CHAPTER VI

EROSION RISK ASSESSMENT WITH ICONA MODEL

6.1 Introduction

The Universal Soil Loss Equation (USLE) model may not be easy to apply under Myanmar Dry Zone conditions. However, the effort should be made for the simple reason that the exercise in itself provides useful information about agro-climatic, soil and landscape characteristics conditions. It provides guidance on what are the main constraints affecting production levels and environmental conditions and suggests the direction to follow to solve problems.

6.2 Indicators for erosion risk assessment

Indicators are quantitative or qualitative variables that can be assessed in relation to a criterion. An indicator describes attributes of the criterion in an objectively verifiable and unambiguous manner, and is capable of being estimated periodically in order to detect trends. In this study, indicators were selected by screening erosion-inducing biophysical, socio-economic and land use factors that are assumed to be good indicators of soil erosion risk. The selection was based on data existing in national and regional database.

Slope

Slope is an important indicator of soil erosion risk. Velocity and volume of runoff increases with the increase of the steepness of the slope, therefore soil erosion also increases with the increase of slope. Again more soils splashes down-slope than up-slope with the increase of slope due to gravitational force and the proportion increases with increasing slope steepness (Morgan, 1986).

Soil texture

Soil texture is also a very important indicator of soil erosion risk. Especially the finer fractions, such as clay and silt, are vulnerable to erosion, if they are not bound in stable aggregates that are resistant to breakdown by erosion forces. Often, the term erodibility is used to define the resistance of a soil to both detachability and transportability. These characteristics vary with soil texture, aggregate stability, shear strength, infiltration capacity, soil organic matter content and soil chemical parameters. Larger soil particles are more resistant to erosion because more force is required to move them. Silt and fine sand require the least force to be moved by rain drop splash or runoff. According to Morgan (1986) soil with high silt content are therefore highly erodible. Evans (1980) reported that soils with low clay content (9 to 30%) are most vulnerable to erosion. The surface soil texture of the study area is predominantly fine sandy loam (49%), sandy soil (37%), clay soil (10%) and 4% of silt. This indicates a generally high erodibility of the area in terms of texture indicator (Figure 20).

Land use type

Land use type plays a very important part in controlling erosion. It refers as a protective layer on the above ground because it absorbs some of energy of falling raindrops and running water.

- *Cultivated area*

The percentage of land that is cultivated within a geographic unit indicates the

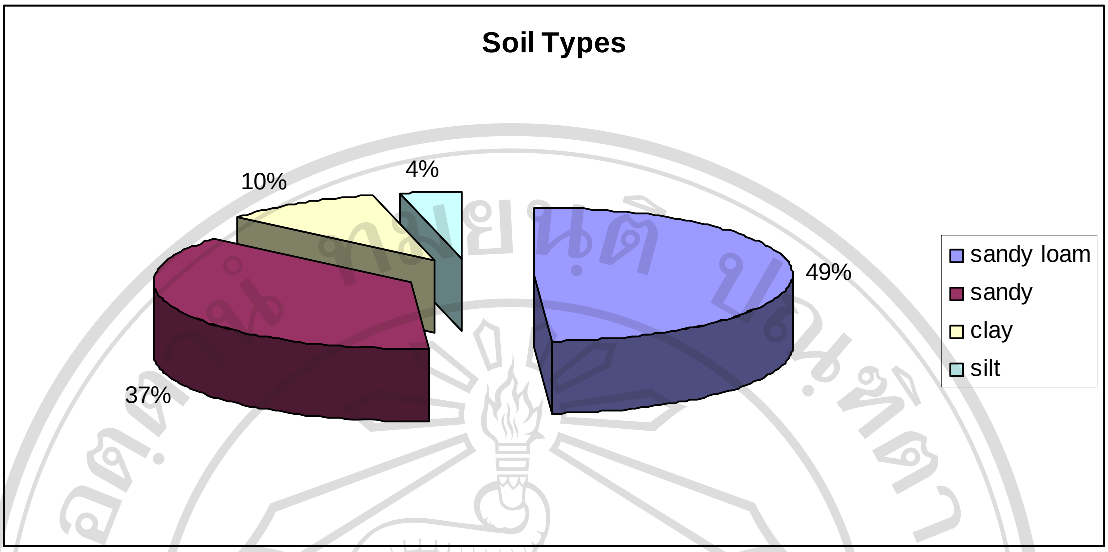

Figure 20. Types of soil in the study area.

stress or pressure on the land, due to anthropogenic disturbance. Natural vegetation- such as forest or grass- protects the soil from the impact of rainfall and runoff, thus reducing erosion risk. With high proportions of cultivated land within an area, high exposure to the erosive agents may be assumes, thus leading to increased erosion risk.

- *Forest cover*

Forest area plays a major role in the interception of rain and the dissipation of its erosive energy. Plants catch the raindrops and from there it slowly trickle down to soil surface reducing surface runoff and allowing more time for infiltration (Holy, 1980). It is widely established that very minor changes in land cover can causes significant changes in soil erosion. As such forest cover is a very important erosion risk indicator. This indicates different degree of protection of the soil from erosion.

- *Cropping intensity*

Cropping intensity indicates the extent to which an area is used for cropping. High cropping intensity means high exposure of the soil to erosive energy and other factors that influence the erodibility of a soil. High intensity seasonal cropping with tillage loosens the soil breaks the soil structure and thus makes the soil more vulnerable to erosion.

Vegetation cover

Vegetation, natural or planted, is the most efficient controlling factor of soil erosion. The above ground parts of the vegetation protect the soil from the energy of raindrops, runoff, and wind while the roots stabilize and improve the mechanical strength of the soil, resulting in reduced soil erosion. The effect of vegetation cover on soil erosion also depends on the type of the plants (e.g., crop), their height and stage of development, and the characteristics of the climate and soil.

6.3 ICONA model for erosion risk

To estimate a spatially-explicit of soil erosion risk in the study area, Digital Elevation Model (DEM), digital geological map and 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 were used with the ICONA model. This method mainly consists of seven steps (Figure 21).

First, the slope layer was generated from DEM data by using topology analysis and classified into three groups of slope percentage, which are flat, medium and steep slope as shown in Table 12. It can be seen that 86 % of the study area has more than a 3% slope varying from flat to medium and 14% of area has steep slope.

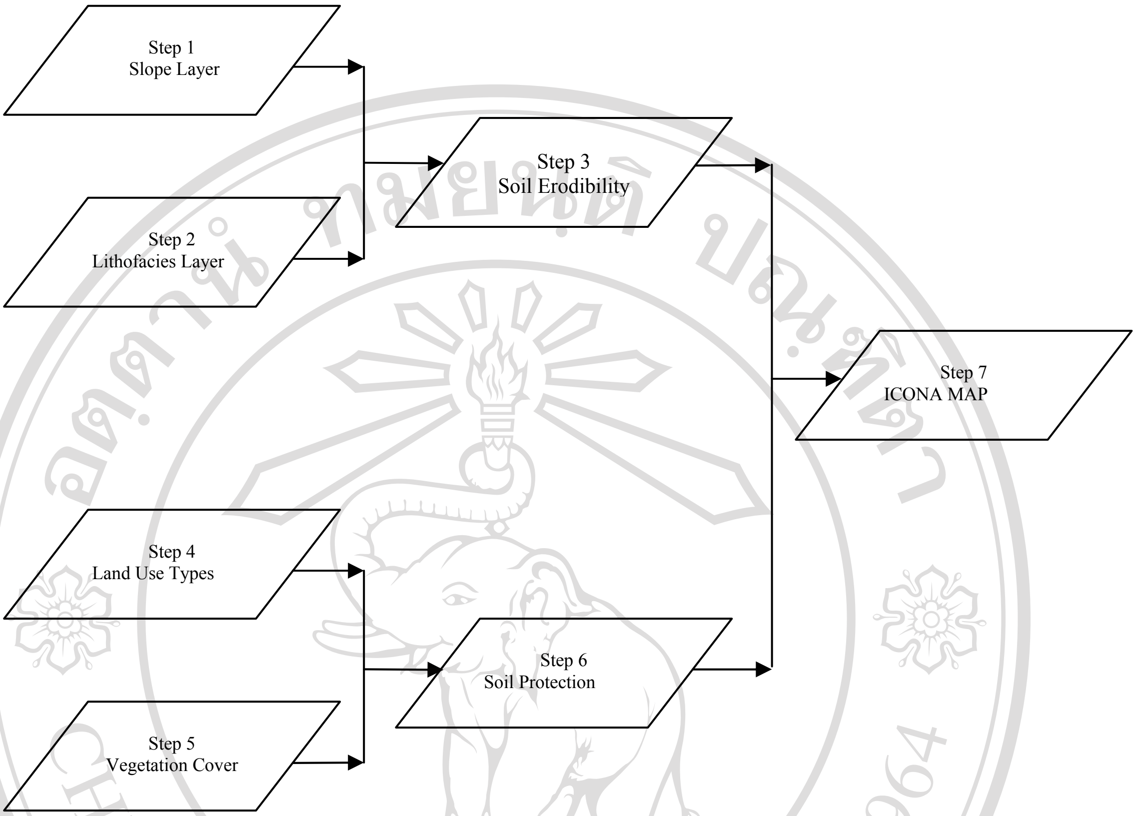

Figure 21. Steps of ICONA model.
(Source: İlhami BAYRAMİN *et al.*, 2003.)

Table 12. Slope classes of the study area.

Class	**Slope Range (%)**	**Label**	**Area %**
1	0-3	Flat and gentle	31
2	3-12	Medium	55
3	12-20	Steep	14

In Figure 22, eastern part of the district has mostly steep slope ranging between 12 to 20 percent.

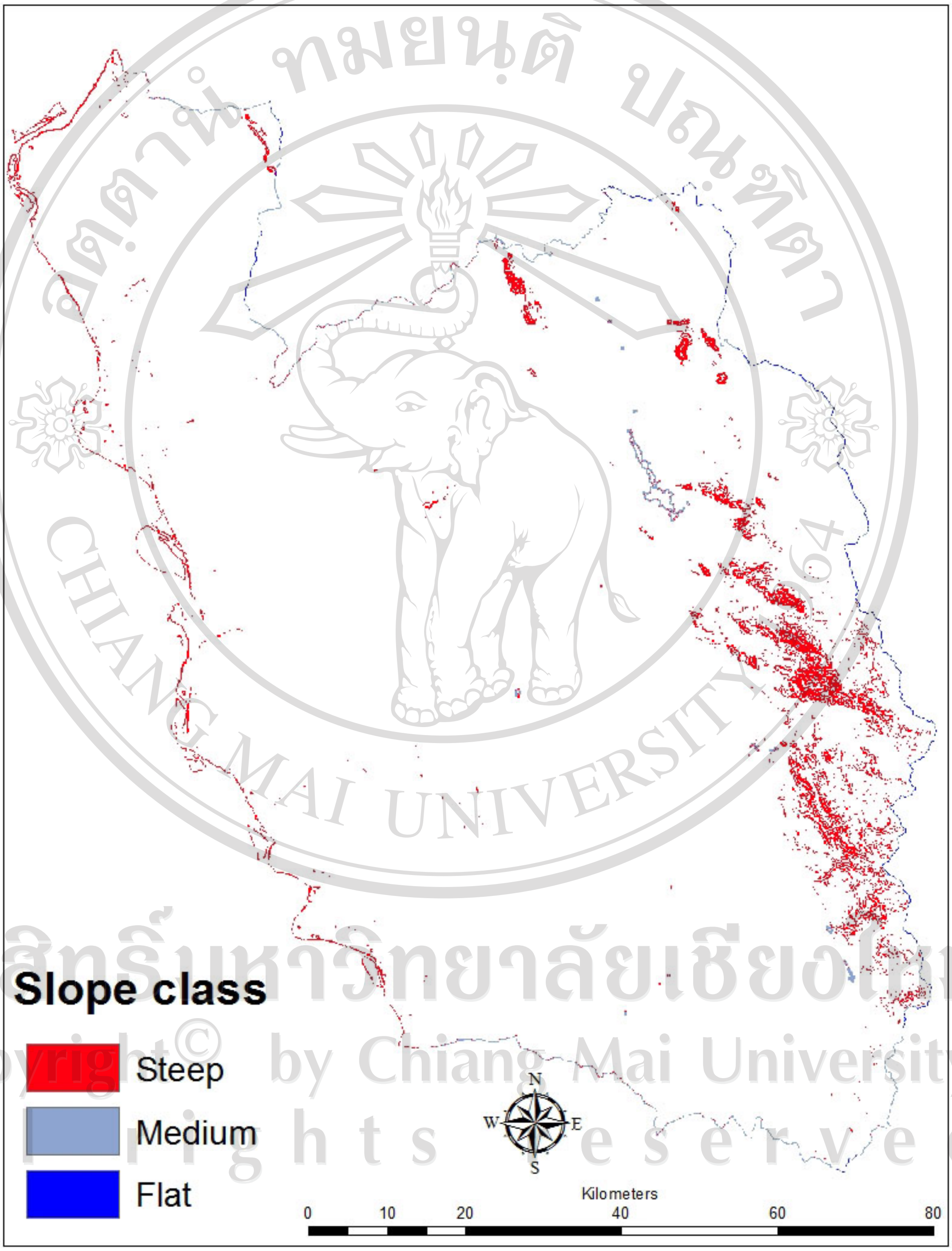

Figure 22. Slope map of the study area.

In step 2, firstly shape file was changed to raster format by using conversion tool. By reclassifying the digital geological map, geological formations were classified into three groups as non-weathered compact rock, medium weathered cohesive rocks and loose and non-cohesive sediments or soils according to their resistance to weathering in order to prepare the lithofacies layer (Figure 23). The details of these 3 categories are presented in Table 13. Mostly eastern part of the area has medium weathered cohesive rocks; the others are non-weathered compact rock except some portion of Taungdwingyi and Chauk townships. Loose and non-cohesive sediments soils are found in Chauk, Myothit and Taungdwingyi townships.

Table 13. Lithofacies classes of study area.

Class	Lithofacies Classes (Types of Material)	Area %
1(a)	Non-weathered compact rock, crusts and hard pans	50
2(b)	Fractured and/ or medium weathered cohesive rocks or soils	29
3(c)	Loose, non cohesive sediments/soils and detritic material	21

The slope layer and the lithofacies layer were then overlapped to produce a Potential Erosion Risk (PER) map in step 3. The resulting soil erodibility map is presented in Figure 24. The map shows that 78.9% of total area has low erodibility, 21% has medium erodibility and only 0.1% has high erodibility.

Table 14. Soil erodibility classes of the study area.

Class	Level of erodibility	Area %
1	Low Erodibility (LEr)	78.9
2	Medium Erodibility (MEr)	21
3	High Erodibility (HEr)	0.1

The erodibility matrix is presented in Table 15, by which the erodibility levels were estimated. For example, compact rock 1(a) having slopes less than 3% has low erodibility (LEr), whereas loose, non cohesive sediments/soils having slopes greater than 12% has high erodibility (HEr) value. The erodibility index results are given in Table 16.

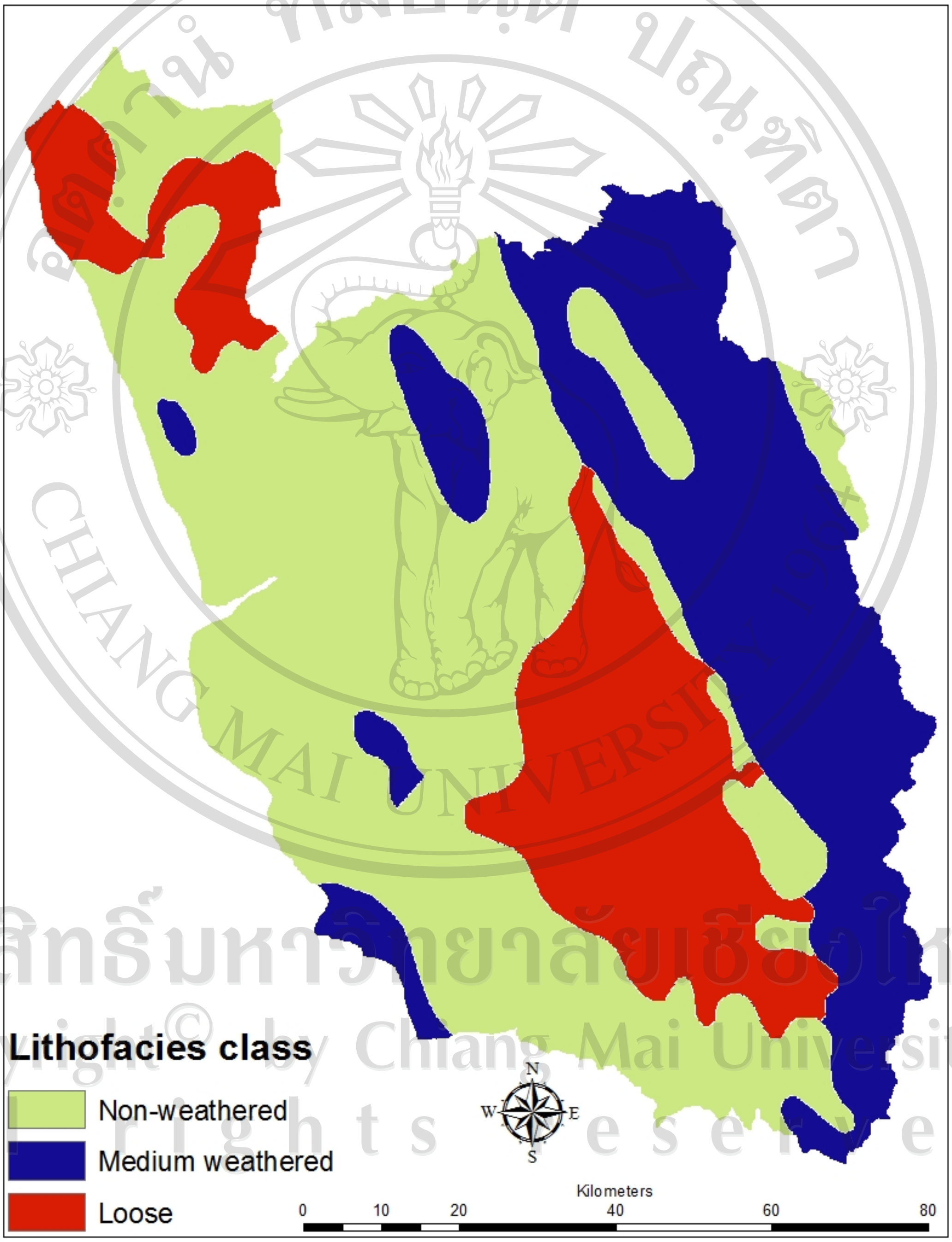

Figure 23. Lithofacies map of the study area.

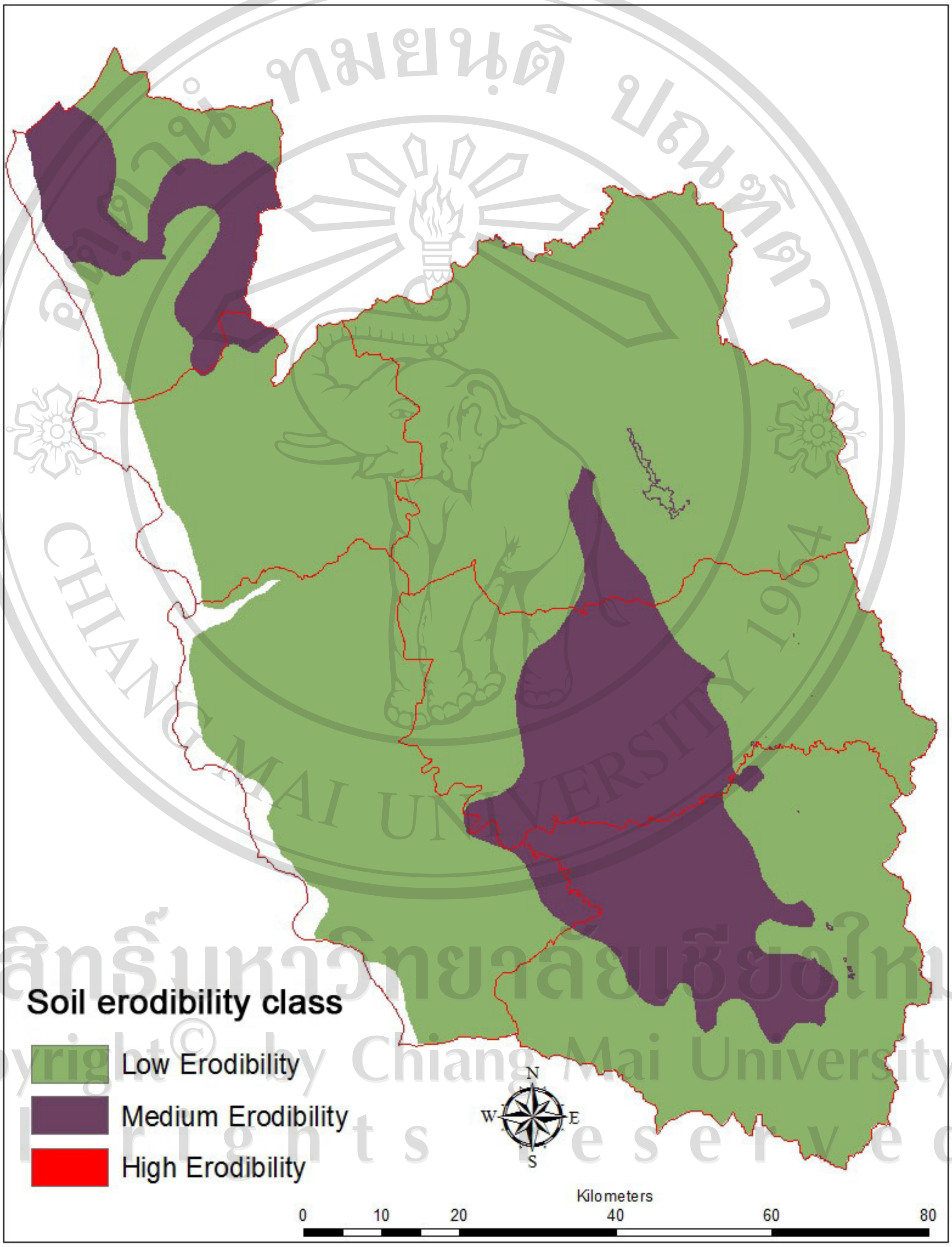

Figure 24. Soil erodibility map of the study area.

Table 15. Erodibility matrix: slope vs. lithofacies.

Slope Classes	**Lithofacies Classes**		
	1 (a)	**2(b)**	**3(c)**
1	1 (LEr)	1(LEr)	2(MEr)
2	1 (LEr)	2(MEr)	3(HEr)
3	2(MEr)	3(HEr)	3(HEr)

Table 16. Soil erodibility index of the study area.

Class	**Label**	**Description**
1	(LEr)	Low Erodibility
2	(MEr)	Medium Erodibility
3	(HEr)	High Erodibility

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 was classified using maximum likelihood algorithm to determine different land use categories within the study area. The resulting land use classes are tabulated in Table 17 and land use map is presented in Figure 25. In Magway district, 73% of total land is widely distributing in agricultural land except eastern part of the district is in forest and scrub land.

Table 17. Land use classes of the study area.

Class	**Description**	**Area %**
1	Forest and scrub land	6
2	Barren land	21
3	Agricultural land	73

In step 5 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 (Figure 26), which was then merged with land use for generating a soil protection layer in step 6.

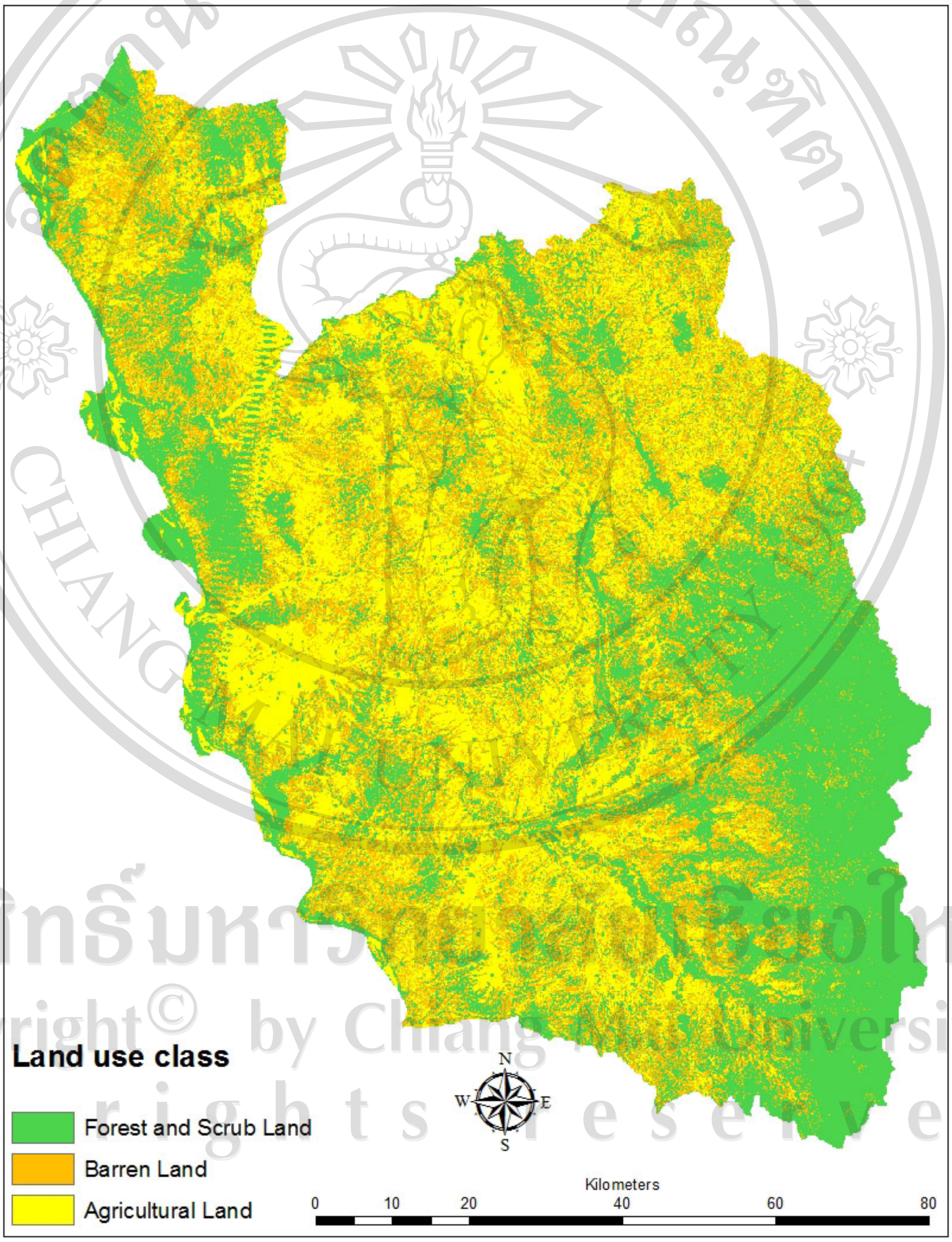

Figure 25. Land use map of the study area.

Table 18. NDVI classes of the study area.

Class	Description	Area %
1(a)	Vegetation Cover less than 25%	59
2(b)	Vegetation Cover between 25% and 50%	34
3(c)	Vegetation Cover greater than 50%	7

In order to determine the soil protection layer map, vegetation cover index layer and land use layer were overlapped. The soil protection matrix is presented in Table 19, by which the protection levels were estimated. The resulting soil protection map is presented in Figure 27. The map shows that 37.7% of total area has low protection, 49.7% has medium protection and 12.6% has high protection.

Table 19. Soil protection index: land use and vegetation cover.

Land use	**Vegetation Cover**		
	1(a)	**2(b)**	**3(c)**
1	3 (LP)	3(LP)	2(MP)
2	3 (LP)	2(MP)	1(HP)
3	2(MP)	1(HP)	1(HP)

Table 20. Soil protection levels of the study area.

Class	Label	Description	Area %
1	HP	High Protection	12.6
2	MP	Medium Protection	49.7
3	LP	Low Protection	37.7

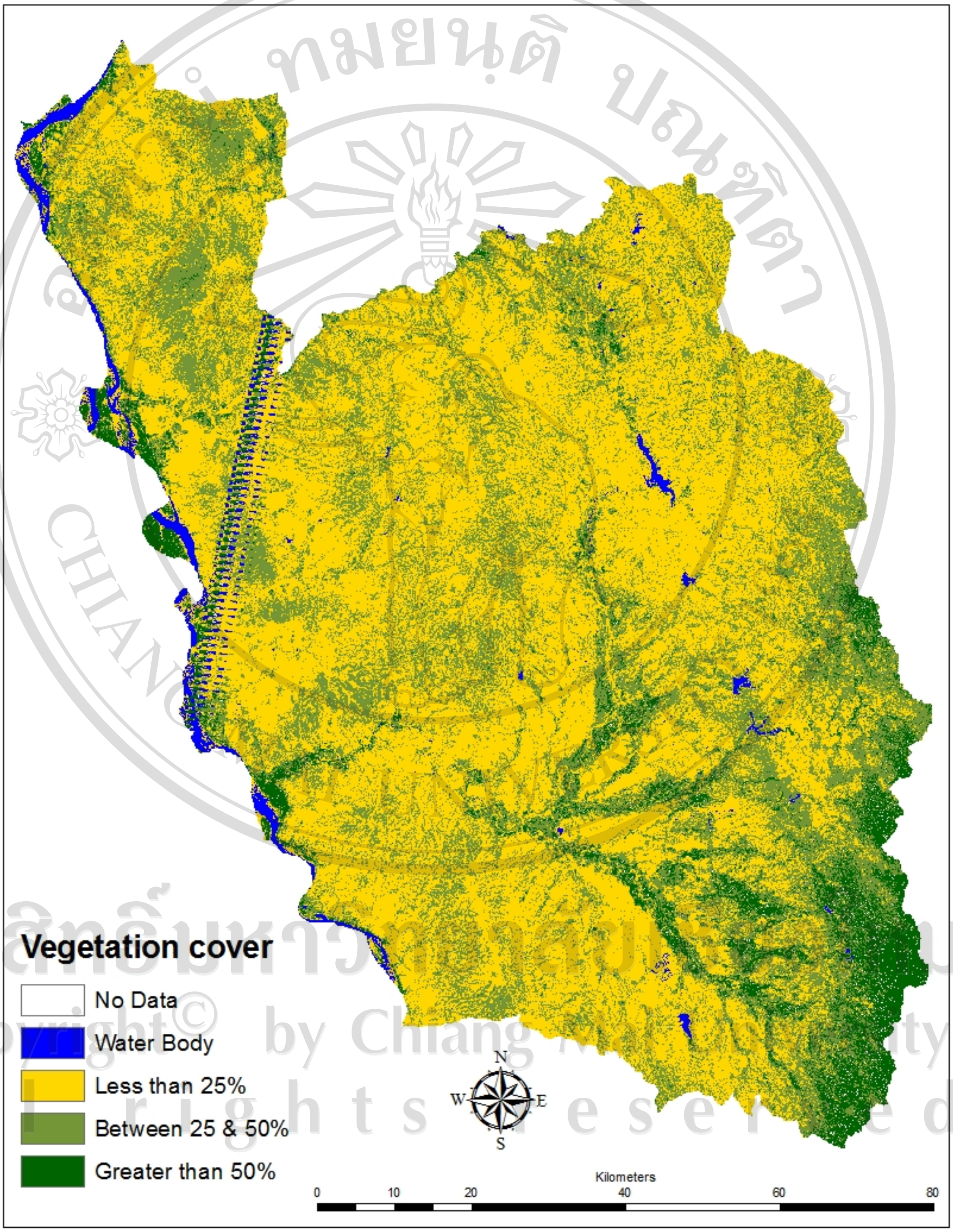

Figure 26. Vegetation cover map of the study area.

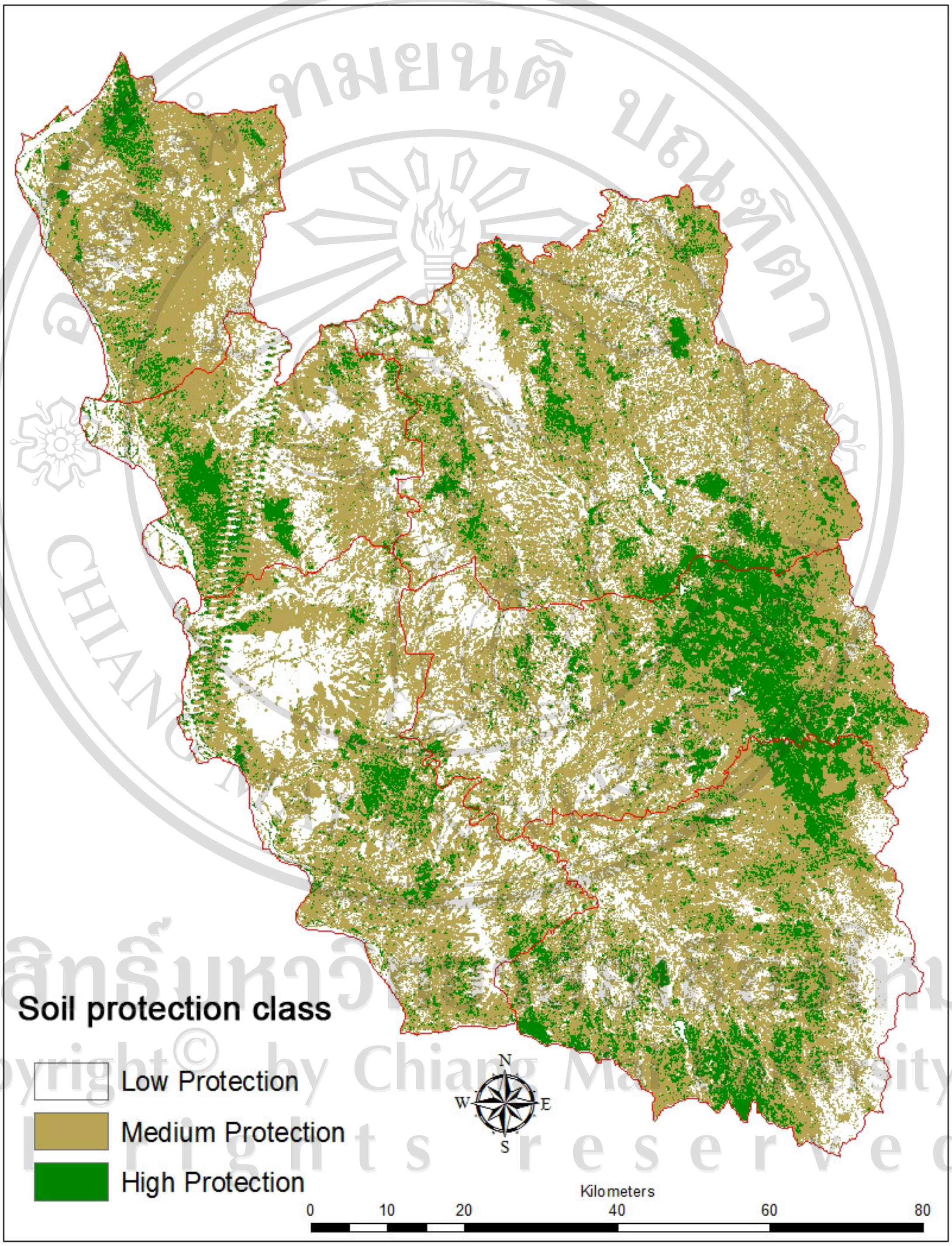

Figure 27. Soil protection map of the study area.

During the final predictive step 7, ICONA erosion risk map was generated by combining soil erodibility map (step-3) and soil protection map (step-6). The final erosion risk map shows that 76.5 % of the area has low erosive status. These areas are including agricultural land and already eroded area in the past. 21.8% of area has medium erosion risk and 1.7% of the area is in high erosion risk status (Figure 28).

Table 21. Erosion status matrix: level of soil protection vs. level of erodibility.

Erosion Risk		**Level of Erodibility**		
		1(LEr)	**2(MEr)**	**3(HEr)**
Level of soil Protection	**1 (HP)**	1 (LE)	1(LE)	2(ME)
	2 (MP)	1 (LE)	2(ME)	3(HE)
	3 (LP)	2 (ME)	3(HE)	3(HE)

Table 22. Erosion risk status of the study area.

Erosion Risk	**Area (ha)**	**Area (%)**
Low Erosion Risk	77824.08	76.5
Medium Erosion Risk	22183.47	21.8
High Erosion Risk	1786.95	1.7
Total	**101794.50**	100.0

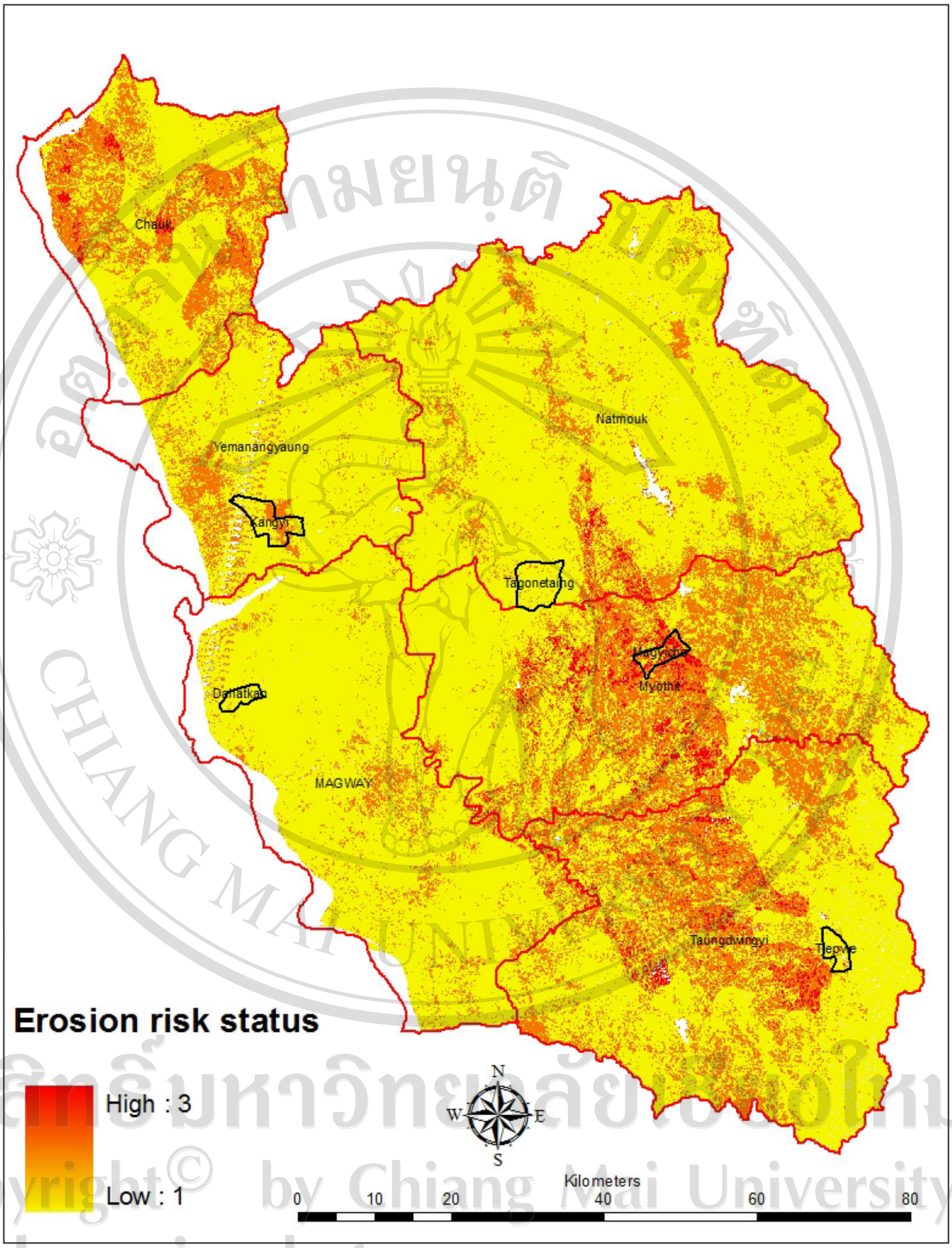

Figure 28. ICONA erosion risk map of the study area.

6.4 Root Mean Square Error (RMSE)

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.

$$\mathrm{RMSE} = \sqrt{\frac{\sum_{i=1}^{n}(Pi - Oi)^2}{n}} \qquad (6)$$

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

Farmers' perception erosion risk and estimated erosion risk were compared for five different villages in the study area.

Erosion risk from farmers' perception can be represented as value 1, 2 and 3 for low, medium and high erosion risk respectively. An average erosion risk level of each village (20 farmers for each village) will be calculated as the following equation;

$$Ej(f)=\frac{\sum_{i=1}^{n}Ei}{n} \tag{7}$$

Where $Ej(f)$ = Mean erosion risk for village j

Ei = Erosion risk from each farmer in the village j

n = number of farmer

To get an estimated erosion risk level of villages based on GIS analysis, erosion risk layer of study area and village tracts polygon were analyzed by using zonal statistic to get the mean of erosion risk level for each village.

Erosion risk status values of five villages from farmers' perception and ICONA model and the results of Root Mean Square Error (RMSE) are described in Table 24.

Table 23. Comparing farmers' perception erosion risk and ICONA erosion risk.

Villages	Comparing Two Models		
	Farmers' perception	ICONA	RMSE
Dahatkan	1.55	1.02	0.014
Kangyi	1.80	1.32	0.011
Tagonetaing	1.30	1.05	0.003
Magyicho	1.90	1.99	0.000
Tiepwe	1.30	1.10	0.002
Total Root Mean Square Error			**0.031**

From the above table, Root Mean Square Error value of Magyicho village is 0.000, it means that ICONA erosion risk status and farmers' perception erosion risk status go together and farmers' perception can improve the estimation and accuracy of the ICONA model for that village.

However, except Magyich village, for four other villages, all values of farmers' perception erosion risk status are greater than that of the ICONA erosion risk status values, because ICONA model is mainly based on soil and vegetation cover factors and farmers perception based on all possible socio-economic factors affecting soil erosion.

Farmers' perception is very important to determine the severity of soil erosion and its underling causes in particular area. It would easily guide the understanding and empirical assessment of the severity and extent of erosion trends and their interrelated causes in the absence of research facilities.