at above 800 m to be converted to alternative land uses; and that rubber should not be planted on slopes steeper than 23°.

Further meetings were organised in order to promote this new strategy to rubber companies. In 2011, this led to two companies establishing 130,000 mu (8,500 ha) of demonstration plots managed according to the guidelines laid out by the Leadership Group for Environmentally-friendly Rubber. It will take a further 5-7 years before the economic value of these plots can be properly appraised. In the meantime, promotional literature has been produced and there is an open invitation for research organisations and businesses to visit the demonstration sites. Small holder training is not directly conducted.

In 2012, the Xishuangbanna Tropical Crops Research Institute also began a program on environmentally-friendly rubber. Their program runs in parallel with that of the Bio-Industrial Crops Office, but includes a greater amount of agronomic experimentation. The Tropical Crops Research Institute was established in order to develop rubber in Xishuangbanna, and plays a strong role in training small holders and developing rubber clones capable of tolerating the region's low minimum temperatures.

Major questions about the implementation of environmentally-friendly rubber at a landscape level still need to be addressed. Questions include how to incentivise environmental management by small holders; how to decrease the expansion of upland rubber; how to deliver training and knowledge of new techniques to small holders; and how to distribute the 20% target for environmentally managed rubber across the region.

2 Despite much discussion of this important report during expert interviews we have not been able to find a copy, or to get a citation.

Environmentally-friendly Tea

The Bio-Industrial Crops Office also manage a program to develop Environmentally-friendly Tea[3]. A set of guidelines has been developed, which includes recommended local variety tea species, limits on chemical inputs, and biodiversity-conscious intercropping of teak, macadamia, cacao, fruit, spices, and moringa other crops. There is a demonstration area of about 100,000 mu (6,500 ha) in Menghai.

A target was set for 30% of tea plantations to be managed according to these principles: the Bio-Industrial Crops Office report that this has already been achieved for 24% of tea plantations.

Payments for Eco-System Services

A provincial level law was passed in 2010 to devolve powers to the Xishuangbanna government for planning and instituting its own eco-compensation mechanisms. Various studies have been conducted on how to best organise and implement such mechanisms. This could be a major component of incentives to promote environmentally-friendly land use in the region.

Conclusions

Xishuangbanna has a well-developed market system, and strong penetration of private sector into rural areas. Government institutions are well funded and well organised, and capacity is high, relative to neighbouring countries. Research institutions are similarly well funded and well developed, with high capacity.

The capacity of farming households is difficult to assess because of a lack of hard data. However, from expert reports, knowledge is generally very low regarding effective management of commercial crops. Farmers generally learn from each other, and have very little knowledge about issues such as soil fertility.

Communication and knowledge exchange between experts and rural households is weak. The government extension service is minimally staffed and not well used. Where private sector companies establish contract farming operations with households, training and materials are provided. The effect of this is however very localised.

3 For the guidelines, see: 勐海县生态茶园建设技术规程， 勐海县茶叶局，2013年11月15日。

Chapter 4: Natural Resource Management and the Environment

Xishuangbanna has two natural environmental features of specific interest in China. The first is that it harbours a disproportionately large amount of the nation's biodiversity. The second is that it is one of only two Chinese locations which can produce rubber (the other is Hainan Island). The major natural resources of Xishuangbanna are described in this chapter in turn, the trends and drivers discussed, and the main efforts for protection, conservation or sustainable management summarised.

Biodiversity

Xishuangbanna covers only 0.2% of China's land area, but it harbors nearly 10% of China's fish species, 15% of amphibians and reptiles, 16% of plants, 22% of mammals, and 36% of birds (Zhang & Cao 1995). Xishuangbanna has been selected as one of 32 national level biodiversity conservation priorities by the Ministry of Environment Protection (Ministry of Environmental Protection n.d.; cited in Yi et al. 2014). Xishuangbanna connects two globally recognized biodiversity hotpots, the Mountains of Southwest China and the Indo-Burma Mountains.

The rapid conversion of forest to rubber plantation now presents a serious threat to Xishuangbanna's biodiversity. Studies on the island of Hainan, China show that monoculture rubber plantations on steep and hilly lands result in increased soil erosion, soil nutrient loss, reduced stream volume, and runoff becoming more seasonal (He & Huang 1987; Zhang et al. 2000; Cha et al. 2005). Rubber trees also withdraw water longer than natural vegetation during the dry season, leading to greater depletion of water in the deep soil. Therefore, the local government is caught between two conflicting objectives: the need for rapid economic development of the rural poor on the one hand; and on the other, the view that the detrimental effects of monoculture rubber plantations on natural forests, ecosystem services and biodiversity are a threat to national security. This tension is compounded by the fact that the areas where rubber grows and yields best are also the most biodiverse areas (Yi et al 2014).

In a comprehensive review of academic and government literature, supported by key informant interviews, Xu et al (2014) found that due to rubber expansion and the abandonment of swidden-fallow agriculture, structural and functional biodiversity was reduced. This environmental degradation has affected charismatic species such as the Asian Elephant and White Cheeked Gibbon. In addition, they found that the abundance and diversity of many other species has diminished; and that habitat fragmentation has increased. Due to habitat loss, all amphibians, reptiles and mammals in Xishuangbanna are now found on the IUCN Red List, meaning they are classified as threatened or endangered (IUCN 2014).

Forest land

Xishuangbanna was originally heavily forested. In 1976 forests accounted for about 70% of land mass (Li et al. 2006). There has been a trend of deforestation since then. Accurate figures on deforestation are difficult to acquire from official governmental sources. However, two systematic studies of satellite imagery between 1976 and 2003 Li et al (Li et al. 2009; Li et al. 2007) found that by 2003 forest cover in Xishuangbanna shrank from 69% to less than 50% of the landscape; that the important tropical seasonal rainforest shrank from 10.9% to 3.6%; that the total number of forest fragments increased; that the average fragment size decreased by almost 50%; and that the amount of edge habitat and the average distance to other forest patches increased. There has been no systematic study of forest area since 2003; but we infer that deforestation has increased, as the amount of land planted with rubber almost tripled between 2002 and 2010 (from 153,000 ha to 424,000 ha, Xu et al 2014).

Water

It has been established that large scale rubber plantations deplete the ground water supply through high water demand (Guardiola-Claramonte et al. 2010; Tan et al. 2011). Figure 25 shows a map of calculated water availability, based on assumed water demand of vegetation type, precipitation, soil type and average soil moisture. It is clear to see that the main regions of low water availability are the areas planted with rubber. See Figure 26.

Water pollution is also a problem. Xu et al (2014) found that fertiliser use for rubber crops has led to the eutrophication of water bodies, and herbicide run off has contaminated local drinking water supplies. Further pollution is caused by rubber processing facilities, producing 14.4 million tons of waste water, 10.6 million tons of which is discharged into the river systems with no treatment. A further 15.4 million tons of water is discharged from households, most of which receives no treatment before entering the river system (information from interview with official at Xishuangbanna Hydrological Bureau). A further threat to water quality is mono-cropped banana. Though there is as yet no published research on water pollution in Xishuangbanna due to banana cropping, banana farmers tend to use high levels of chemical inputs, and significant run off into water bodies is likely. Data on the levels of water pollution was difficult to find, but according to interviews and anecdotal evidence, water which was safe to drink ten years ago is no longer safe, and the numbers of river fish have declined markedly during the last ten to twenty years.

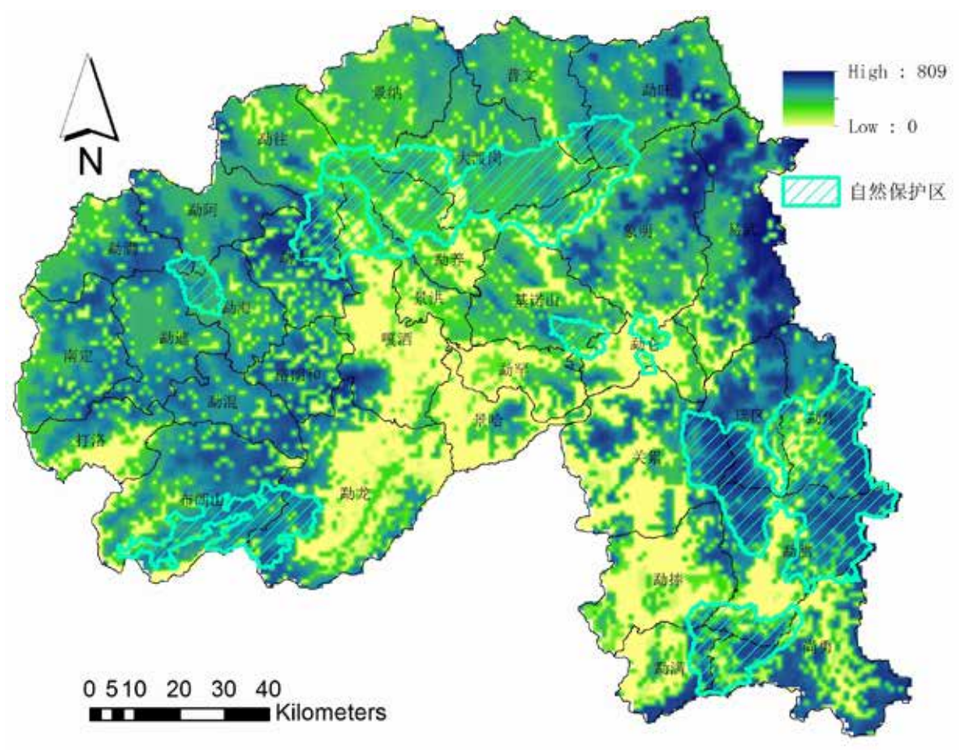


Figure 25. Calculated water availability for Xishuangbanna. Source: Yi 2013.

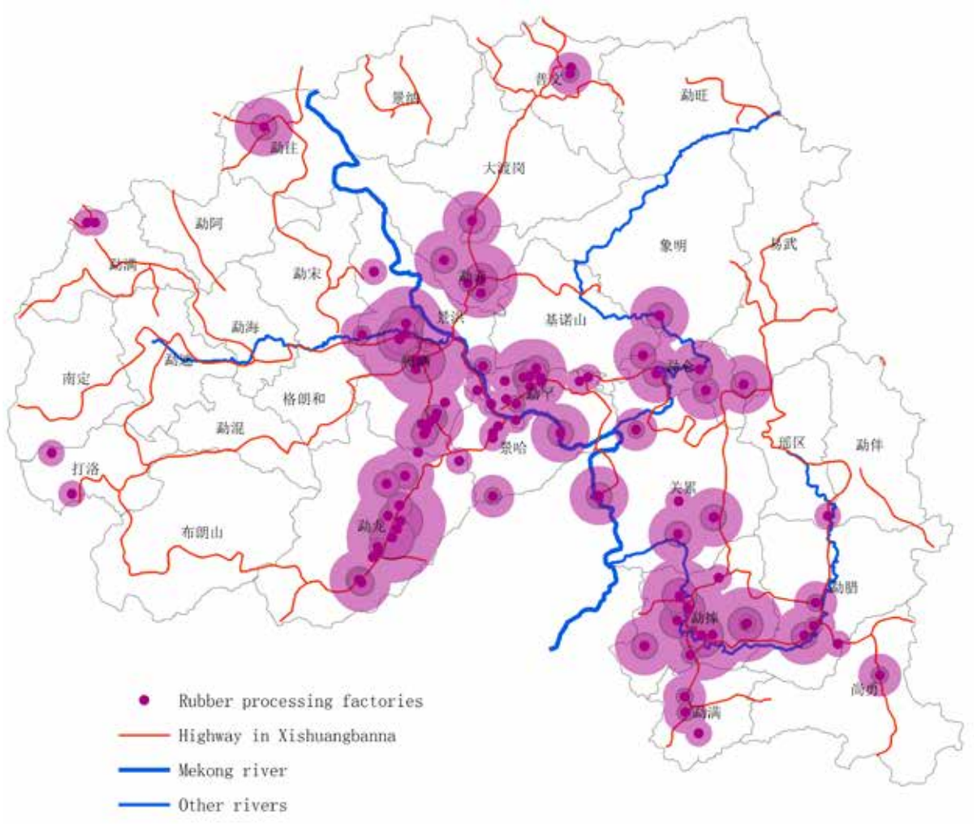


Figure 26. Rubber processing plants in Xishuangbanna, and the major waterways. Highways are also shown on this map.

Carbon Stocks

The conversion of forest land to rubber and other crops has resulted in a net release of carbon dioxide to the atmosphere (Li et al. 2008; de Blécourt et al. 2013)for which the impacts on soil carbon stocks have hardly been studied. In montane mainland southeast Asia, monoculture rubber plantations cover 1.5 million ha and the conversion from secondary forests to rubber plantations is predicted to cause a fourfold expansion by 2050. Our study, conducted in southern Yunnan province, China, aimed to quantify the changes in soil carbon stocks following the conversion from secondary forests to rubber plantations. We sampled 11 rubber plantations ranging in age from 5 to 46 years and seven secondary forest plots using a space-for-time substitution approach. We found that forest-to-rubber plantation conversion resulted in losses of soil carbon stocks by an average of 37.4\u00b14.7 (SE. Conversely, ecologically sensitive management could result in net carbon storage. One possibility that has been mooted is for the raising of funds through carbon credits as an incentive for ecological management, although the carbon price would need to be very high in order to completely cover the opportunity costs in high profit regions (Yi et al 2014). A more promising alternative is that carbon payments could be used to dissuade farmers from establishing marginally profitable high altitude rubber plantations.

Li et al (Li et al. 2006) estimate that by 1976 above ground carbon stocks in Xishuangbanna were approximately 87 Mt, but that this fell to about 80 Mt by 2003. Yi et al (2014) estimate that a conservation oriented land use plan could sequester approximately 2 Mt of carbon by 2035; whereas all out rubber development would release an additional 2Mt. Yi et al (2014) also estimate that a carbon price of 20 USD/t could completely fund their conservation oriented scenario; and that a carbon price of 10 USD/t could fund 59% of their conservation scenario.

Below ground carbon is more difficult to estimate. De Blécourt et al (de Blécourt et al. 2013)for which the impacts on soil carbon stocks have hardly been studied. In montane mainland southeast Asia, monoculture rubber plantations cover 1.5 million ha and the conversion from secondary forests to rubber plantations is predicted to cause a fourfold expansion by 2050. Our study, conducted in southern Yunnan province, China, aimed to quantify the changes in soil carbon stocks following the conversion from secondary forests to rubber plantations. We sampled 11 rubber plantations ranging in age from 5 to 46 years and seven secondary forest plots using a space-for-time substitution approach. We found that forest-to-rubber plantation conversion resulted in losses of soil carbon stocks by an average of 37.4\u00b14.7 (SE published results from experimental plots in Xishuangbanna showing that the loss of carbon from soils was greater than the change in above ground biomass carbon, when converting secondary forest to rubber. On average 37tC per ha was lost from soil carbon, compared to an estimated maximum of 18tC per ha from above ground biomass.

Soil

The major challenge to soils in Xishuangbanna are erosion due to cultivation on steep slopes. Further challenges are declining fertility and soil biological activity due to unsustainable monocropping with high agro-chemical inputs (Xiao et al. 2014); and soil hardening in locations where rubber has been long established.

Although the degradation of soil is one of the most fundamental declines in ecosystem services, it has not been clearly described in the literature concerning Xishuangbanna. Lack of awareness about soil health was also cited as a common problem when attempting to educate farmers about more environmentally-friendly practices.

Contribution of Major Land Uses to Environmental Degradation

Finally, we conceptualise the major land uses and the environmental problems they contribute towards in Figure 27. For example, rubber establishment first entails conversion from a previous land use (usually forest), then extensive use of agro-chemicals. Many rubber plantations are on sloping sites and increase soil erosion until the rubber trees have established sufficient root structures (after about 5 years). At the landscape scale, the water table is depleted. These factors all combine to lead to biodiversity loss. Other land uses can be conceptualised in the same way.

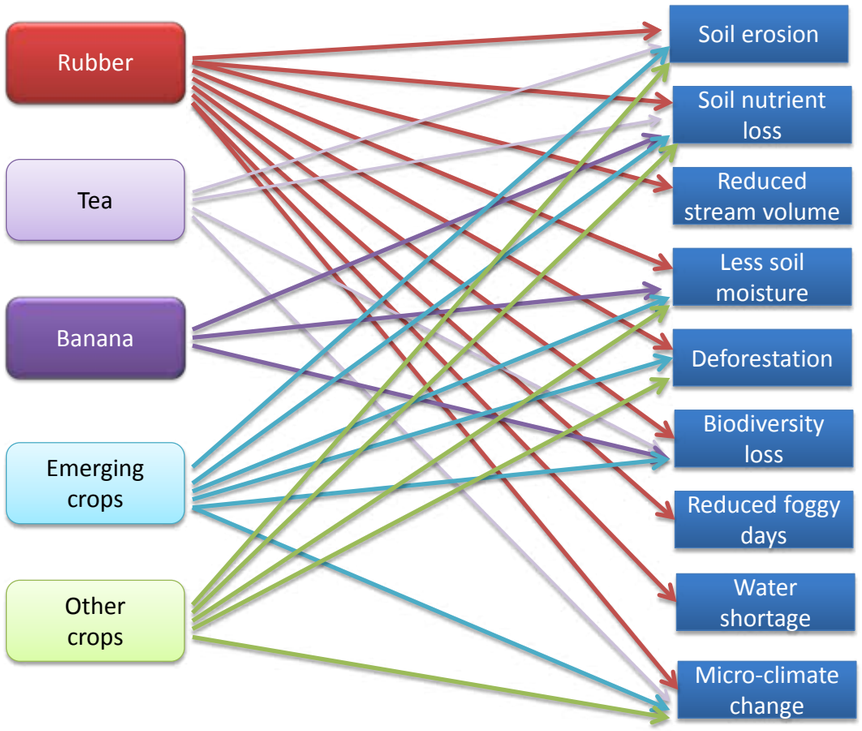


Figure 27 shows the major land uses and the environmental problems which they contribute towards.

Proposed Solutions to Environmental Problems

National Parks and Conservation Corridors

The first national nature reserve was established in Xishuangbanna in 1958, and today 12.6% of the total land area is protected (Xu et al 2014). The nature reserves have been a success in terms of conservation of some species, especially elephants, and undoubtedly have conserved more biodiversity than otherwise would have been possible. Even so, the pressure of rubber expansion has caused damage to natural resources and biodiversity, and further measures are needed in order to limit further damage.

A major study funded by the Asia Development Bank and performed by the Greater Mekong Subregion Core Environment Program attempted to develop a conservation strategy for Xishuangbanna, taking into account not only biodiversity but also the value of ecosystem services (Xi 2009).

Figure 28 shows the biological corridor plan which was developed in order to connect the nature reserves of Xishuangbanna. The areas within the yellow boxes are the two case study locations for valuation of ecosystem services. The project findings were well received locally and government funds were released to plant the corridors with the chosen tree species; work was completed in 2011. However since then there has not been any monitoring strategy to check on the condition and development of those corridors.

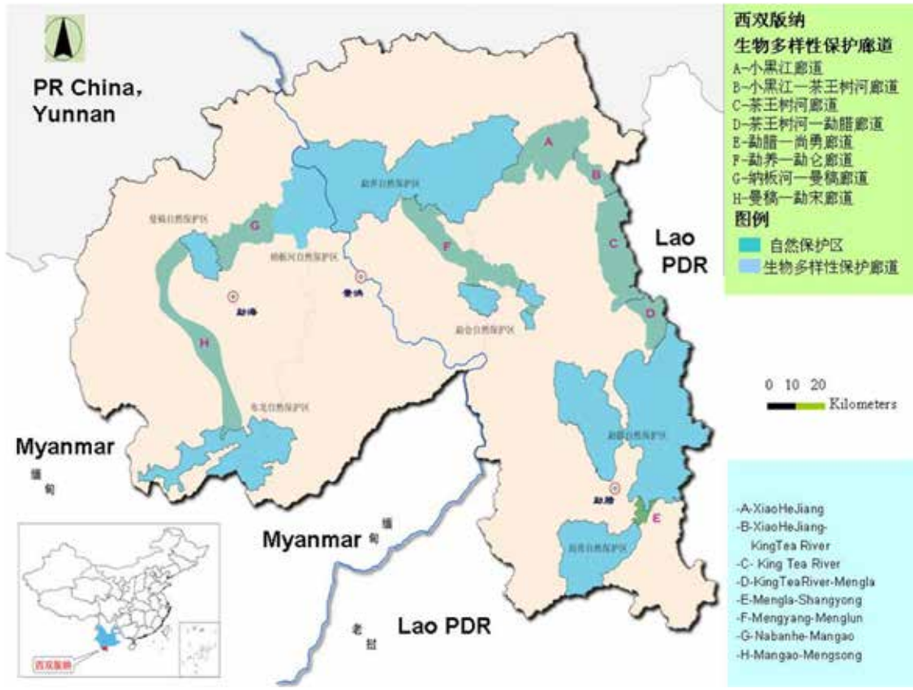


Figure 28. Proposed biodiversity corridors between national parks in Xishuangbanna. Source Xi 2009.

Payments for ecosystem Services

The two ecosystem valuation case studies (covering a total area of 164,913 ha) carried out by Xi (2009) show a potential value of $1.16 billion USD from forest ecosystem services. Carbon sequestration contributes the largest proportion of these potential benefits, followed by water regulation and nutrient cycling. Non timber forest products (NTFPs) turn out to provide only a minor factor due to limited collection and market opportunities in the case study areas. NTFPs nevertheless play a very important role in people's lives and have the greatest potential to provide a cash realisation of the value of the ecosystem services. The major recommendations from Xi's (2009) report were: incentives for forest conservation, restoration and watershed protection; and disincentives for uncontrolled expansion of rubber and forest conversion on marginal soil and steep slopes.

The local government, in collaboration with scientists from Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences, has been exploring policy mechanisms to control forest conversion and provide economic incentives for forest restoration. In 2009, the "Leadership Group for Environmentally-Friendly Rubber" (LGEFR) was established, followed by the approval of the "Green Rubber Management in Xishuangbanna" guidelines, which clearly require the design of market-based eco-compensation/payment schemes and rewards for ecosystem services. In 2011, the Government of Yunnan approved the "Regulation and administration of natural rubber growing in Xishuangbanna". This regulation includes a regional environmental rewards mechanism. According to the regulation, developing a regional, market based rewards scheme will be an opportunity for Xishuangbanna to bring back natural forests. Yi et al (2013; 2014) found that although current carbon prices were too low to stimulate major land use changes in areas where rubber profits are high, much of the new rubber expansion has been into higher elevation, steeper land where rubber is only marginally profitable. The offer of carbon payments may be enough to reduce the expansion and even re-convert these marginal rubber plantations back to other land uses.

Diversified Land Use

The Bio-Industrial Crops Office of the Xishuangbanna Prefectural Government is the most active major stakeholder in developing new crops and diversified cropping strategies, along with the Tropical Crops Research Centre, and the Xishuangbanna Tropical Botanical Garden. There are also a number of private companies and small holders developing such schemes; sometimes in partnership and sometimes individually.

The Bio-Industrial Crops Office have published a five year plan which outlines a rubber land use strategy which takes into account ecosystem services (Chen et al. 2012). The main points are that high altitude, hilltop (higher than 800 m) and steep (more than 23°) rubber should be avoided, and that water courses and other corridors should be planted with buffer zones of native plant species.

Conclusions

Xishuangbanna's extremely high biodiversity has been badly damaged by deforestation and the conversion of large tracts of land to rubber farming, and other commercial farming systems. In recent years, much of the remaining high altitude forest has been lost to new rubber plantations. Population expansion has also contributed to over exploitation of resources (see chapter 1). No comprehensive survey was found on the state of biodiversity in Xishuangbanna at present.

Agro-environmental problems are common and well reported in interviews but, again, data is not easy to find. Such problems include soil erosion, soil hardening, declining soil fertility, water pollution and water scarcity.

Chapter Five: Conclusions

The purpose of this report is to provide an evidence base and first step in the process of identifying entry themes for Humidtropics to work on. The following entry themes are tentatively offered, based on the findings of this report.

Entry Themes

Rubber and other Plantations

1. Rubber is fast expanding into high altitude areas where profits are low and the impact on ecosystem services (water catchments, soil erosion, forest loss) may be high. How can we simultaneously improve living standards, and protect biodiversity? How can we slow rubber expansion into new high altitude areas, and reduce the impact of existing plantations?

2. Low and mid-elevation rubber is already well established and gives high profits. How can we incentivise and encourage more sustainable management for ecosystem services (such as clean water and biodiversity)?

3. Expansion of new plantation crops such as banana or coffee can lead to unregulated forest loss and damage to ecosystem services.

Unequal Economic Benefits

4. Those who own lowland rubber plantations are wealthier and have more opportunities than those who live further up the valley sides or on the hill tops. This has come at the expense of much loss of forest. However, those who live higher up and have mostly kept forests which sustain services such as naturally regulated water flow throughout the year, and biodiversity preservation. How can this balance be made more equitable, so that the uplanders receive fair reward for maintaining ecosystem services?

5. Some ethnic groups seem to be considerably poorer than others: we identified the Bulang and the Aini as groups who may benefit particularly from assistance schemes. These groups may also be able to advise on traditional integrated agricultural methods.

6. There are some problems which have come with the economic benefits of rubber to the lowland peoples – most notably lack of interest in youth education and the risks that a rubber price crash would leave few options for alternative incomes.

Alternatives to Plantation Expansions

7. Using crops and tree species which are high value, contribute to more diverse agricultural systems and benefit ecosystems. Intercropping techniques and new varieties can draw on traditional knowledge and the new niche crops investigated by the Bio-Industrial Crops Office and Tropical Crops Research Institute.

8. Developing eco-compensation schemes. What is the potential of payment for ecosystem services to incentivise changes in land management? Payments could be for carbon sequestration, water catchment management, biodiversity protection, and reducing chemical pollution

9. Tourism is a major element of the economy in Xishuangbanna. Can eco-tourism be developed to spread benefits amongst land managers (such as small holders, nature reserves or forest managers) in order to encourage sustainable management?

10. Enhance capacity for local processing of crops into value added products – for example roasting coffee before sale.

Constraints

11. Knowledge transfer mechanisms from experts to farmers are weak. Can we improve knowledge transfer systems using the government extension services (who have widespread coverage) or partnerships with contract farming companies (who have expertise but not geographic coverage)?

Blind Spots for Further Investigation

1. Lack of verified information and official data on water pollution.

2. Lack of high quality data on the overuse of fertilisers and pesticides

3. Illegal wildlife trade – mainly for meat and medicine. Wildlife is both hunted locally and imported from neighbouring countries (Laos, Myanmar).

4. The timber trade from Myanmar and Laos is reported to be a route for illegally or unsustainably logged timber to enter the Chinese market. As deforestation increases in Laos and Myanmar, there are reports of large wildlife (tigers, elephants) being driven into Xishuangbanna.

5. This report lacks detailed information on livelihoods, ethnicity or agricultural practices in Menghai. Jinghong and Mengla counties are covered by a household survey.

6. Border trade and interactions with neighbouring countries

References

Ahmad, F., 2001. Sustainable agriculture system in Malaysia. In *Regional Workshop on Integrated Plant Nutrition System (IPNS), Development in Rural Poverty Alleviation, United Nations Conference Complex, Bangkok, Thailand*. pp. 18–20.

Van Asten, P.J.A. et al., 2011. Agronomic and economic benefits of coffee–banana intercropping in Uganda's smallholder farming systems. *Agricultural Systems*, 104(4), pp.326–334.

De Blécourt, M. et al., 2013. Soil carbon stocks decrease following conversion of secondary forests to rubber (Hevea brasiliensis) plantations. *PloS one*, 8(7), p.e69357. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3716606&tool=pmcentrez&rendertype=abstract [Accessed December 5, 2014].

Cha, Z. et al., 2005. Sustainable land management practices for rubber plantations in Mountainous Area of Hainan. *Soils (China)*, 15(3).

Chen, J. et al., 2012. *Xishuangbanna Bio-Industrial Crops Office 12th 5 year plan*,

Cohen, P., 2000. Lue across Border: Pilgrimaging and the Muang Sing Reliquary in Northern Laos. In G. Evans, C. Hutton, & K. E. Kuah, eds. *Where China meets Southeast Asia : social & cultural change in the border regions*. New York: St. Martin's Press.

Coward, E.W., 2006. Tai Valley-based Polities and the Uplands in Montane Southeast Asia. *Mountain Research and Development*, 26(3), pp.284–289.

Davis, S., 2003. Premodern Flows in Postmodern China: Globalization and the Sipsongpanna Tais. *Modern China*, 29(2), pp.176–203.

Guardiola-Claramonte, M. et al., 2010. Hydrologic effects of the expansion of rubber (Hevea brasiliensis) in a tropical catchment. *Ecohydrology*, 3(3), pp.306–314.

He, K. & Huang, Z., 1987. *Rubber Cultivation at the North Fringe of the Tropics*, Guangdong: Guangdong Science and Technology Publishing House.

IUCN, 2014. *IUCN Red List*,

Leshem, A. et al., 2010. Can intercropping innovations bring ecological and economic goals together? The case of Nabanhe Nature Reserve, China. In *Building sustainable rural futures: the added value of systems approaches in times of change and uncertainty. 9th European IFSA Symposium, Vienna, Austria, 4-7 July 2010.* BOKU-University of Natural Resources and Applied Life Sciences, pp. 1103–1108.

Li, H. et al., 2009. Clearance and fragmentation of tropical rain forest in Xishuangbanna, SW, China. *Biodiversity and Conservation*, 18(13), pp.3421–3440. Available at: http://link.springer.com/10.1007/s10531-009-9651-1 [Accessed November 19, 2014].

Li, H. et al., 2006. Demand for rubber is causing the loss of high diversity rain forest in SW China. *Biodiversity and Conservation*, 16(6), pp.1731–1745. Available at: http://link.springer.com/10.1007/s10531-006-9052-7 [Accessed November 19, 2014].

Li, H. et al., 2007. Land Use/Land Cover Dynamic Change in Xishuangbanna Based on RS and GIS Technology. *Journal of Mountain Science*, 3, p.003.

Li, H. et al., 2008. Past, present and future land-use in Xishuangbanna, China and the implications for carbon dynamics. *Forest Ecology and Management*, 255(1), pp.16–24. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0378112707004549 [Accessed August 1, 2014].

Li, Y., 2007. *The situation and direction of Xishuangbanna Prefecture's elderly population*, Jinghong: Xishuangbanna Prefectural People's Consultative Conference.

Liu, H. et al., 2002. Practice of conserving plant diversity through traditional beliefs: a case study in Xishuangbanna, southwest China. *Biodiversity and Conservation*, 11(4), pp. 705–713.

McCarthy, S.K., 2009. *Communist multiculturalism : ethnic revival in southwest China*, Seattle: University of Washington Press.

Ministry of Environmental Protection, *China National Biodiversity Conservation Strategy and Action Plan (2011-2030)*.

Nijman, V. & Shepherd, C.R., 2015. Trade in tigers and other wild cats in Mong La and Tachilek, Myanmar – A tale of two border towns. *Biological Conservation*, 182, pp.1–7. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0006320714004121 [Accessed December 9, 2014].

Pei, S., 1985. Some effects of the Dai people's cultural beliefs and practices upon the plant environment of Xishuangbanna, Yunnan Province, southwest China. In *Cultural values and human ecology in Southeast Asia*. University of Michigan, Center for South and Southeast Asian Studies.

Rajasekharan, P. & Veeraputhran, S., 2002. Adoption of intercropping in rubber smallholdings in Kerala, India: a tobit analysis. *Agroforestry Systems*, 56(1), pp.1–11.

Reuse, G., 2010. *Secularization of sacred space: an analysis of Dai farmers planting rubber trees on holy hills in Xishuangbanna, Yunnan, China*. Environment: Department of Geography.

Riedel, S. et al., 2014. The productivity of traditional smallholder pig production and possible improvement strategies in Xishuangbanna, South Western China. *Livestock Science*, 160(0), pp.151–162. Available at: http://www.sciencedirect.com/science/article/pii/S1871141313005027.

Rodrigo, V.H.L., Stirling, C.M., et al., 2005. Interplanting banana at high densities with immature rubber crop for improved water use. *Agronomy for Sustainable Development*, 25(1), pp.45–54.

Rodrigo, V.H.L., Stirling, C.M., et al., 2005. The growth and yield of rubber at maturity is improved by intercropping with banana during the early stage of rubber cultivation. *Field Crops Research*, 91(1), pp.23–33.

Ruf, F.O., 2011. The Myth of Complex Cocoa Agroforests: The Case of Ghana. *Human ecology: an interdisciplinary journal*, 39(3), pp.373–388. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3109247&tool=pmcentrez&rendertype=abstract [Accessed November 13, 2014].

Sturgeon, J.C., 2013. The Cultural Politics of Ethnic Identity in Xishuangbanna, China: Tea and Rubber as "Cash Crops" and "Commodities." *Journal of Current Chinese Affairs*, 41(4), pp.109–131.

Tan, Z.-H. et al., 2011. Rubber plantations act as water pumps in tropical China. *Geophysical Research Letters*, 38(24).

Xi, J., 2009. Valuation of ecosystem services in Xishuangbanna biodiversity conservation corridors initiative pilot site, China. *Greater Mekong Subregion Enviroment Operations Center*.

Xiao, H.F. et al., 2014. Intensive rubber cultivation degrades soil nematode communities in Xishuangbanna, southwest China. *Soil Biology and Biochemistry*, 76(0), pp.161–169. Available at: http://www.sciencedirect.com/science/article/pii/S0038071714001734.

Xu, J., 2005. Rattan and Tea-Based Intensification of Shifting Cultivation by Hani Farmers in Southwestern China. In *Voices from the forest : integrating indigenous knowledge into sustainable upland farming*.

Xu, J., Grumbine, R.E. & Beckschäfer, P., 2014. Landscape transformation through the use of ecological and socioeconomic indicators in Xishuangbanna, Southwest China, Mekong Region. *Ecological Indicators*, 36, pp.749–756. Available at: http://linkinghub.elsevier.com/retrieve/pii/S1470160X12003147 [Accessed December 1, 2014].

Xu, J., Lebel, L. & Sturgeon, J., 2009. Functional links between biodiversity, livelihoods, and culture in a Hani swidden landscape in southwest China. *Ecology and Society*, 14(2), p.20.

Yi, Z., 2014. The possibility of Eco-certificating nature rubber and tea along their supply chain in Mekong: A case study from Xishuangbanna, SW China.

Yi, Z.-F. et al., 2014. Developing indicators of economic value and biodiversity loss for rubber plantations in Xishuangbanna, southwest China: A case study from Menglun township. *Ecological Indicators*, 36, pp.788–797. Available at: http://linkinghub.elsevier.com/retrieve/pii/S1470160X13001222 [Accessed December 1, 2014].

Yin, S., 2001. *People and forests : Yunnan swidden agriculture in human-ecological perspective*, [Kunming]: Yunnan Education Publ. House.

Yunnan Statistics Bureau, 2013. *Yunnan Statistical Yearbooks 2013*, Beijing: China Statistics Press.

Zhang, J. & Cao, M., 1995. Tropical forest vegetation of Xishuangbanna, SW China and its secondary changes, with special reference to some problems in local nature conservation. *Biological Conservation*, 73(3), pp.229–238.

Zhang, L. et al., 2015. The expansion of smallholder rubber farming in Xishuangbanna, China: A case study of two Dai villages. *Land Use Policy*, 42, pp.628–634. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0264837714002105 [Accessed October 29, 2014].

Zhang, L., Kono, Y. & Kobayashi, S., 2014. The process of expansion in commercial banana cropping in tropical China: A case study at a Dai village, Mengla County. *Agricultural Systems*, 124, pp.32–38. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0308521X13001303 [Accessed December 29, 2014].

Zhang, Y., Uusivuori, J. & Kuuluvainen, J., 2000. Econometric analysis of the causes of forest land use changes in Hainan, China. *Canadian Journal of Forest Research*, 30(12), pp.1913–1921.

Zomer, R.J. et al., 2014. Environmental stratification to model climate change impacts on biodiversity and rubber production in Xishuangbanna, Yunnan, China. *Biological Conservation*, 170, pp.264–273. Available at: http://linkinghub.elsevier.com/retrieve/pii/S000632071300414X [Accessed September 29, 2014].

The World Agroforestry Centre is an autonomous, non-profit research organization whose vision is a rural transformation in the developing world as smallholder households increase their use of trees in agricultural landscapes to improve food security, nutrition, income, health, shelter, social cohesion, energy resources and environmental sustainability. The Centre generates science-based knowledge about the diverse roles that trees play in agricultural landscapes, and uses its research to advance policies and practices, and their implementation that benefit the poor and the environment. It aims to e-nsure that all this is achieved by enhancing the quality of its science work, increasing operational efficiency, building and maintaining strong partnerships, accelerating the use and impact of its research, and promoting greater cohesion, interdependence and alignment within the organization.

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