Chapter 3

Methodology

3.1 Research Design

This is a empirical study. It applies epidemiological model to analyze the problem resulted from economics field. The methodology will focus on the impact of malaria control from border-crossing mobile population by modeling and measuring different activities in the implementation of malaria control using the secondary data. Then analysis the malaria control activities in Yunnan from economic point of view to develop some policy implication under this special situation.

3. 2 Conceptual Framework

Generally speaking, Malaria parasite have 2 stages which one will occur in human body, the other will process in mosquito. When a man is bitten by an infected mosquito after biting a malaria patient. The transmission of the disease of malaria finish one cycle. This round trip, which is from man to mosquito then back to man, is the chain of malaria transmission. Most of malaria control activities are aimed to break the channel. Many epidemiological study has identified the factors influencing malaria endemicity, which involve environment. social economic status, and human behavior.

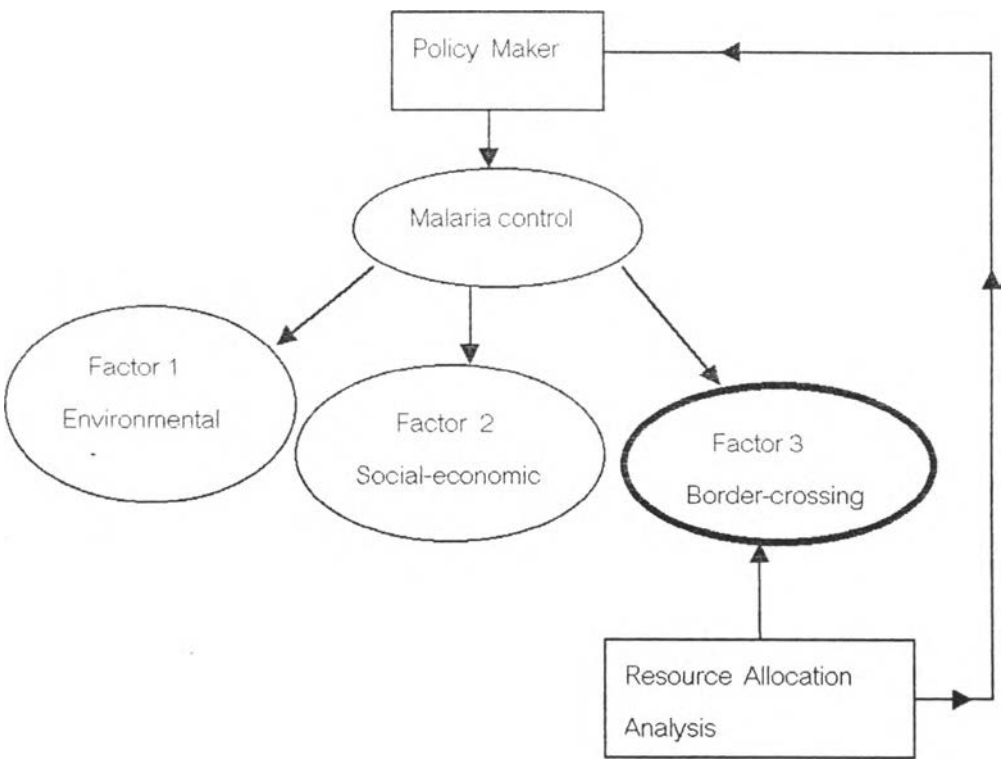
For malaria control, what kind strategy should be implement mainly depend on the factors influencing malaria transmission in the areas. After a

period of implementation of one strategy. It is necessary to evaluate the strategy in order to improve the control of malaria according to the local situation and reality. Then, whether adjustment of the policy or new strategy is adopted will be depended on the awareness of the influential factors. After that, another turn will follow it in the same process. This process looks like a spiral circle. So far, environmental factors, social-economic factors and human behavior factors are regarded as the main factors which influence malaria transmission at present. This study will center the effect of human behavior on malaria transmission. We assume that the environmental factors, which cause malaria transmission along the international boundary line, are almost same. Identifying the role of mobility population along the boundary line will clear or help us know the real situation better. Meanwhile, we hope that some findings which is helpful for policy maker will be available to attribute to consideration at this pacific situation. As we kwon already, social economic factor always effect malaria transmission, and economic activities always associated to the pattern of human behavior. Integrating risk of malaria and resource allocation in the pacific circumstance will imply the direction of efficient allocation in control resource. As a result, better malaria control can be reached. The conceptual framework of this study is shown in Figure 3.

3.3 Indicator and Determination of Malaria Control

From epidemiological point of view, Annual Parasite Rate (API) is closer the reality than any other indicators. That is, It response the prevalence more accurate since it is definited as positive case per population over a period time. It seem to be a better indicator when we specify the severity of malaria in a place. The disadvantage of API is that several positive case can come from one single patient compared with malaria morbidity. It will be disadvantage too when we compare the situation of disease in one place to that of the other place.

Figure 3. Conceptual Framework :



Since API is very sensitivity to the number of blood smear taken during that period of time (the denominator). It can varied very much from year to year due to the reason mentioned above.

Morbidity of malaria is definite as the ratio of the new confirmed case over the total population during that period time. The problem is that there is a time lag since it get from the report system officially. Although it is not a good indicator when we look upon the severity of malaria situation. It would be a better choice when the trend of malaria situation in time series is consideration. As mentioned in introduction, case report isn't complete due to its limitation. Official morbidity rate only respond partial situation. It is not wise to make decision only depending on the morbidity rate in a specific period of time because the problem of under-reporting and time lag. However, when we look at

the trend of malaria situation in specific place, it will be another story. We assume that the factors caused to the weak point of this indicator keep same during a certain time series. The way of report is dame, reporter may same too. In other words, we can catch the point of trend when we compare the malaria situation in many year. That is, we know generally when the situation worsen or better.

3.4 Malaria Situation in Neighboring Countries

Vietnam had malaria morbidity of 9.0 /1,000, 7.1 /1,000, and 5.8 /1,000 in 1995, 1996, 1997, respectively according to statistics yearbook. Vu Thi Phan shows that the malaria situation in the border areas linked with Combodia, Lao People 's Democratic Republic is more serious than other.

Lao People 's Democratic Republic has suffered the public problem malaria seriously since malaria prevalence in all 17 provinces as reported by Pholsena. The mortality was very high. The malaria morbidity was 63.2, 68.26, and 82.46 per thousand population in 1995, 1996, 1997, respectively according to Khamphithoune.

Myanmar has malaria morbidity of 22.75 / 1,000, 25.6 / 1,000, and 20.7 / 1,000 in 1995, 1996, 1997 according to Cho Min-Niang.

3.5 Border Crossing Movement

Mobile population has been recognized as an important factor influencing malaria transmission since 1960s. With the movement from one place to another, it can bring new reservoirs to the place with lower malaria transmission. Which infected in the place with higher incidence rate of malaria. Meanwhile it can

introduce the new drug resistant of parasite strain too. Thus, a negative role on malaria control was played by mobile population. Strengthening or focusing malaria control on target mobile population should lower the risk of malaria transmission. However It is quite difficult to deal with it so far. We know the annual statistics figure by official port on the border. The reality may be higher than it due to the complication of geographic. Weighting the foreigner malaria situation by length of boundary line will be rational to measure its magnitude of effect on the border counties of Yunnan under such an implicit situation about the border crossing movement.

Theoretically, malaria situation in one county will be affected by mobile population from all its surrounding counties since there are mobile population to move in or out from different direction. That is, considering all neighbours around it is necessary. Although the figures of border-crossing mobile population are available from official statistics, the reality may higher than that figure due to the complication of International boundary line. For malaria control, taking into account those unofficial mobile population may be more appropriate.

We assume that border crossing movement for the counties of Yunnan will depend on the distance from the boundary line with the three foreign countries. We also assume that the longer the boundary line is, the more mobile population will. That is, the number of population will depend on the length of boundary line. When i focus on the border areas, the counties which connect with the border area will be taken into account by weight it according the length of boundary line. Those counties do not share border line with foreign countries will be assumed no international border crossing movement. As a result, we hope that the unofficial border crossing movement can be measured, which seems to have far higher than the figures shown by official statistics records. There are should some different effect from foreign country and

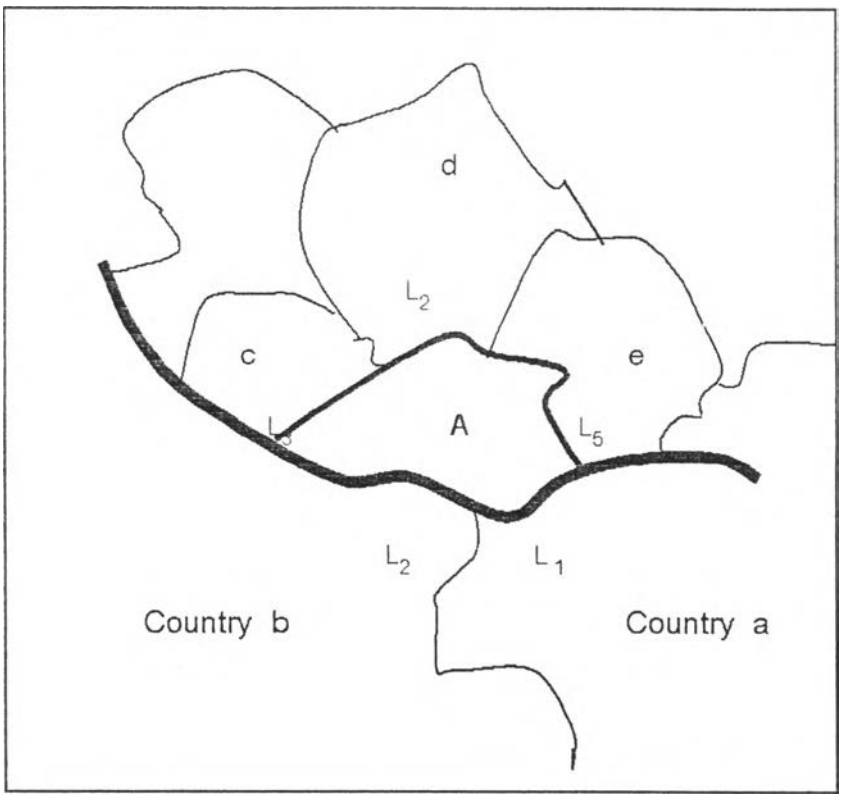
neighbour counties in inland since the background of malaria situation, malaria control strategy and so on are different. Therefore, i grouped it into two indicator. One is foreign group. The other is neighbours in inland.

For example, border county A has 5 neighbours totally. Two are foreign countries. (say, a, b) Three are inland counties of Yunnan, (say, c, d, e). As mentioned in previous part, most influential factors are same among counties e, d, c, since they have same character such as control policy, economic, social background and human behavior. Similarly, three foreign nations with higher malaria incidence, different control strategy from China can be regard as same character among them. Therefore, the two group can be analyzed by regress model. One is INCF, The other is INCNEI. Suppose the boundary line of county A with other neighbors is L_1, L_2, L_3, L_4, L_5, respectively. For border county A, effect of malaria situation in foreign country is $Inc_a * L_1 + Inc_b * L_2$. Effect of malaria situation in inland neighbors is $Inc_c * L_3 + Inc_d * L_4 + Inc_e * L_5$ (shown In Figure 4).

3.6 Regression Analysis

By employing epidemiological empirical model, 48 cross-section data during four years were analyzed under the assumption of same environmental factor on the both side of the international boundary line, More attention will draw to the effect of mobile population on the malaria transmission. According to the dame character of foreign or domestic, two group were built in order taking into measure the effect from foreign countries and inland neighbors by this regress analysis. Some study show the previous malaria incidence is one factor influence malaria transmission. Involving this variable can show the pattern of malaria transmission in term of human behavior more or less. Surveillance and vector control are main composition for malaria control in most country in the world.

Figure 4 The relationship of malaria transmission among neighbors



Considering its efficient allocation is necessary when we analyze allocation of resource in malaria control program. More detail about the two variable will be explain in the following part.

3.6.1 Malaria Control

According to the chain of malaria transmission, different measures will be employed for controlling malaria. Generally speaking, it is a integrated system for malaria control in Yunnan province. No any single measure was performed or completed identical measure was employed in whole province. The measures of control will depends on the species of mosquito, human behavior, health

knowledge, sensitivity of mosquito to insecticide and social economic factors and so on. For instance, using bed-net impregnated is a good way to protect from malaria, but it is nothing for some minority nationalities without health education since they aren't used to sleeping under the bed-net.

Surveillance :

Usually, it is a broad term for malaria control. It comprise Active Case Detection (ACD), Passivity Case Detection (PCD), the monitor of mosquito density, the monitor of mosquito sensitivity to insecticide, and the monitor of the resistant to anti-malaria drugs. The function of surveillance is to find patient early. As a result, the patient found by surveillance system can be treated as early as possible. This can stop or reduce the malaria transmission to the others.

ACD is that agency of malaria control take actions to find the malaria patient among healthy population. They often deep into the field to take blood smear in order to detect patient as quick and much as possible. In China, the activities of ACD usually is conducted in the possible problematic area so that the situation of transmission is discovered as early as possible, then a quick response will following in order to stop this transmission as quick as they can. By contrast, PCD is that the agency of malaria control only passive take blood smear when patient come to seek treatment at the agency. PCD will routinely be conducted among those febrile case in China, which include four categories, clinically diagnosed malaria ,suspected malaria, fever of unknown origin and suspected common cold in endemic area. As a result, the amount of PCD is quite big and unstable. It depends on the patient more than the effort from control agency. That is, PCD will change easily whenever some disturbed factor occur, such as, when a flu outbreak in one endemic county, the fever patient will definitely increase. Thus, the number of blood slide will increase too according to

the criteria of surveillance in China. Therefore, the amount of PCD will increase compare to the year without the breakout out of flu. Unlike this character of PCD, ACD can be controlled easily, and a stable activities is always be implemented every year. We anticipant it should reflect the effort of control more or less from this point of view.

This study take ACD as a proxy of surveillance in malaria control. It can provide some evidence about the prevalence in some place for decision - maker. It is a routine work for each anti-epidemic and preventive station at every level. When the result of each activity is available, an analysis of the local situation must be done by local level then report to upper level as show in the figure 1. ACD will responds the effort done by each county more or less as the reason mentioned above. It is estimated that a negative lagged relationship between the malaria morbidity and ACD. Since the more serious malaria situation is in some place, the more activities of ACD should be done. As a result, the more malaria control will carry out in that year or the following year.

Vector Control

Each anti-epidemic and preventive station will implement either DDT residual house-spraying, or bed-net impregnated or both following the guideline according to the stratification of malaria in Yunnan. Insecticide residual spraying will kill mosquito touched the wall. There should be a immediately effect or a short term effect within the period of insecticide last its effect. Bed -net impregnated using an either keep human being from bite of mosquito, or kill the mosquito which touch the bed net impregnated A negative relationship are estimate since the more mosquito control will lower the morbidity of malaria due to the reduction of vector.

Chemoprophylaxis :

For risky population, chemoprophylaxis is another way to prevent malaria infection or to lower the severity as malaria infection. It is employed as one measure of malaria control in Yunnan, China. It performs generally before the transmission season's coming. However, with the problem of mobile population, Its role need more study since the miss-track appear. As malaria control activities was carried out at the people's original location , mobile population which move out for trade, mine, or other reason, will be untargeted by the measure of control activity. This is the reason that this study exclude chemoprophylaxis from modeling analysis.

Treatment

Treatment is an important measure for malaria control since it kill malaria parasite in human blood cell. Generally, When a patient is confirmed either by microscopy or by clinical symptom, a Standardized radical treatment will following and one more standard dose will be administered again in the next year by anti-epidemic and preventive station according to the record if the patient is P. vivax. It is not necessary if it is a Plasmodium Falciparum patient. It can reduce the infectious resource to spread the disease in the community further. If patient was treat early, the community will face less risk to get infected. The payment mechanism in china decides malaria patient have to pay by their out of pocket. This cause some missing report more or less since patient can seek for treatment at any place no matter private or public. Reporting system still not cover the private section yet so far. Moreover, from the provider point of view, government can ignore the cost of this part. Thus the number of treatment be excluded from this study too.

3.6.2 Regression Model

Based on all discussed above, An empirical model will be

$$LogInc_{p,t} = \alpha_0 + \alpha_1 * Incf_{q,t} + \alpha_2 * Incnei_{k,t} + \alpha_3 * Vec_{p,t} + \alpha_4 * Sur_{p,t} + \alpha_5 * LogInc_{p,t-1} \quad (3.6.1)$$

p = subscript index for border county

q = subscript index for foreign county

k = subscript index for inland county

T = subscript index for year

$Inc_{p,t}$ = Incidence of county P (= 1, 2, ..., 47, 48) in the year t (= 1, 2, 3)

$Incf_{q,t}$ = Incidence of foreign country q weighted by boundary line (= 1, 2, 3) in the year t (= 1, 2, 3)

$Incnei_{k,t}$ = Incidence of inland county k weighted by boundary line (= 1, 2, ...) in the year t (=1,2, 3)

$Vec_{p,t}$ = population covered by DDT spraying at county p (= 1, 2, 3, ..., 47, 48) in the year t (= 1,2, 3)

$Sur_{p,t}$ = No . of blood smear taken at county p (= 1, 2, 3, ..., 47, 48) in the year t (= 1, 2, 3)

$Inc_{p,t-1}$ = Incidence of county P (=1,2, ... , 47,48) in the previous year.

Log = Logarithm

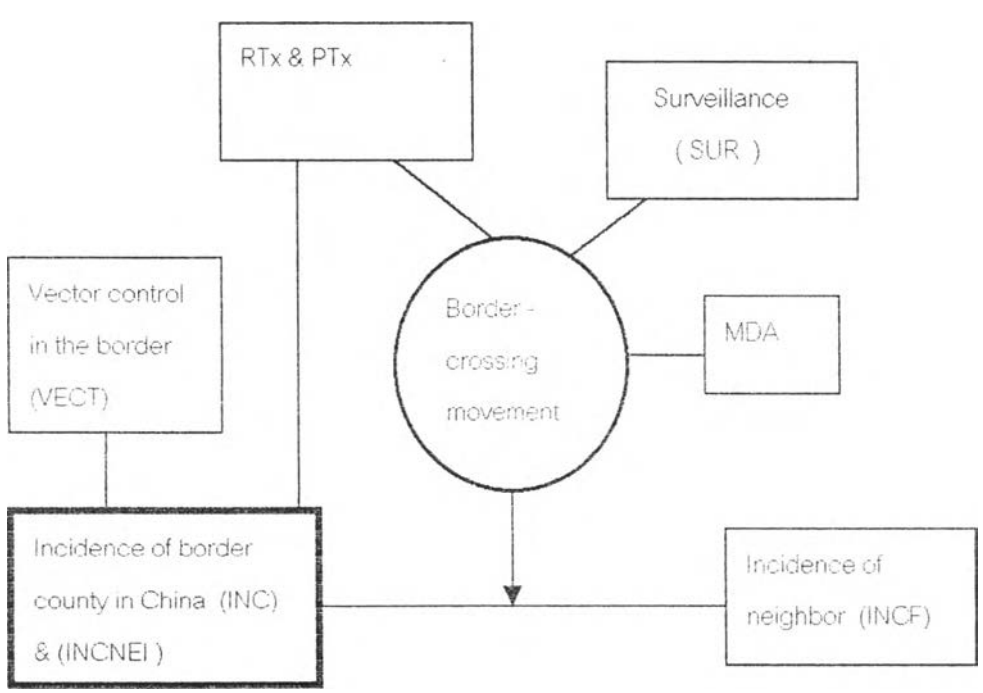
It is always diminishing return both from malaria control activities and risk factors when the morbidity close to zero. The marginal effect of independent variable on morbidity of malaria posses this character. As the morbidity reduce to zero gradually, log form of morbidity can reflect exactly the character of diminishing

effect of independent variable on morbidity. The assumption of this model is that a log-linear relationship existing between these variables and the malaria incidence rate. The coefficient of each variable is the indicator of magnitude. It imply how much the change in independent variable will be explained by each variable. The sign of coefficient indicate that a positive or negative effect exists between independent variable and dependent variable. We also assume that the shorter distance from the foreign country is, the higher risk is.

3.6.3 Analysis of Model

As we know form the introduction, Myanmar, Lao PDR, Vietnam have different malaria situation, the figures of mobile population crossing the border line to each of them are different too. We hypothesis that the effect on malaria transmission will be different from zero which resulted from the foreign countries or inland neighbor counties. When the coefficient of INCF or INCNEI in regress

Figure 5. The Framework of Regression analysis



model is significantly different from zero, it implies the relationship of LogINC and INCF or INCNEI exists. In other word, malaria incidence rate will change the percentage amount of coefficient as one unit of independent variable changes.

This hypothesis will be tested by t- test individually be equation (shown in equation 3.7.1).

$$T = \frac{\hat{\beta}_x - \beta_x}{Se(\hat{\beta}_x)} \qquad (3.7.1)$$

Suppose, There are significant different from zero according to t-value ($p < 0.01$ or $p < 0.05$), thus, the relationship between LogINC and INCF or INCNEI is not rejected. It can come to the conclusion how much the negative contribution from foreign countries by mobile population is when the number of crossing borderline is available.

Unfortunately, county-based data of border - crossing is not available this moment. Are there significant effect on malaria transmission from mobile population as a whole? Are the effect from each country same by mobile population? This is need to make it clear.

Moreover, social - economic factors is a important one in malaria transmission since mobile population will contribute economic development. It is not simply bring the trouble. According to the result got from regression analysis , it will only tell me the relationship between the two variable, Nothing else can be get beyond it. Therefore, take economic factors into consideration will know the situation more. Three group will compared based on the connection

of the three foreign countries due to lacking of country-based data. China-Myanmar group is those border counties which locates along the boundary line with Myanmar. Similarly, another group is China-Lao, and the other is China-Vietnam. As mentioned above, economic status attribute to malaria transmission very much. Therefore, comparing the income level will help us to know its effect. The official number of border crossing will give the more idea whether mobility of population attribute to malaria transmission after taking use of coefficient from regression model above. Moreover, the length of boundary line may be one factor. In order to have more clear idea of different situation on the both side of border line, It is necessary to give the figures mentioned above to help us draw conclusion.

3.7 Analysis of Resource Allocation of Malaria Control

After analyzing the model, the coefficient of mobile population which is affluent to malaria situation in the border of Yunnan, will be available. Since a log-line model was employed, It actually will show us the effect on dependent variable result from a unit change of independent variable.

Health resource is always limited, but allocate efficiency can satisfy the society as much as it can. Therefore efficient allocation is come to the agenda of economic in anywhere. Malaria control have several inputs. We believed that more control resources spending on malaria can prevent more people from suffering it. The best output of those inputs is the reduced morbidity, or the reduced mortality or the number of case prevented by control measures. From those indicator of output, we can drive to the direction of efficiency of resource allocation among alternative options.

Usually, efficiency was divided into allocate efficiency and technical efficiency. Distinguishing the two sub-concept can help us know the concept of efficiency more clear.

Technical efficiency is where the input of producing a given output are minimized, or where output is maximized for a given input. It is aimed to meet program' s objective by using scarcity resource in best way. Allocate efficiency of health resource is pursing the health intervention or the amount of the consumed resource which the activity is worthwhile. That is, Marginal benefit must equal to marginal cost at least no matter how market failure the health care is in any place due to the externalities and asymmetric information between the provider and the consumer.

Regarding the efficiency of malaria control activities, at first, we suppose that every member of this society are treated as the same case. When the number of malaria case prevented by control activity are maximized under the limitation of resources, an overall efficiency can be achieved. As a result, shortage occurred in one place, and wastage or overuse in another place will be prevented at all.

The efficiency of resource allocation depends on the recent malaria situation commonly. When the same amount of malaria control activities was invested in an lower transmission place, and in an endemic area, the similar reduction in morbidity or in mortality is expected. However, the number of case prevented will be quite different each other. Setting priority in the endemic area will maximize the number of malaria case prevented. In other words, overall efficiency allocation can be touched in theory.

From the regression model, not only are the coefficient of neighbor countries and counties available, but also vector control and surveillance were taking into account. As discussed above, the main activities regarded as the proxy of this study, can reflect the resource input. Looking at the determination on malaria incidence rate from VECT and SUR, will indicate where and how much resource allocation is. Considering the spillover effect of risky factor and resource allocation some time, will imply the efficiency and equity of resource allocation somehow. In short, specifying the spillover effect of risky factor can briefly direct the efficient resource allocation.

It is hard to set a standard criteria directing what the distribution should be. Generally, the following aspect was taking into account in term of this concern. Horizontal equity and vertical equity are two sub-title. Horizontal equity is concern with 1) the equal expenditure for equal need; 2) equal utilization for equal need; 3) equal access for equal need and 4) equal health. Vertical equity is concern about the unequal treatment of unequal which is under different condition.

As we know, marginal product is the additional output produced by employed one additional unit of a factor. It can be employed to analyze the efficiency of malaria control activities. Comparing marginal product can come out some implement for resource allocation in malaria control. We believed that the diminishing marginal return to input is the reason. The higher marginal product is, the more contribution to the morbidity of malaria is in this case. On the other hand, when higher marginal product is priority of malaria control. the higher return will be got from the input. In the other word, the number of case prevented was maximized. We can touch more efficient allocation of scarcity resource in the end. Otherwise Lower return or less efficiency will be the case.

Similarly, mobile population has spill over effect on malaria transmission. That is, the risky factor of population mobility make malaria situation worsen. In term of mobile population as a whole, its spill over effect have the same function as marginal production mentioned above. What is the difference from marginal effect is the opposite or negative contribution for spillover effect. It can imply the direction of efficient allocation by comparing the spillover effect among the border counties. The higher one is worth to input more in order to allocate efficiently. Looking at the study, there are two resources of mobile population One is from inland side, the other is from foreign side. Considering the spillover effect of mobile population as a whole can make us know how much risk the border county is facing. According to the definition of marginal production or spillover effect, the spillover effect will get from total effect from inland side and foreign side divided by unit change of factor both from inland side and foreign side. Therefore, the spillover effect of mobile population on malaria transmission in the border area can be measured by spillover effect as following equation (3.8.1). The efficient allocation among different counties will by imply according to the analysis of spillover effect.

$$\text{Spillover effect} = \frac{\alpha_2 * INCF + \alpha_3 * INCNEI}{INCF + INCNEI} \qquad (3.8.1)$$

As the present of equation below, marginal effect of malaria control actually related to the morbidity of the place and the unit cost of activities When the total utility of malaria control maximized, it is the condition of efficiency that each marginal utility per dollar spend are equal in all activities.

According to marginal utility discussed above, when marginal effect of vector control equal to marginal effect of surveillance, total utility of malaria

$$\frac{MU\ activity_1}{P\ activity_1} = \frac{MU\ activity_2}{P\ activity_2} = \ldots\ldots = \frac{MU\ activity_n}{P\ activity_n} = ME \qquad (3.8.2)$$

control in Yunnan is maximized. Referring to the Log- linear model, the result will be equation (3.8.2). If coefficient of different activities is different from zero statistically, Marginal effect can be employed to direct efficient allocation of resource according to equation (3.8.5), which process by equation (3.8.3) and equation (3.8.4)

$$\frac{D\ LOGINC_{tk}}{D\ x_{tk}} = \alpha_j \qquad (3.8.3)$$

$$\frac{D\ INC_{tk}}{D\ x} = INC * \alpha_j \qquad (3.8.4)$$

$$\frac{D\ Inc_{tk}}{P_j * D\ x} = \frac{INC * \alpha_j}{P_j} = ME \qquad (3.8.5)$$

As equation (3.8.4) shown, marginal effect affected by incidence rate, coefficient of control activities and the unit cost of each control activity. The Marginal effect of different control activities can imply for resource allocation optimally under the theory of marginal utility. The higher marginal effect of

activities will be worthwhile more than lower marginal effect from economic point of view. When we integrate the coefficient in the regress analysis, more resource allocation in term of surveillance and vector control will be analyzed if the coefficient of measures are different from zero statistically.

3.8 Data Collection

The data used in this study have several resources. One is the annual report record from Yunnan Institute of Malaria Control. Such as of the incidences of 48

counties in 1994, 1995, 1996, 1997. The amount of the malaria control activities

Table 3. 2 The resource of data :

Variables	*Resource of data*
Incident	Annual report of YIMC in 1994, 1995, 1996, 1997
GCP per capita	Annual statistics Year Book in 1995,1996
Incidence of foreign country	Thesis ,statistics , unpublished data in 1995, 1996, 1997
No. of crossing border	Record in 1995, 1996, 1997
No. of blood smear taken	Annual report of YIMC in 1995, 1996, 1997
Vector control activity	Annual report of YIMC in 1995, 1996, 1997
Incidence of inland county	Annual report of YIMC in 1995, 1996, 1997

carries out among these counties. Another is statistics year books. The other is from the thesis and unpublished data (as shown in Table 3. 2).

3.8.1 Data Available in Case Reporting System

As mentioned in the introduction and the Figure 2, all malaria case in each counties, every malaria control activities, like number of ACD, the population covering by DDT spraying and bed net impregnated and the total population in each counties are available in Yunnan institute of malaria control (referring to Appendix Table A.1).

The variables of this study will be derived from above (as shown in Table 3.3).

$$INC = \frac{\text{Number of new malaria cases confirmed in a county in a year}}{\text{Total population in the county in the year}} * 10{,}000$$

$$VECT = \frac{\text{Population covered by DDT -spraying}}{\text{Total population in the county in the year}}$$

$$SUR = \frac{\text{Number of ACD in a county in a year}}{\text{Total population in the county in the year}}$$

$$INCF = L_1 * Inc_1 + L_2 * Inc_2 + \ldots\ldots + L_n * Inc_n$$

$$Incnei = L_a * Inc_1 + L_b * Inc_2 + \ldots\ldots + L_k * Inc_n$$

Table 3.3 The definition of variable in regress analysis :

Variable	Unit	Definition of variable
INC	Case / pop	Incidence rate of malaria in a border county of Yunnan province, China in a year
INCF	Case / pop	Incidence rate of malaria in a foreign country weighted by length of boundary line in the year
INCNEI	Case / pop	Incidence rate of malaria in the inland neighbor county weighted by the boundary line in the year
VECT	Ratio	Population covered by DDT –spraying in the county of Yunnan in the year
SUR	Ratio	Percentage of Number of ACD blood smear in total population in the county of Yunnan in the year

3.8.2 Data Available in the Statistics Yearbooks

The average Income of farmers in each counties of Yunnan can be draw from the statistics yearbooks. The incidence of malaria in Vietnam is available from the statistics yearbooks too (referring to Appendix Table A.1).

3.8.3 Other Data Resources

Incidence of malaria in Lao PDR abstracted from Mr. Khamphithoune Somsamouth' s thesis. which was submitted to the college of public health, Chulalongkorn University, named Developing Information, Education and Communications Strategies For the Promotion Of The Use Of Insecticise Treated Bed Nets For Malaria Prevention In Laos (referring to Appendix Table A.1).

Incidence of malaria in Myanmar was got from unpublished data(referring to Appendix Table A.1).