CHAPTER IV

RESEARCH METHODS

This study consisted of two parts; GIS analysis and field survey. In order to gain an over view on the erosion status of the study area and to identify potential areas where effective erosion protection measures might be useful, erosion risk assessment was carried out based on both farmers' perception and RS and GIS analysis. The purpose of field survey is to explore the influence of major socio-economic factors on erosion processes and conservation measures in the context of individually farmer's perception in a Dry Zone farming context for producing Erosion Risk Map of the study area. The in-depth work was conducted with 100 farmers at different land use and slope levels in the study area.

4.1 Field survey

4.1.1 Household survey

During field survey, information was collected to gain understanding about land management systems, land use practices and patterns, current farmers' cultural practices in the systems, access to variation of crop yield and limiting factors of crop yield and socio-economic constraints for agricultural production. The formal survey was focused on the factors that influence on erosion.

4.1.2 Sampling techniques

Five villages were selected from five different townships (sub-districts) for field survey; selection was based on slope and land-use practices factors with stratify sampling method. Twenty households in each village were chosen for the survey with questionnaires.

4.1.3 Data collection

4.1.3.1 Primary data collection

Major socio-economic and physical data related to erosion including: farm household characteristics, land use management characteristics (farming practices, land use, land tenure system, fertilizer application etc.), soil conservation management characteristics (crop residues management and farmer ranking factors affecting soil erosion) and farmers' problems were collected as primary time series data from field survey.

4.1.3.2 Secondary data collection

Secondary data for erosion risk assessment including: Digital Elevation Model (DEM), geological map and satellite imagery data, Landsat-5 TM (Thematic Mapper) with 7 bands acquired on 23 March 2007 over the study area at the path of 133-134 and the row of 46. The data were collected from the Forest Department, Ministry of Forestry and reliable authorities and institutions.

4.1.4 Data analysis

To achieve the objectives of the study, multinomial logit model, ICONA erosion model with GIS technique and Root Mean Square Error (RMSE) method were used. Following conceptual framework was carried out to fulfill the study (Figure16).

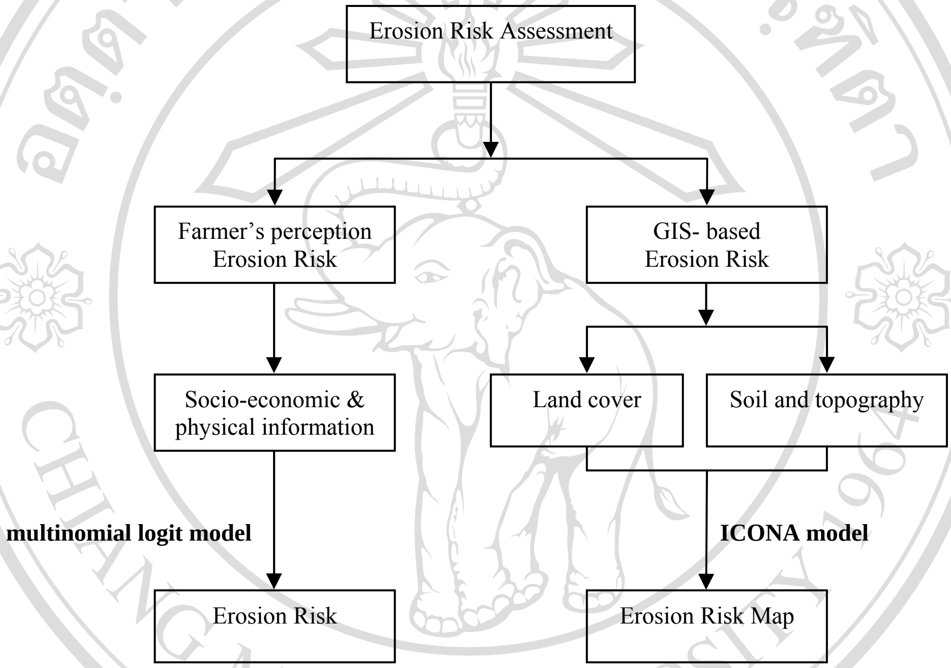

Figure 16. Conceptual framework of erosion risk study.

4.1.4.1 Multinomial logit model for erosion risk

The methodological approach chosen for the empirical analysis of socio-economic and physical factors influence on soil erosion is an explorative, econometric one, based on time series data.

The multinomial logit model has chosen for this study. This model makes it possible to study the identification of major socio-economic and physical factors influencing on soil erosion in the context of individually farmer's specific data on multiple choice.

In this study, the dependent variables are assumed to be ranged from low occurrence (1) to high (3) reflect increasing levels of erosion risk occurrence *(J)* (low= 1, medium= 2 and high= 3) and non-occurrence= 0.

Selected representative independent variables were including: farm household characteristics of farming practices, land use, land tenure system, fertilizer application etc., soil conservation management characteristics of crop residues management and farmer ranking factors affecting soil erosion and farmers' problems.

The following model was applied to compute the probability of occurrence of soil erosion *(J)* rather than non-occurrence of erosion (0) from selected socio-economic and physical driver variables.

$$P(Y = J) = \frac{\exp(\beta_J X_i)}{1 + \sum_{k=1}^{J} \exp(\beta_k X_i)} \quad (1)$$

Where:

Y is the observed outcome of erosion occurrence J

X_i are the independent variables and

β_j are the estimated coefficients of unknown parameters

The probability of choosing the non-occurrence is as follow:

$$P(Y=0)=\frac{1}{1+\sum_{k=1}^{J}\exp(\beta_k X_i)} \qquad (2)$$

The relationship between the dependent variable and independent variables follows a logistic curve. The logistic transformation of Eq. (1) linearizes the model, so that the dependent variable of the regression is continuous in the range of 1–3, as indicated by Eq. (3):

$$ln\ (P/\ 1+P) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots.. + \beta_k X_i + \epsilon \qquad (3)$$

The model assumes that the data are generated from a random sample. There is no restriction on the independent variables, except that they cannot be linearly related.

To compute the model, statistical package of the SPSS version 12.0 was used with a Maximum Likelihood Estimation procedure to find the best fitting set of coefficients.

- The explanatory factors X_1, X_2 . . . X_i are assumed to be selected independent variables.
- ϵ is the error due to the fact that the postulated independent variables do not completely account for the variation in P.
- The parameter β_0, β_1 . . . β_k are the regression coefficients for the selected independent variables.

4.2 GIS analysis

4.2.1 ICONA model

To estimate a spatially-explicit of soil erosion risk in the study area, Digital Elevation Model (DEM), digital geological map and Landsat TM image were used with the ICONA model. This method mainly consists of seven steps (Figure 17).

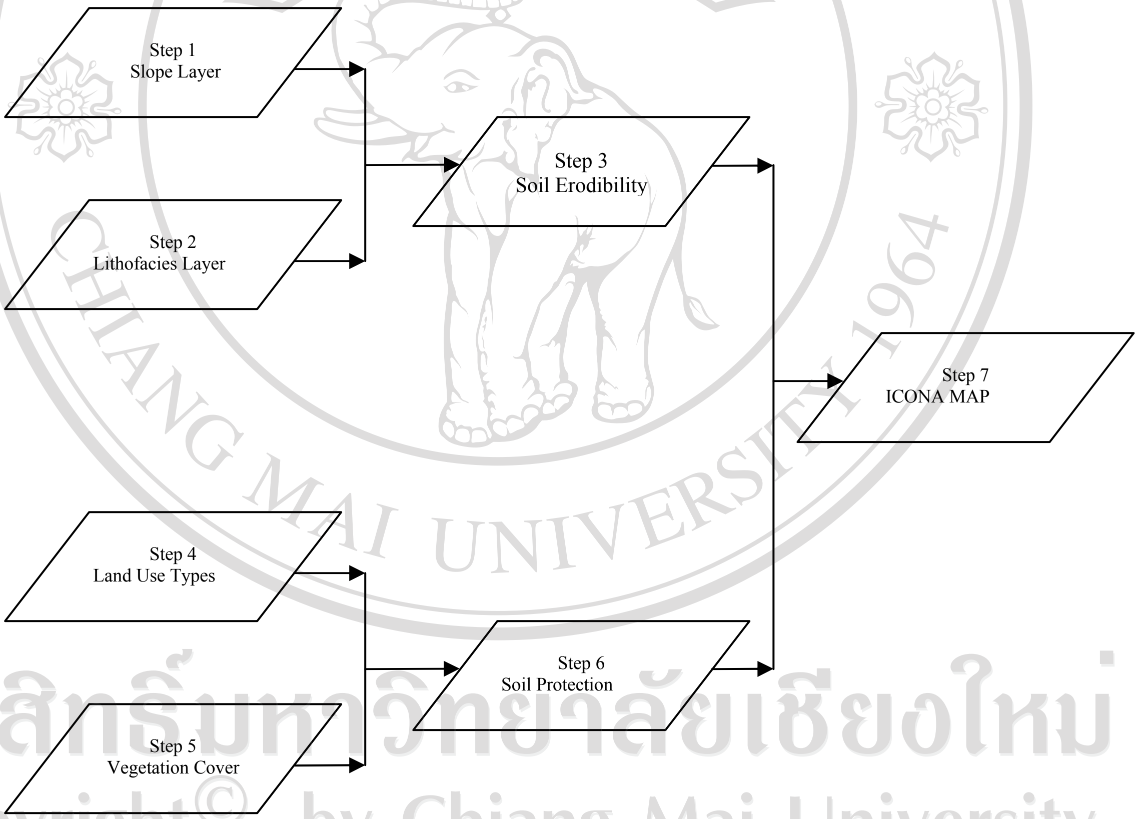

Figure 17. Steps of ICONA model.

(Source: İlhami BAYRAMİN *et al.*, 2003.)

First, the slope layer was generated from DEM data and classified into three groups. And then by analyzing the digital geological map, geological formations were classified into three groups in step 2 according to their resistance to weathering in order to prepare the lithofacies layer.

The slope layer and the lithofacies layer were then overlapped in step 3 to produce a Potential Erosion Risk (PER) map.

In step 4 Landsat TM imagery was classified using the maximum likelihood algorithm to determine three different land use categories in the study area. A normalized difference vegetation index (NDVI = NI band - R band / NI band + R band) defined by Tucker *et al.,* (1985) was performed and applied to the Landsat TM image. The NDVI layer was classified into three groups and a vegetation cover layer was produced in step 5, which was then merged with land use for generating a soil protection layer (step 6).

During the final predictive phase, soil erodibility and soil protection layers were combined to generate the ICONA soil erosion risk map.

4.3 Comparing field survey and ICONA

Finally, to compare and explain the goodness of observed values (identified factors) versus the estimated values (spatial data); the Root Mean Square Error (RMSE) was used as a comparison measure. This error was quantified the relationship between observed and predicted values.

$$\text{RMSE} = \sqrt{\frac{\sum_{i=1}^{n}(Pi - Oi)^2}{n}} \qquad (4)$$

Where:

RMSE	- Root Mean Square Error
P_i	- the estimated value at sample i
O_i	- the observed value at sample i
n	- Number of the observation