CHAPTER 3

STUDY AREA AND RESEARCH METHODOLOGY

3.1 STUDY AREA

South-east Sulawesi Province is one of 27 provinces in Indonesia. The area of study is located in the southeastern of Sulawesi Island, from 3° - 6° south latitude and 120°45' - 124°06' west longitude. The area is 27,686 Km^2; consisting of 4 districts, 1 municipality, 64 sub-districts and 835 villages. The total population in 1993 was 1,450,500 with the population growth 3.66% and population density 52 per km^2. The dependency ratio was 88.32.

The GDP per capita (1990) at current price was Rp 615.850 and at constant price (1983) was Rp 394.100. Income distributions (1990) were : 21.75% of 40% lowest, 40.28% of 40% median and 37.96% of 20% highest. Gini Ratio was 0.29% and the poverty by village was 39.16% (327 villages).

Health facilities (1993) were : 11 general hospitals, 1 special hospital. 94 health centres, 404 sub-health centres, 93 mobile health centres, 1,934 posyandu (integrated services station), 81 polindes (village deliveries station), and 856 POD (village drugs station). Total hospital beds are 679. The ratio of health personnel/population i.e. physicians were 1: 10,073; dentists were 1: 80,583; nurses were 1: 1,013 and the overall health personnel were 1: 471.

The health status (1992) i.e. : IMR was 64 per 1000 life-birth, CMR was 92 per 1000 life-birth and life expectancy was 61.31 years.

3.2 RESEARCH DESIGN :

3.2.1 **Study Type / Approach** :

The type of this study is historical control evaluation research.

3.2.1 **Subject Selection :**

(a). *Population* : malaria units at province and districts levels.

(b). *Sample size*: all malaria units at province and districts levels (total population)

(c). *Sampling Method* : Non-probability (purposive) sampling.

3.2.3 **Variables to be measured** :

(a). *Dependent Variable* : prevalence of malaria (Parasite Rate)

(b). *Independent Variables*:

(1). Costs of vector control measures
(2). VCM methods .
(3). Vector behavior
(4). Malaria treatments
(5). Related socio-economic/ environments: Income and Literacy Rate

(c). *Confounders :*

(1). Community (hosts) behavior and culture
(2). Impacts of development which potential for vector breeding places

3.2.4 **Instruments/Tools** :

The tools that have been used are dummy tables and check-lists.

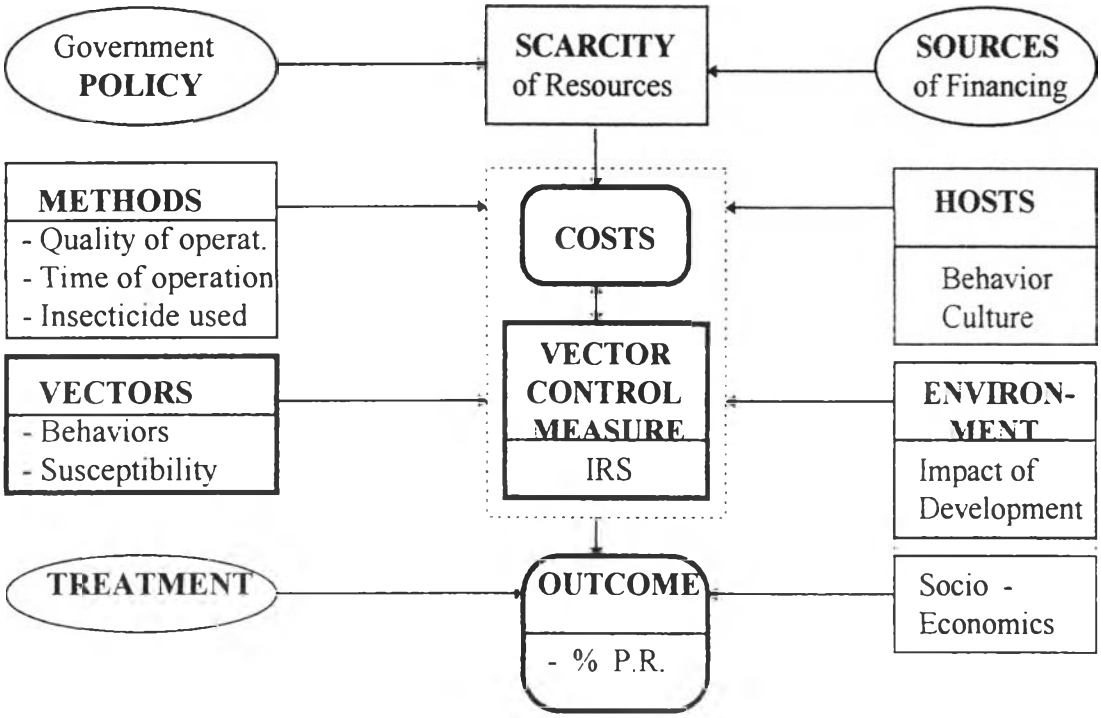
3.3 CONCEPTUAL FRAMEWORK

This study aims to describe and identify the relationship between costs and outcome of vector control measures from providers perspective for recommending actions. The broad concerns of the study are presented in Figure 3.1.

The costs of vector control measures are incurred from the providers (Government). There are many factors affecting the costs and outcome of vector control measures. The availability of costs are affecting by sources of financing and the government policy. While the efficiency of costs are affecting by methods of control, vectors, hosts and socio-economic (environment).

The efficiency of IRS depends on the insecticide used, time of operations and quality of operations, and susceptibility and behavior of vectors. Quality of operations could be determined by the coverage, completeness, sufficiency and regularity. Change in vector behavior and development of vector resistance lead to the funds for vector control becoming wasted. Hosts or community behavior and culture affect the cost-effectiveness of the vector control, however, although clearly important, are not included in this study but treated as confounders. Income and literacy rate could support the cost-effectiveness of vector control. Another factors which affect the cost-effectiveness of vector control are the impacts of development such as irrigation, paddy fields, fish ponds and mangrove forest explorations because could make widespread the breeding places of vectors. These factors are also treated as confounders.

Figure 3.1. Framework of the research



The possible relationship between outcome of VCM (PR) and vector indoor resting density are :

(a). If vector indoor resting decreased and PR decreased, means that IRS is effective.

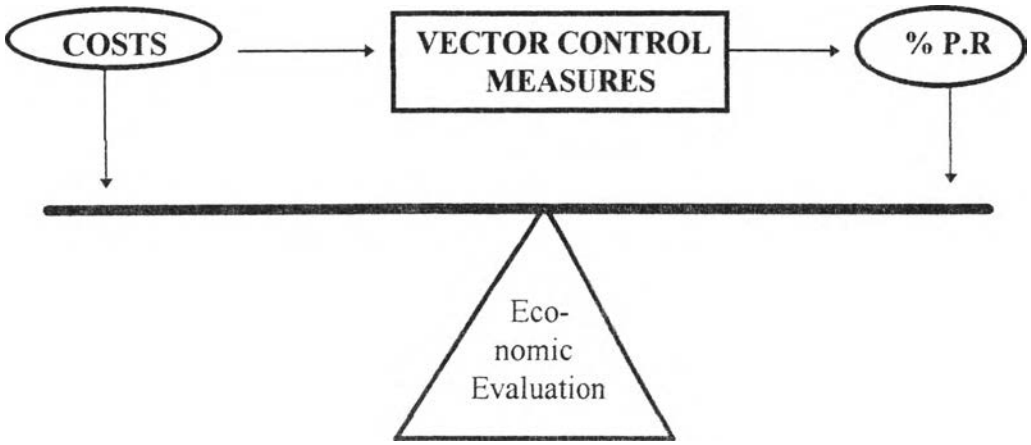
(b). If vector indoor resting increased and PR decreased, means that there is an effect of other factors (e.g. income, literacy, etc.)

(c). If vector indoor resting increased and PR increased, there is resistance of vector to insecticide(s)

(d). If vector indoor resting decreased and PR increased, a change in behavior of vector occurred.

The measurements used in the economic evaluation for vector control measures are effectiveness and cost-effectiveness(for efficiency) as illustrated in Figure 3.2 below.

Figure 3.2. The form of economic evaluation for VCM



The figure above can be transformed in the following models :

$$PR_t = f (PR_{t-1} , VCM_t , Vector\text{-}behavior_t , Treatment_t , Host_t , Environment_t)$$

The tool to be used in evaluating the effectiveness and efficiency of vector control measures is regression analysis.

Assumptions :

(1). The efficiency of insecticides (DDT, Ficam^R and Icon^R) used are the same.
(2). The effect of host behaviors and culture, and other environment factors to the outcome of vector control measures are treated as confounders
(3). When the vector indoor resting density decreased while PR increased or fluctuated, a change has occurred in resting behavior of vector.

3.4 OPERATIONAL DEFINITIONS

The key words of this research are : economic evaluation, vector control measures, malaria control programme, and South-east Sulawesi Province Indonesia. Other words which are important in this research are : evaluation, effectiveness, cost-effectiveness, efficiency, marginal cost, control, indoor residual spraying, vector behaviors and parasite rate.

Evaluation is the process of making judgments about the desirability, usefulness and/or importance of an activity or product (Kaewsonthi and Harding 1991). Its means the relationship between objective, input and outcome. Such evaluation could : a) determine if a project is viable; b) decide if an alternative project

is most desirable for the community (input vs. cost and return) and c) decide if continued use of resources is justified.

Economic evaluation can be defined as the quantitative analysis of the relative desirability of investing in alternative projects (Mills, 1987). It also can be defined as the comparative analysis of alternative courses of action in terms of both their costs and their consequences. The basic task of any economic evaluation will be to identify, measure, value and compare the costs and consequences of the alternatives being considered.

Efficacy or effectiveness evaluation is a type of evaluation situation in which the consequences of two ore more alternative are compared. The question addresses to efficacy are : Can it work? Does the health procedure, service or programme do more good than harm to people who fully comply with the associated recommendations or treatments? (Drummond, 1989). The efficacy of insecticides are measured by the Lethal Dose - 50 (LD_{50}) i.e. the dose amount of insecticide in which can kill 50% of the experimental animals (e.g. mosquitoes).

Effectiveness is directed towards assessing the extent to which a planned of intended objective has been attained as a result of programme activity (Deniston, 1968). This form of health care evaluation, which considers both of the efficacy of a service and its acceptance by those to whom it is offered. The questions which can be addressed to effectiveness or usefulness are : Does it work? Does procedure, service, or programme do more good than harm to the people to whom it is offered? (Drummond, 1989). On the other hand, effectiveness is the degree to which objectives (desired out-come) are achieved (Reynolds, 1992). Effectiveness of VCMs means the degree of decreasing of parasite rate to which objectives of malaria control programme are achieved.

Cost-effectiveness is an analysis in which cost is related to a single common effect that may differ in magnitude between the alternative programmes. It is one form of full economic evaluation, where both the cost and consequences of health programmes or treatment are examined. The costs are expressed in money terms but some of the consequences are expressed in physical units, e.g. life-years gained, cases detected, etc.(Drummond, 1989).

Efficiency may be defined as the ratio between an output (net attainment of programme objectives) and input (programme resources expensed (Deniston, 1968). Efficiency relates to output per unit cost of the resources employed. Resources are being used efficiently if a given output is produced at minimum cost (Mills and Drummond, 1985). In addition, efficiency relates to whether the service is provided at the lowest possible cost (WHO Study Group, 1993). Efficiency in VCM means the minimum cost used in reducing of 1% of parasite rate of malaria.

Marginal Cost is the change in total cost at a given scale of output when a little more or a little less output is produced (Mills and Drummond, 1985). These are

the costs per unit of producing an additional unit, beyond the present level of production (Kaewsonthi and Harding, 1993).

Control means that a disease is reduced to a level where it is no longer a major public health problem, and implies that control measures may have to be continued indefinitely (Davey and Wilson, 1969).

Malaria Control can be defined as operations aimed at reducing the prevalence of malaria to a level at which it is not a major public health problem (Gabaldon, 1963). The main methods of malaria control are vector control and treatment of malaria cases.

Vector Control means the operations aimed at shortening the longevity of vector to prevent the transmission of disease. There are several methods of vector control measures in Indonesia (MOH-Indonesia, 1993), i.e. :

(i). *adult vector control* : indoor residual spraying (IRS), fogging/space spraying, insecticide impregnated bed-net, etc.
(ii). *larva control* : (a) larviciding control; and (b) biological control : by using predator fish, insect growth regulator (IGR), etc.
(iii). *environmental management* : source reduction, environmental sanitation. etc.
(iv). *integrated control* : using two or more methods of vector control measures.
(v). *vaccination* : still in trials.

Indoor Residual Spraying is the vector control measure which involved covering the sprayable surfaces inside the house with insecticide. Mostly, insecticides used with long term residual effect (3-6 months), e.g. DDT, Bendiocarb (Ficam^{R}), Lambdacyhalotrine (ICON^{R}), etc. The vectors will be killed after resting at the surface with insecticide.

Vector Behaviors : malaria vector is any species of anophelline mosquito which is able to transmit malaria disease in nature. Two of the most important of vector behaviors in relation to indoor residual spraying are : feeding habit and resting habit. The relative tendency of mosquitoes to feed indoors is known as endophagy, the opposite tendency is exophagy. While the relative tendency of mosquitoes to rest indoors is known as endophily; the opposite tendency to shun enclosed space whether by day or by night is termed exophily. Expected vector behaviors for IRS are feeding and resting indoor to allow contact with insecticides.

Parasite Rate, is a point prevalence of malaria which describes the percentage of population (0 - 9 years of age) with parasites in their blood at a point in time as the measurement of outcome of vector control measures of the malaria control programme. This rate can be found as the result of malariometric survey, once a year.

3.5 DATA COLLECTION

There were several methods of data collection in this study, i.e. reviews of reports/documents, interviews and discussion. The details of data collected are shown in the list below :

Table 3.1. The Detail of Data Collections in the Study

Variables	Type of Data	Nature of Data	Methods	Source of Data
(1)	(2)	(3)	(4)	(5)
1. Malaria Prevalence (Outcome)	% P.R., # of Cases	Secondary Data	Review of Reports	Malaria Units (Prov./District)
2. Costs of VCMs	Capit.Costs Oper. Costs	Secondary Data	Review of Financing Doc'nt	Malaria Units (Central/Prov.)
3. IRS and other VCM activities	# of houses spraved,etc.	Secondary Data	Review of Reports	Malaria Units (Prov./District)
4. Vector(s)	Behavior & Resistancy	Secondary Data	Review of Reports	CDC-Division (Central/Prov.)
5. Malaria R_x	# cases treat	Secondary Data	Review of Reports	Malaria Units (Prov./District)
6. Environment : *. Socio-Econ.	Income	Secondary Data	Review of Reports	Prov.Statistics Office
7. Factors affecting Cost	Sources, Policy	Primary Data	Interviews/ Discussion	Malaria Chief (Central/Prov.)

The scope of data collections in this study are :

(a) The costs of MCP and VCMs which incur from the financial documents of the Communicable Diseases Control Project of Southeast Sulawesi Province, from National Development Budgets. Other costs of MCP and VCM which incur from Malaria Headquaters, Other Ministries, Foreign Aid, Health Services units (hospital, health, clinics) of government and private, NGOs, community, and individual/patients are not included in this study.

(b) Time-series entomological data from monthly study for three years or more. Cross-sectional entomological data and the monthly studies for less than three years are not included in this study.

3.6 DATA ANALYSIS

All of data collected by the various methods were processed with the following steps, i.e. data editing, coding of data, transforming of data and tabulations of data. Processing of data used Lotus 1-2-3, TSP and SPSS software.

Analysis of data was done by using descriptive and inference statistics (regression analysis), as shown in the Table 3.2 below:

Table 3.2. The Detail of Data Analysis in the Study

Research Objectives	**Variables**	**Indicator**	**Methods of Analysis**
(1)	(2)	(3)	(4)
1. Costs of VCMs	Capital Costs Operating Costs	Total Costs Average Costs	Computing
2. Effectiveness	-Malaria Preval.	% P.R. ⇓ # of Cases ⇓	- Regression Analysis
3. Efficiency	Cost-Outcome	Outcome/Cost	- Regression Analysis
4. Factors Affecting :.			
4.1. Outcome	- Treatment	# of cases treated	- Regress. Anal.
	- Vectors	% Indoor Rest. % Indoor M.B. % Outdoor M.B.	- Regress. Anal.
	- Socio-econom.	Income/Literacy	- Regress. Anal.
4.2. Costs	- Source of Fin.	# Costs/Source	Computing
	- Gov.'nt Policy	Priority Level	Descriptive

In case of incompleteness data, such as data for some variables are available only for a few years in which the degree of freedom (df) becomes inappropriate, then regression analysis by one equation model can not be applied. Therefore, more than one regression analysis is needed based on the characteristics and the availability of data. If any missing data should be included in the regression analysis, it will be treated by dummy variable.

3.6.1 **Costs of VCM**

The costs of VCM are described annually; they consist of capital cost and recurrent cost, the costs of activities, sources of costs and unit costs. Analysis of costs by descriptive statistics such as presented in tables, summarized in percentages, etc.

For the analyzing of VCM efficiency, the real value of costs are used instead of current value which are measured in the cost per population.

3.6.2 **Effectiveness**

Regression analysis for effectiveness of VCM is carried out to measure the effects of the activities and factors affecting VCM in term of physical units, to outcome (decreasing of parasite rate). Since the existing data are incomplete there are several models to be used in the regression analysis to avoid bias and autocorrelation.

To measure the effect of vector control activities, malaria treatment and factors affecting reduction in the parasite rate of malaria for the period of 1974-1994 is used the equation model below :

$$PR_t = f_1 (PR_{(t-1)}, VCM_t, TREAT_t, INCOME_t) \quad (3.6.1)$$

Where : PR_t = parasite rate at time t
f_1 = function of the effectiveness for overall observations of model 1
$PR_{(t-1)}$ = lagged parasite rate at time t-1
VCM_t = % population coverage by vector control measures
$TREAT_t$ = number of malaria treatment per 100 population
$INCOME_t$ = per capita income of the people (in rupiahs)
t = time of application

The effect of each activity and factor are determined by its coefficient (slope)s in the result of regression analysis.

The effectiveness of IRS before and after change in behavior of vectors can be evaluate from the equation model below :

$$PR_t = f_2 (PR_{(t-1)}, IRS_{before}, IRS_{after}) \quad (3.6.2)$$

Where : PR_t = Parasite rate at time t
f_2 = function of the effectiveness for before and after change in behavior of vectors of model 2
$PR_{(t-1)}$ = Lagged parasite rate (at time t-1)
IRS_{before} = % population coverage by IRS before changes behavior of vectors for $t < 1978$
IRS_{after} = % population coverage by IRS after changes behavior of vectors for $t \geq 1978$
t = time of application

Coefficient of β_2 and β_3 of the result of regression analysis can be compared. The bigger coefficient means the higher effectiveness.

3.6.3 **Efficiency**

Regression analysis was used for efficiency of VCM in order to measure relationship between the costs of VCM, beside the cost of treatment and surveillance

against the outcome of the malaria control programme. Since the outcome is also affecting by per capita income, then this variable is included in the regression analysis. Because the costs of VCM and other MCP activities are available only for the period of 1988-1994 while the period analysis is 1978-1994, then the cost of MCP to be used instead of missing data of the costs of VCM and other MCP activities. The equation model to be used are :

$$PR_t = f_3 (PR_{(t-1)}, MCPCost_t, VCMCost_t, SURCost_t, TRECost_t, INCOME_t) \quad (3.6.3)$$

Where :

PR_t = parasite rate at time t

f_3 = function of the efficiency for overall observations of model 3

$PR_{(t-1)}$ = lagged parasite rate (at time $t-1$)

MCPCost = costs per population (in rupiahs) of Malaria Control Programme, including the costs of VCM, surveillance and treatment

VCMCost = costs per population (in rupiahs) of VCM

SURCost = costs per population (in rupiahs) of surveillance

TRECost = costs per population (in rupiahs) of malaria treatment

INCOME = per capita income of the people (in current value of rupiah)

t = time of application

The effect of each cost and income to the outcome (PR) are determined by their coefficient (slope)s in the result of regression analysis.

The contribution of each independent variable to dependent variable (outcome) can be estimated by using the equation below :

$$R^2 = b_1 \frac{\Sigma x_1 y}{\Sigma y^2} + b_2 \frac{\Sigma x_2 y}{\Sigma y^2} + \ldots + b_6 \frac{\Sigma x_6 y}{\Sigma y^2} \quad (3.6.4)$$

Where :

$x_1 = X_1 - \bar{X}$ and $y = Y - \bar{Y}$

R^2 = coefficient of determination

b_i = OLS coefficient of independent variables, i = 1, 2, 3, ... 6

For example, the contribution of Vector Control Measures by Indoor Residual Spraying in reducing the prevalence of malaria is determined by the proportion of the value : $b_2 \frac{\Sigma x_2 y}{\Sigma y^2}$ to the R^2.

The efficiency of VCM before and after change behavior of vectors can be evaluated from the equation model below :

$$PR_t = f_4(PR_{(t-1)}, VCOST_{before}, VCOST_{after}) \quad (3.6.5)$$

Where :

PR_t = parasite rate at time t

f_4 = function of the efficiency for before and after change in behavior of vectors of model 4

$PR_{(t-1)}$ = lagged parasite rate (at time t-1)

$VCOST_{before}$ = costs per population of VCM before changes in behavior of vectors for t < 1978

$VCOST_{after}$ = costs per population of VCM after changes in behavior of vectors for t ≥ 1978

t = time of application

Coefficients of β_2 and β_3 from the result of regression analysis can be compared to evaluate the efficiency of VCM before and after changes in behavior of vectors. The bigger the coefficient, the more efficient the VCM.

3.6.4 **Affecting Factors :**

a) *Factors Affecting Outcome*

There are two variables that affect the outcome of VCM. i.e. malaria treatment and resting behavior of vectors. Resting behavior of vectors affect the implementation of VCM by indoor residual spraying, in which if the behavior of vectors are exophilic (resting outdoor) or if it has been changed from endophily (resting indoor) then there is no effect of VCM in the reduction of PR, while treatment of malaria cases will eliminate the parasite in the blood of patients, and reduce the number of people with malaria parasite (PR). Both of them are analyzed by regression analysis.

Changes in resting behavior of vectors can be determined by the decreasing in indoor resting density while outdoor resting density increased. However, data on outdoor resting density are not available and very difficult to compare with indoor resting density. Therefore, indoor resting density will be compared to the indoor and outdoor man-bite densities. Since the density is affected by the seasonal variation, then proportion to be used as the measurement. When the proportion of indoor resting decrease while the proportion of outdoor man-bite increase, it means that most of vectors bite the man at outside the house and avoid to enter inside the house and resting on the wall surfaces. The decreasing of proportion unfed vectors - number of female mosquitoes without blood in their abdomen - indicate that the proportion of mosquito vectors which is resting on the wall surfaces before feeding have been decreased. Those conditions could be used as the indicators to estimate the change in resting behavior of vectors.

When the behavior of vectors have been changed or the vector becoming resistant to insecticide, then IRS becomes ineffective. The measurement used to indicate the ineffectiveness of IRS is Parity Index or Parous Rate. Parous Rate is the

proportion of parous - female mosquitoes which have oviposited at least once - and nullyparous - new emerging female mosquitoes.

The equation model to be used to measure the effect of changed vector resting behavior in reducing the parasite rate of malaria is :

$$PR_t = f_5 (PR_{(t-1)}, IRS_t, PIRD_{ansub\,t}, PIRD_{anfla\,t}, PIRD_{anbar\,t}, TREAT_t, INCO_t) \quad (3.6.6)$$

Where :

PR_t = parasite rate at time t
f_5 = function of the effect of factors affecting of model 5
$PR_{(t-1)}$= lagged parasite rate (at time t-1)
IRS = % population coverage by Indoor Residual Spraying
$PIRD_{ansub}$= Proportion of Indoor Resting Density of *An. subpictus*
$PIRD_{anfla}$ = Proportion of Indoor Resting Density of *An. flavirostris*
$PIRD_{anbar}$= Proportion of Indoor Resting Density of *An. barbirostris*
TREAT = number of malaria treatment per 100 population
INCO = per capita income of the people (in current value of rupiah)

Period of data used in the analysis is from 1976 to 1986. Proportion of indoor resting density is derived from the density of indoor resting itself which is divided by the sum of densities of indoor man-biting, outdoor man-biting and indoor resting. While density of such species of malaria vector is the number of mosquitoes vector which is collected by one man (collector) for one hour.

The effect of changes in vector resting behavior on the outcome are determined by the coefficient (slope)s β_2, β_3 and β_4 respectively from the result of regression analysis.

Other factors which also could affect the outcome of VCM are socio-economic factors such as per capita income and literacy rate of the people. People with a high per capita income have a better quality of life, and they have greater accessibility to treatment and preventing malaria disease. If the literacy rate of the people is high, this increases the chance of knowledge about malaria, then they know how to prevent malaria disease and how to get treatment when they get sick with malaria.

The effect of per capita income can be determined by the coefficient β_6 of the regression equation (3.6.3) above. To measure the effect of literacy rate to the decreasing of malaria parasite rate, can be analyze from the equation model below :

$$PR_t = f_6(PR_{(t-1)}, LITERACY_t) \quad \ldots\ldots (3.6.7)$$

Where :

PR_t = Parasite Rate at time t
f_6 = function of the effect of literacy rate of model 6
$PR_{(t-1)}$ = Lagged Parasite Rate (at t-1)

LITERACY = Literacy Rate of population
t = time of operation

The reason why literacy rate is analyzed in the separate equation is because data of literacy rate are available only for the periods of 1980, 1985 and 1990. Since only three observations are available, then the effect of lagged PR will be omitted from the regression analysis to avoid autocorrelation.

b) *Factor Affecting Costs* :

The availability of costs for VCM in the Malaria Control Programme depend on the sources of financing and government policy. When the sources of financing are scarce then the availability of costs for VCM becomes limited. If the priority for malaria control is low, the costs for MCP and VCM in the government budget policy also become low.

Since the data of those variables are only derived from reviews reports and limited interviews/discussion, then descriptive analysis is used.

3.6.5 **Hypothesis Testing**

(a). Hypothesis testing will use F-test statistics to test the good of fit of the model. The overall significance of regression model will be analyzed by the Analysis of Variance Approach (ANOVA), for the hypothesis :

$H_0 : \beta_1 = \beta_2 = ... = \beta_k = 0$ (All slope coefficients are simultaneously zero)
$H_1 : \beta_1 \neq \beta_2 \neq .... \neq \beta_k \neq 0$ (Not all slope coefficients are simultaneously zero)

Test statistics :

$$F = \frac{MSR}{MSE} = \frac{ESS/df}{RSS/df} = \frac{ESS/(k-1)}{RSS/(n-k)} \text{ ; with df : } r_1 = k - 1 \text{ and } r_2 = n - k \qquad (3.6.8)$$

where : MSR = Mean Square Regression ESS = Error of Sum Square
MSE = Mean Square Error RSS = Regression of Sum Square

The value of computed F-test can be found from the results of regression analysis. Reject the null hypothesis (H_0) if the value of computed F-ratio is greater than the critical value F, otherwise do not reject it.

(b). Testing the hypothesis to test the slope (individual partial regression coefficient) is used to measure the contribution that each individual independent variable is making to the model. Its test whether an independent variable contributes significantly, in a statistical sense, to a model already containing the remaining predictor variables :

$H_0 : \beta_i = 0$ (there is no linear relationship or influence on Y_t)
$H_1 : \beta_i \neq 0$ (there is a linear relationship or influence on Y_t)

The t-test statistic is computed in the following manner :

$$t = \frac{b_i - \beta_i}{s_{bi}} \qquad i = 1, 2, ...k \qquad \ldots\ldots\ldots\ldots\ldots\ldots (3.6.9)$$

where : b_i = sample slope
β = population slope (usually hypothesis to be zero)
s_{bi} = the standard error of the regression coefficient, b_i
k = number of estimated coefficients including the intercept

The value of t can be found from the result of regression analysis. The computed t-value can be compared with a critical value t with df = n-k.

(c). Testing the hypothesis to test the effectiveness of IRS before and after changed resting behavior of vector between coefficient β_2 against β_3 of the regression equation below :

$$PR_t = \beta_o + \beta_1 PR_{(t-1)} + \beta_2 VCM_{before} + \beta_3 VCM_{after} + \varepsilon_t \quad \ldots\ldots (3.6.10)$$

Where : PR_t = Parasite Rate at time t
β_o = constant
β_i = slope, where i = 1, 2, 3
$PR_{(t-1)}$ = Lagged Parasite Rate (at t-1)
VCM_{before} = % population coverage by VCM before changed for $t < 1978$
VCM_{after} = % population coverage by VCM after changed for $t \geq 1978$
ε_t = Error term

Hypothesis to be tested :

$H_0 : \beta_2 = \beta_3$ (the effectiveness of IRS before and after changed in behavior of vector are the same)
$H_1 : \beta_2 \neq \beta_3$ (there is different effectiveness)

Test statistic to be used :

$$t = \frac{\hat{\beta}_2 - \hat{\beta}_3}{\sqrt{\text{var}(\hat{\beta}_2) + \text{var}(\hat{\beta}_3) - 2\,\text{cov}(\hat{\beta}_2, \hat{\beta}_3)}} \quad \ldots\ldots\ldots (3.6.11)$$

where : β_i = coefficient of slope to be tested, i = 2, 3
var = variance; cov = covariance; and df = n - k

The value of $\hat{\beta}_i$, variance and covariance can be found from the result of regression analysis. Reject null hypothesis when computed t-value exceeds the critical t-value; otherwise do not reject it, with df = n-k.

(d). Testing the hypothesis to test the efficiency of IRS before and after changed in resting behavior of vector between coefficient β_2 against β_3 of the equation below. Since the costs IRS and VCM are incomplete, then the costs of MCP are used.

$$PR_t = \beta_o + \beta_1 PR_{(t-1)} + \beta_2 MCPCost_{before} + \beta_3 MCPCost_{after} - \varepsilon_t \quad \ldots\ldots \quad (3.6.12)$$

Where : PR_t = Parasite Rate at time t
β_o = constant
β_i = slope, where i = 1, 2, 3
$PR_{(t-1)}$ = lagged parasite rate (at time t-1)
$MCPCost_{before}$ = cost per population of MCP before changed for $t < 1978$
$MCPCost_{after}$ = cost per population of MCP after changed for $t \geq 1978$
ε_t = Error term

Hypothesis to be tested :

$H_0 : \beta_2 = \beta_3$ (the efficiency of IRS before and after changed in behavior of vector are the same)
$H_1 : \beta_2 \neq \beta_3$ (there is different efficiency)

Test statistic to be used : t - test for the equality of two regression coefficients as mentioned at formula (3.6.11) above.

(e). Other t-test also applied to test the different of two mean and correlation of pairs variables in this studies.

3.6.5 **Alternative model of VCM**

The alternative model selected from all the possible combination methods of VCM. The model with the smaller *p-value* of F-ratio will be selected as an alternative model of VCM.