Chapter 3

Research Methodology

This chapter is divided into four parts. The first part introduces conceptual framework of the research. The second part describes data the research needs. The third part discusses the tools used in the data collection process. The forth part introduces the data analysis methodologies. The final part elaborates conditions of the study area.

3.1 General research concept

Forestry policy plays a role in forest protection and development of forest production, meanwhile, a valuable policy impact assessment is a good guide to keep forestry policy going.

The Reform of Collective Forest Using Rights (RCFUR) provided more rights to farmers to use collective forests, which aimed to improve farmers' well being and forest protection. The main concept of the research is impact analysis of the RCFUR in a village of Yunnan province, China. Firstly, economic analysis clarifies production activities in the study area and analyzes their costs and benefits, which were used as coefficients of Linear Programming analysis. Linear Programming was used as a tool to analyse the impact analysis, which measures the future impact of the RCFUR by comparing the development with and without RCFUR. At the same time, different scenarios settings are used to analyze farmers' decision makings in different situation,

which is adding other new Settings (SLCP, mulberry tree transferring and logging quotes (for settings' details, see) in associated with RCFUR (See Figure 2).

The results of impact analysis could be used as a guideline for policy makers and/or decision-makers of related institutions as well as farmers.

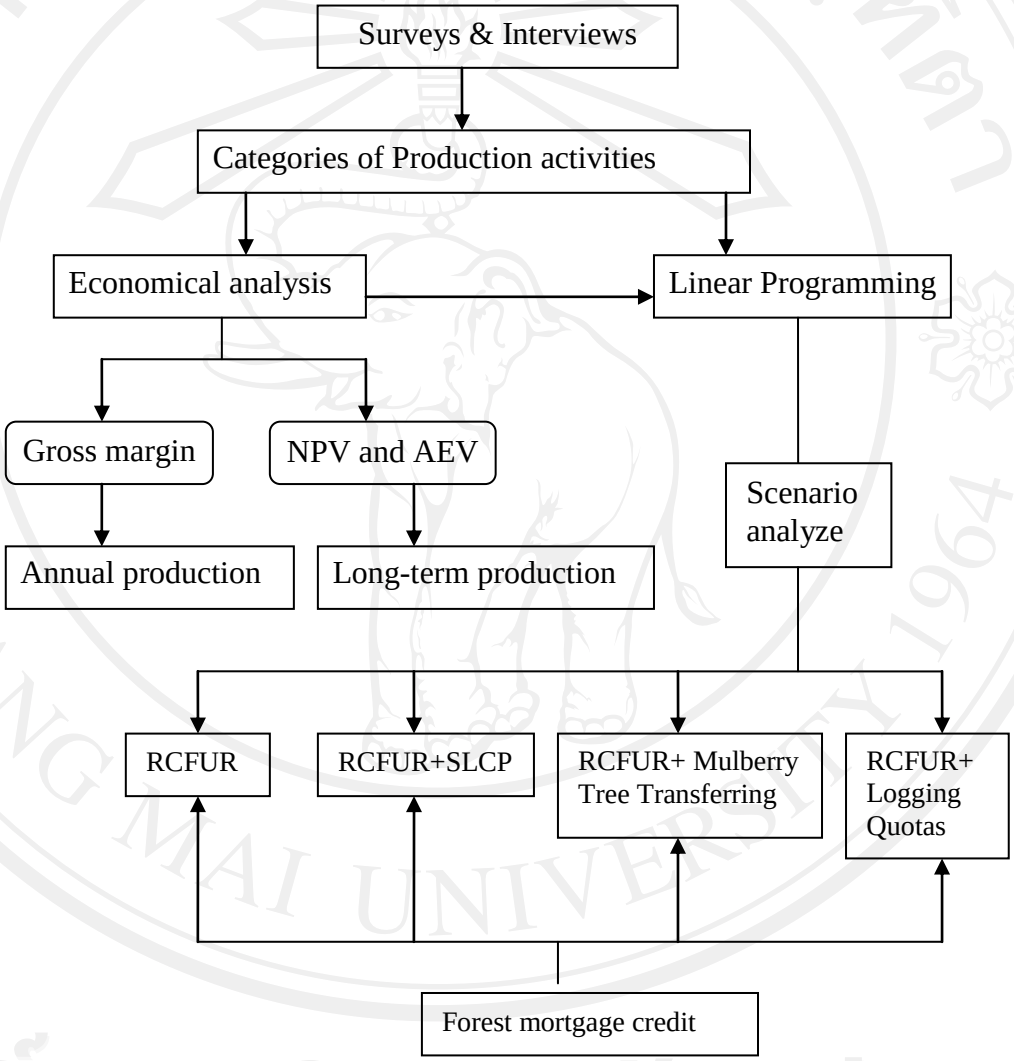

Figure 2 : General Concept of the Research

3.2 Data required and collection methods

3.2.1 Primary data

Primary data the research needed includes: production information, income and consumption data, farmers' resource use and family conditions as well as possible

future strategies of using forest after getting the collective forest use rights. All of these data were from the production period of 2010-2011.

In order to get this data, firstly there was a meeting with Heishui village headman to introduce the research objectives and understand general information of the village. Forty households were randomly selected as household samples from the total of 239 households in Heishui village. Thirty-one samples were used for data analysis. Questionnaires were used for gathering information about production activities and input used as well as farmers' income. There was a semi-structure to understand farmers' opinions towards the new reform and their evaluation of the RCFUR.

In-depth interviews (key households) also were done. The key household selected are most intelligential and experienced people in the village, such as headman of the village and expert farmers. These interviews involved their opinion about possible activities in the future in their collective forests with the RCFUR.

3.2.2 Secondary data collection

Because the research reviewed history of forest policies from 1949-2010 in China, a large number of references were reviewed. They come from government documents, academic papers and statistics yearbooks. Of course, local specific implementation plans of the RCFUR and local social-economical information in the study villages were also collected.

3.3 Data analysis methods

There are two main methods used for data analysis, i.e. economic analysis and linear programming model. The details of methods are as follows.

3.3.1 Economic analysis

Two methods were used to analyse the economic returns of farm activities. One is gross margin and the other is Net present value. Gross margin analysis was used for annual crops.

Gross Margin = Total Revenue – Variable Cost

The details of gross margin calculation of crop and animal husbandry as well as annual forest activities are shown in Table 1. Annual forest activities are picking up mushroom and pine tree needles collection, which can be calculated each year as annual production.

Table 1: Theoretical Calculation Frame of gross margin analysis

1. Income from crop production	
a) Value of output	b) Production cost
1) Cash sale	1) Arable land rent in
2) Products consumed in household	2) Cost of chemical fertilizer and pesticide
3) Arable land rented out	3) Cost of manures
	4) Hired labour cost
	5) Other costs (transportation, electricity, water and so on)
Gross margin = a) – b)	
2. Income from animal husbandry	
a) Value of output	b) Production cost
1) Cash sale	1) Purchase of small animals
2) Animal consumed in household	2) Feedstock from purchase
	3) Feedstock from own farm
	4) Medical services
	5) Labour cost
	6) Others (transportation, electricity, water and so on)
Gross margin = a) – b)	
3. Income from annual forest production	
a) Value of output	b) Production cost
1) Cash sale	1) Planting cost
2) products consumed in household	2) Cost of management
	3) labour cost
	4) Other costs (transportation, electricity, water and so on)
Gross margin = a) – b)	

Note: In this study, animal farmers primarily keep pigs and farmers usually keep pigs for one year or less.

For long-term investment such as perennial crops calculation of Net Present Value (NPV) was used: the algebraic sum of all costs and benefits discounted at a stated rate. Discount rates were usually chosen to reflect the return on alternative investment opportunities (Siregar et al., 2007). The Discount rates the research used is bank interest rate.

Net Present Value can be calculated by following equation.

$$NPV = \sum_{t=0}^{n} \frac{B_t - C_t}{(1+i)^t}$$

Where: B_t is the revenue incurred in year t and C_t is the cost incurred in year t, and

i is a discount rate

After that, NPV were converted to Annual Equivalent Value (AEV) which was used to calculate how much NPV from long-term investment transfer into each year equally.

Annual Equivalent Value can be calculated by using the following formula.

$$AEV = \frac{NPV * i}{1-(1+i)^{-n}}$$

Where n is the lifetime of the project which was 20 years and i is the discount rate.

Table 2 shows detailed items of calculation of NPV and AEV of long-term productions.

Table 2: Theoretical Calculation Frame of NPV and AEV of Long-term Activities

	Cost	Benefit
Year 1	1. Sapling	-
	2. Clearing land cost	-
	3. Planting cost	-
Year 2 - Year before harvesting	Cost of management	
Year of harvesting	Cost of harvesting	1. Cash of sale
		2. Products consumed in household
NPV	NPV of cost	NPV of benefit
AEV	AEV of cost	AEV of benefit

3.3.2 Linear programming

The essence of mathematical programming is optimization of decisions under constraints (Hazell & Norton, 1986). In order to analyse the impact of the reform, a linear programming (LP) model was applied for impact analysis through scenario testing. The LP model used in this study is a single periodical model to stimulate a household's production activities with and without RCFUR in an average year. The household is set as a middle level household in the village. All coefficients used in the LP model are average or median values of the 32 samples.

3.3.2.1 Objective function

The objective function is to maximise the family income subject to family resource availability and other constraints, for a period of one year. The objective equation is sum of value of crop, animals, forest products, off-farm income, other incomes. The mathematical form of linear programming model is as follows:

$$Max\ Z = \sum_{j=1}^{n} (P_j X_j - C_j X_j)$$

Subject to

$\sum_{j}^{n} a_{ij} X_j \leq b_i$, all i =1 to m and all j=1 to n

$X_j \geq 0$,

Z = total net income of a household in the study village

X_j = the level of the j^{th} activity. Let n denote the number of possible activities; then j=1 to n

P_j = the price of a unit of the j^{th} output activity

C_j = the cost of a unit of j^{th} input activity

b_i = amount of i^{th} resource available

a_{ij} = technical coefficient (amount of i^{th} input/resource required to produce unit of j^{th} activity)

n = number of possible activities

m = number of resources and constraints

3.3.2.2 The components of the objective function

• **Variables of cost of crop production, annual forest activities and animal husbandry** are production cost of crop, animal and forest activities respectively. Cost includes seeds, chemical fertilize, pesticide and machine cost, excluding labour cost.

• **Arable land rented out and rented in** are variables in the objective function. A part of income comes from renting out land. At the same time, renting in land is expenditure.

• **Off-farm activities** are other resources of family income excluding farming. During the off-season of farming, farmers can go out to do other jobs, such as construction, cleaner, entrance guard. Off-farm activities involved in the research only

are short-term jobs nearby the village. They are determined by the average wage as reported by farmers.

• **The household consumption of cropping, animal husbandry and forest products**, which has a zero value in the objective function and has to be forced in by respective conditions in the right hand side (equation). Considered as one kind of income, it is externally calculated using market prices and integrated as the component of family income. (Kitchaicharoen, 2003)

• **Crop and meat purchase,** which are also in objective function, are a minus variable in family income. Farmers can provide crop and meat by themselves, but it is also possible to purchase from the market. (Kitchaicharoen, 2003)

• **Hired labour cost.** Farmers can hire labours from other places. Sometime, they have to hire labourers, because some activities need professional labour, such as injecting medicine for animals. They are determined by the average wage per man-day as reported by farmers. Hired labours for different activities are separated into different variables, because costs of hired labour for different activities are different. For high technological requirements, price of hired labour for forest activities and animal husbandry are higher than cropping activities.

• **Credit.** In the beginning of planting, cash is tight, so farmers were allowed to apply for credit from the bank. It is determined by the average interest rates of formal and informal credit. The value of credit is cost of interest, because it is not income since it needs be returned at the end of the year or the beginning of the next year.

• **Saving.** It is a plus value in the objective function. It is money saved in banks as initial capital at beginning of the year, which can be used for production activities.

See the structure of the model in Figure 3.

3.3.2.3 Constraints

Constraints on resources are a basic feature of the farming systems (MAURER, 1999). All the information on resource constraints was derived from the micro survey and statistic yearbook in 2010/2011. Several main constraints were explained following as:

• **Land:** Values of arable and forest land available are average values from 30 samples. It is a constraint that total land can be used for productive activities. (For detail, see 4.1.3)

• **Labour**: Each activity needs labour input. Total labour used should be less than total labour available. (For detail, see 4.1.1)

• **Crop and meat consumption:** Yang (2010) wrote that based on nutrition requirement and living level, crop and meat consumption of an adult per year should be 400kg and 24kg. Maize, rice and wheat is planted to guarantee adequate food supply.

• **Forest product consumption**: In the study village, pine tree needles are used as firewood or to bed down the livestock. For meeting farmers' living needs, a minimum amount of pine tree needles is set as a constraint. (For detail, see 4.1.5)

• **Production balance:** This is a common constraints used in each activity. The equation is amount of production = amount consumed and amount sale.

• **Forest products limitation:** In order to reach sustainable development, there are limitations from maximum products people can get from forest. (For detail, see 4.1.5)

• **Household expenditure:** The average household expenditure reported by farmers is assumed to be the annual household expenditure requirements per family, excluding rice and meat, as living constraints.

• **Off-farm activities:** Farmers only go to do off-farm activities during the farming off-season. (For detail, see 4.1.1)

• **Cash flow:** At the beginning of the year, money used in production should be less than total amount of credit and saving from previous year.

• **Credit:** Farmers can get credit from banks or governments. For financial security, banks or governments only provide credit equal or less than 10,000yuan.

See details in Figure 3.

	Cost of crop produc -tion	Arable land rented out/in	Cost of annual forest activities	Cost of animal husbandry	Off-farm activities	Hired labor	Crop /meat consump-tion	Consume forest product	Sell crop/ meat	Sell forest products	Buy crop /meat	House-hold expendi-ture	Saving	Credit	RHS
Objectives (solution vector)	-	+/-	-	-	+	-	0	0	+	+	-	0	0	-	
Constraints															
Arable land from March to Oct. [mu]	1	1/-1													=bj
Arable land from Nov. to Feb. [mu]	1	1/-1													=bj
Arable land rented out [mu]		1													<=bj
Crop balance [kg]	aij						-1		-1						=0
Min. crop consumed [kg]							1				1				>=bj
Forest land available [mu]			1												<=bj
Max. of forest product produced [kg]								1							<=bj

Figure 3: General Structure of the Baseline Farm-household-family Linear Programming Matrix for One Average Year

	Cost of crop produc -tion	Arable land rented out/in	Cost of annual forest activities	Cost of animal husbandry	Off-farm activities	Hired labor	Crop /meat consump-tion	Consume forest product	Sell crop/ meat	Sell forest products	Buy crop /meat	House-hold expendi-ture	Saving	Credit	RHS
Objectives (solution vector)	-	+/-	-	-	+	-	0	0	+	+	-	0	0	-	
Constraints															
Mini. forest product consumed [kg]								1							>=bj
Forest product balance [kg]			aij					-1		-1					=0
Mini. meat consumed [kg]							1				1				>=bj
Animal husbandry balance [kg]				aij			-1		-1						=0
Labor needed [man-day]	aij		aij	aij	1	-1									<=bj
Hired labor for animal husbandry				aij		-1									=0
Credit [yuan]														1	<=bj

Figure 3: General Structure of the Baseline Farm-household-family Linear Programming Matrix for One Average Year (continued.).

	Cost of crop produc -tion	Arable land rented out/in	Cost of annual forest activities	Cost of animal husbandry	Off-farm activities	Hired labor	Crop /meat consump-tion	Consume forest product	Sell crop/ meat	Sell forest products	Buy crop /meat	House-hold expendi-ture	Saving	Credit	RHS
Objectives (solution vector)	-	+/-	-	-	+	-	0	0	+	+	-	0	0	-	
Constraints															
Off-farm labour available [man-day]					1										
Maximum household expenditure												1			<=bj
Minimum household expenditure												1			>=bj
Saving [yuan]													1		
Cash balance at beginning of the year [yuan]	-aij		-aij	-aij		-aij							1	1	=0
Cash flow [yuan]	-aij	Aij	-aij	-aij	aij	-aij			aij	aij	-aij	-1	1	1	=0

Figure 3: General Structure of the Baseline Farm-household-family Linear Programming Matrix for One Average Year (continued.).

3.3.2.4 Scenarios

Six scenarios were tested to see their impact on farmers' production activities and income in different situations. One is used to see the impact of the RCFUR, and the other scenarios tested changes of farmers' production activities and income with other policies or situations. The details of each scenario are as follow.

Baseline scenario (without RCFUR): This is a fundamental scenario which simulates farmers' production activities without RCFUR. In study area, before RCFUR, farmers' incomes mostly came from planting and animal husbandry. For forest production, individual farmers only had very limited right to use a little part of the forest, so called family plots (family plots, see Chapter 1. introduce). Each family can get 12 mu forests as family plots; on average (see Table 3). Farmers' activities in forest can only be collecting forest products in family plots (such as mushrooms, fruits and firewood) (see Table 3).

Scenario 1a (with RCFUR): Under this scenario, productive activities for crop production are the same as with baseline scenario (13.5 mu per family), but activities in forest are different from baseline scenario. With RCFUR, except family plots, farmers get use right of collective forests which used to be managed by a committee of the village in the past. This change means that more areas of forests can be used for each household. 60 mu of forest can be used with RCFUR, which is 48 mu more than without RCFUR. Meanwhile, activities in forest also increase, such as pine tree rosin collection, timber extraction, planting walnut trees, forest land rent in/out (see Table 3).

Scenario 2a (RCFUR+SLCP): Because of the severe drought of 1997 and massive floods in 1998, the Chinese government decided to implement Sloping Land

Conversion Program (SLCP). The project aims to convert 14.7 million hectares of cropland on steep slopes in the upper reaches of the Yellow and Yangtze River Basins back to forestland and into natural grassland by 2010 (Qu, 2011). The government encourages farmers to plant trees in former arable land, too sloped to plant annual crops. This will help to amend the soil. If farmer changed this kind of land into forest, the government would give some subsidies to farmers by area.

According to the policy, this scenario was tested with increase of forest land and decrease of arable land based on some total area of total arable land, showing the change of farmers' incomes. There are three tests in Scenario 2a, one is Scenario 2a(4 mu) tested the transferring of 4 mu arable land to forest, which means there are 9.5 mu of arable land and 64 mu of forest land. Another test is Scenario 2a (3 mu), which transferred 3 mu to forest (10.5 mu arable land and 63 mu forest land, and third is Scenario 3a (3 mu), in which 3 mu of arable land was transferred into forest land (See Table 3).

Scenario 3a (RCFUR +Mulberry tree transfer): Planting mulberry trees and feeding silkworm are traditional and important resource income for the study village. Because there were no complete rights to using forest before the RCFUR and, also, costly management of planting mulberry trees in forest, farmers only plant mulberry trees in arable land. Due to occupation of mulberry trees, lands for other crops are less. With the RCFUR, a long-term and legal using right guarantee, farmer can plant mulberry trees in forest, and arable lands planted with mulberry trees can be planted with other annual crops. Therefore, scenario 3a is that planting mulberry trees share forest lands with other forest productions; therefore they don't occupy arable land anymore.

Scenario 4a (RCFUR + Logging quotas changing): To deal with serious deforestation, the Chinese government imposed logging quotas in ecologically sensitive natural forests and restricted harvest levels in severely degraded watersheds. It limited the quantity of timber extraction each year. Nowadays, many villagers and experts complain that the logging quotas are set based on those years when there was serious deforestation, but it is too strict for the current situation. From a natural science perspective, one mu mature forest can harvest $13m^3$ of wood per year. This amount will not hurt the healthy of forest. However, Logging quotas allow only $0.23m^3$ of wood to be harvested in the study area for each household. Therefore, different sectors are discussing if the logging quotas need to be widened.

In term of this situation, Scenario 4 is that the constraints of trees which can be cut is 13 m^3 per mu instead of 0.2 m^3 (see Table 3)

Scenario 1b, 2b, 3b and 4b (forest certification mortgage credit): Forest certification mortgage credit is one kind of new mortgage credit, which is that farmers' forest certifications can be used as mortgages; farmers get credit from banks. Currently, this new credit is still in process. The research tested how of farmers livelihoods changed with the credit. Scenario 1b, 2b, 3b and 4b were tested, which are 5000 yuan loans were added in Scenario 1a, 2a, 3a and 4a. Because forest certification mortgage was designed to support forest production, it is only allowed to be used for forestry activities. In practice, the mortgage was designed as a long time loan, about 5 years. However, the model in the research is only an average year's model, so the credit is only a one-year loan.

Table 3: Difference of Constraints and Variables in Different Scenarios

	Available arable land (mu)	Available forest land (mu)	Planting mulberry tree in arable land (Y/N)	Planting mulberry tree in forest (Y/N)	Timber extraction (Y/N)	Pine tree rosin collection (Y/N)	Walnut tree planting (Y/N)	Forest land rented out (mu)	Forest land rented in (mu)	Logging quotas (m3)	Forest certification mortgage (yuan)
Baseline	13.5	12	Y	N	N	N	N	N	N	0	0
Scenario 1a	13.5	12+48=60	Y	N	Y	Y	Y	Y	Y	0.23	0
Scenario 1b	13.5	12+48=60	Y	N	Y	Y	Y	Y	Y	0.23	5000
Scenario 2a (4 mu)	13.5-4=9.5	12+48+4=64	Y	N	Y	Y	Y	Y	Y	0.23	0
Scenario 2a (3 mu)	13.5-3=10.5	12+48+3=63	Y	N	Y	Y	Y	Y	Y	0.23	0
Scenario 2a (2 mu)	13.5-2=11.5	12+48+2=62	Y	N	Y	Y	Y	Y	Y	0.23	0
Scenario 2b (4 mu)	13.5-4=9.5	12+48+4=64	Y	N	Y	Y	Y	Y	Y	0.23	5000
Scenario 2b (2 mu)	13.5-3=10.5	12+48+3=63	Y	N	Y	Y	Y	Y	Y	0.23	5000
Scenario 2b (3mu)	13.5-2=11.5	12+48+2=62	Y	N	Y	Y	Y	Y	Y	0.23	5000
Scenario 3a	13.5	12+48=60	N	Y	Y	Y	Y	Y	Y	0.23	0
Scenario 3b	13.5	12+48=60	N	Y	Y	Y	Y	Y	Y	0.23	5000
Scenario 4a	13.5	12+48=60	Y	N	Y	Y	Y	Y	Y	13	0
Scenario 4b	13.5	12+48=60	Y	N	Y	Y	Y	Y	Y	13	5000

Note: Y (Yes) means that the activity as a variable was added in the equivalent scenario of LP model. N (No) means that the activity was not involved in the scenario

3.3.2.5 Model validation

The purpose of validation is to test how realistic the basic model is and how suitable it will be for future strategy testing (PRANEETVATAKUL, 1996). A good model should present results that are close to reality (REGASSA, 2000). Hence, the basic models were established as close as possible to reality (actual farmers' practices). However, a gap between the basic model and reality still exists due to the complexity of the real world. If the model couldn't generate feasible solutions, the matrix and formulas were rechecked and adjusted where necessary.

3.3.2.6 Software implementation

Primary data clearing and correction work as well as mean value calculation for parameters used in LP model was finished via Microsoft Excel. Data analysis, model input data calculation and Cost-Benefit Analysis were implemented in an Excel workbook. Model building and different scenarios were done in a Microsoft Excel workbook. The LP models were solved by Microsoft Excel Solver. For a small LP with less than 100 activities and constrains, Excel solver is fast and stable. Results of different scenarios could be compared.

3.4 Description of the study area

3.4.1 Natural conditions of the study area

The study area is selected on two villages (Heishui and Dadian) of Heqin County (between 100° 01' - 100° 29' east longitude and 25° 57' - 26° 42' north latitude) in the west of Yunnan Province (see Figure 4). Yunnan is located in south-western China, surrounded by Guizhou, Guangxi, Sichuan and Tibet, and bordering Myanmar,

Lao People's Democratic Republic and Vietnam. It is a highland province with a terraced topographical feature stretching from the northwest to the southeast, resulting in a diversity of elevations and climates.

The study area is located in the west of Yunnan province, which is often referred to as the “Three Rivers Area”, because the Salween (Nu Jiang), Mekong (Lan Cang Jiang), and upper reaches of the Yangtze (Jin Sha Jiang) rivers flow at close distance mountain agro-ecosystems. The Mekong and Salween go through many countries of Southeast Asia, so they are important not only for Yunnan and China but also for the whole of mainland Southeast Asia, providing watershed services for millions of people.

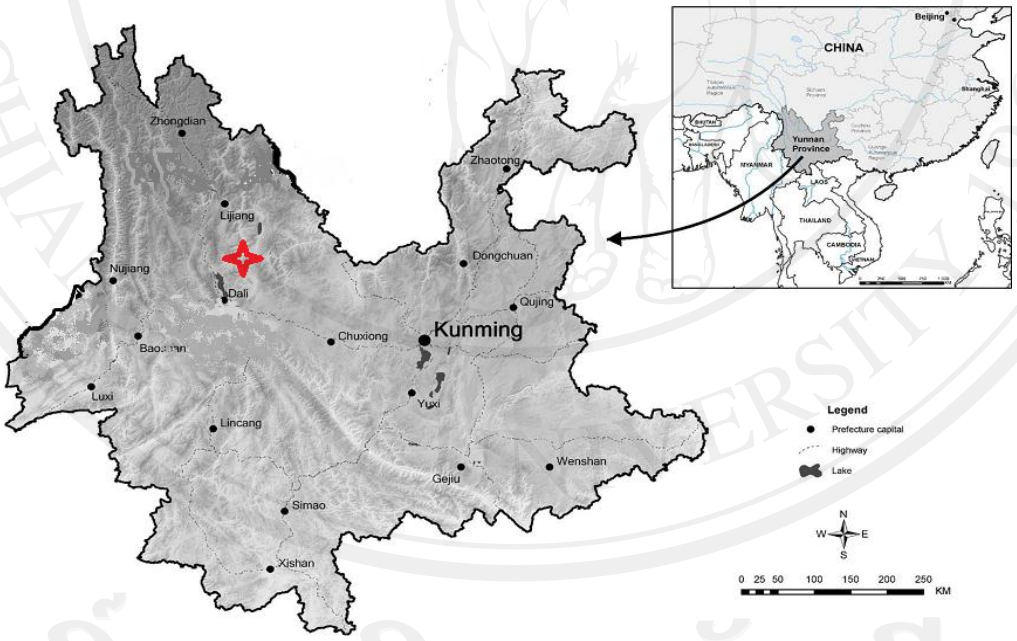

Figure 4: Map of Yunnan Province of P.R of China

Source: Horst Weyerhaeuser, 2006.

Note: The star is the study area.

Total national area of Heqin County is 2395 km2. Area of forest in Heqin county is 2560,000 mu (1 hectare = 15 mu), occupying 75% of total area. Collective forest

covers 92% of all forest. Collective forest comprises 1367,700 mu of economical forest and 994,2000mu of public forest. The forest coverage is 48.99%. The stumpage volume is 5890,000 km3 (Yunnan statistics yearbook, 2011). The study area is one of the villages with the biggest area of forest. Total national area of Heshui village is 12.3 km2. Area of forest in Heshui is 16475.2 mu, occupied 89.3% of total area. Collective forest covers 88.86% of all forest, which is 14640 mu.

3.4.2 Socio-economics

The population of Heishui village is 1215. 305 households are in 2010. Several minority tribes live in the village. The Bai minority group has the majority or all minority tribes; the total population of the Bai group is 1202 people. Most of villagers support themselves by planting, animal husbandry and off-farm activities. Because too much limitation, little income comes from forestry. Main crops planted are rice, maize and tobacco. Currently, with the continued low price of alimentary crops, farmers' lives turn more and more difficult. Meanwhile, forestry produce prices continue to increase sharply.