CHAPTER V

RESULTS AND DISCUSSION

5.1. Geoprocessing Models Construction

Models in this study were built to standardize all factors for land suitability assessment in the study area based on fuzzy method with MF values of individual land characteristics such as the model to standardize factors for optimum range (Model 2, Equation (4.2)); for asymmetric left (Model 3, Equation (4.3)), for asymmetric right (Model 4, Equation (4.4)), for soil loss calculation, and also standardize that factor by asymmetric right function, then there factors will be combined using a joint membership function (JMF) of all attribute (Equation (4.5)), which are shown in the Figure 5.1 to Figure 5.7, and appendix B .

All models were built to standardize factors of crop suitability, to calculate, standardize soil loss, and joint membership function by using Spatial Analysis Tools.

5.1.1 Optimum Range for Standardize Factor Model

For optimum range (Model 2, Equation (4.2)), firstly, the factor maps will divided in to three parts, equal, less than and greater than ideal point by using Equal To Frequency, Less Than Frequency and Greater Than Frequency tools. Secondly, if the value of the factor map equal the ideal points was assigned with the value of 1, the less than or greater than the value of ideal points would be assigned with the asymmetric left and asymmetric right by using Singe Output Algebra tools. The function $MF(x_i) = [1/(1 + \{(x_i - b_1 - d_1)/d_1\}^2)]$ has applied for asymmetric left, and the function $MF(x_i) =[1/(1 + \{(x_i - b_2 + d_2)/d_2\}^2)]$ has applied for asymmetric right. Finally, all values were combined to obtain the standardized maps for optimum range.

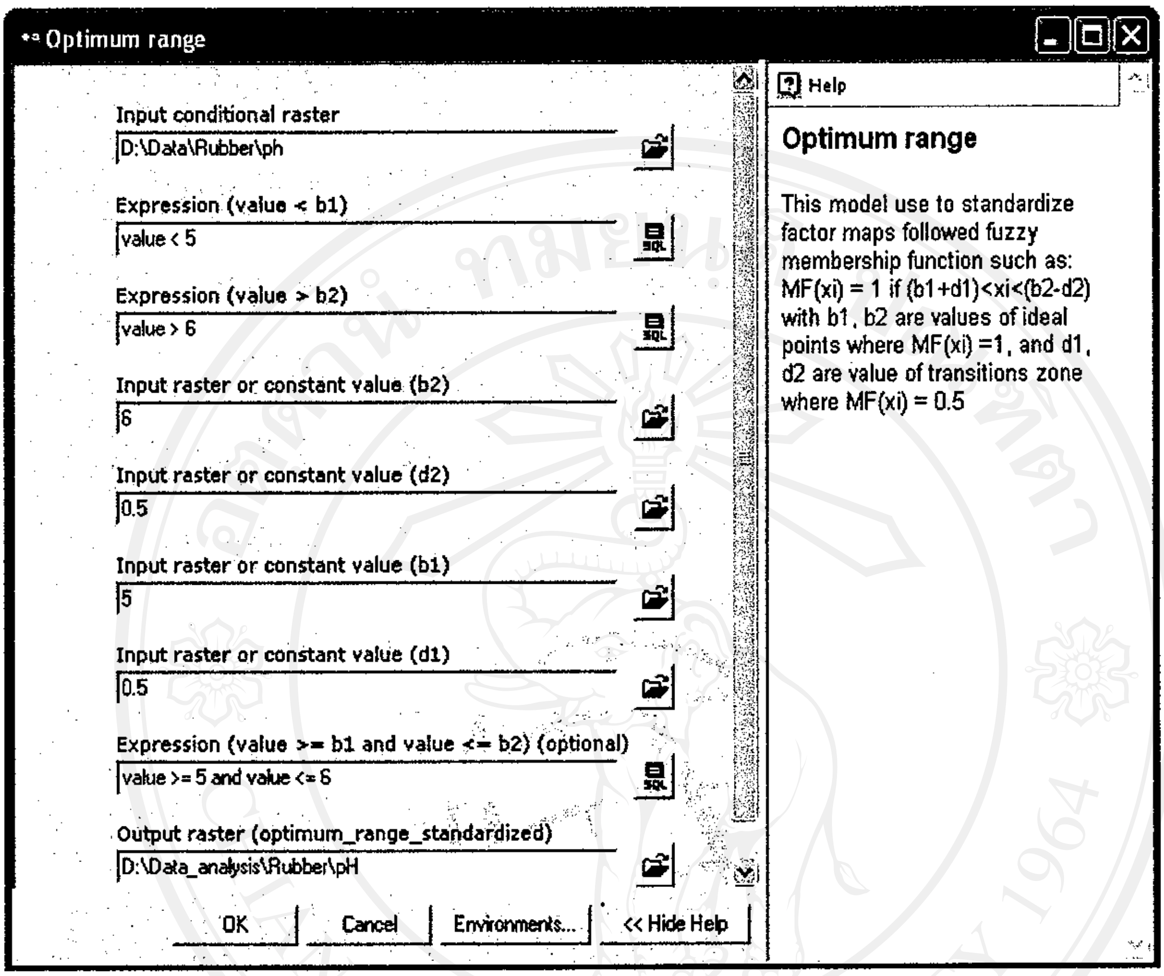

Figure 5.1 The window to enter parameters in optimum range model (Model 2).

The optimum range model represented in Figure 5.1 showed that the factor maps need for standardizion would be assigned to the “Input conditional raster”. The value of b_1 and b_2 was assigned in “expression (value < b_1)”, “expression (value > b_2)”, “Input raster or constant value (b_1)” and “Input raster or constant value (b_2)”. The value of d_1 and d_2 was assigned in “Input raster or constant value (d_1)” and “Input raster or constant value (d_2)”with b_1, b_2 are values of ideal points, and d_1, d_2 are value of LCP and UCP, respectively. In the “Expression (value >= b_1 and value < b_2) (optional)” set the value to be equal to 1. By assigning the location and the name of output maps and click OK, the standardized map would be obtained.

5.1.2 Asymmetric Left for Standardize Factor Model

For asymmetric left model (Model 3, Equation (4.3)), the factor maps were divided in to two parts, less than and greater than ideal point by using Less Than Frequency and Greater Than Frequency tools. If the value of the factor map greater than the value of ideal point, it was assigned with the value of 1. And the value of factor map less than the value of ideal points would be assigned with the asymmetric left by using Singe Output Algebra tools. Model was built by using Singe Output Algebra tools, to carry-out the equation $MF(x_i) = [1/(1 + \{(x_i - b_1 - d_1)/d_1\}^2)]$. The model was used to standardize factor maps in case of asymmetric left has built. All factor maps need to standardize with asymmetric left could be achieved by entering parameters in the model represented in Figure 5.2.

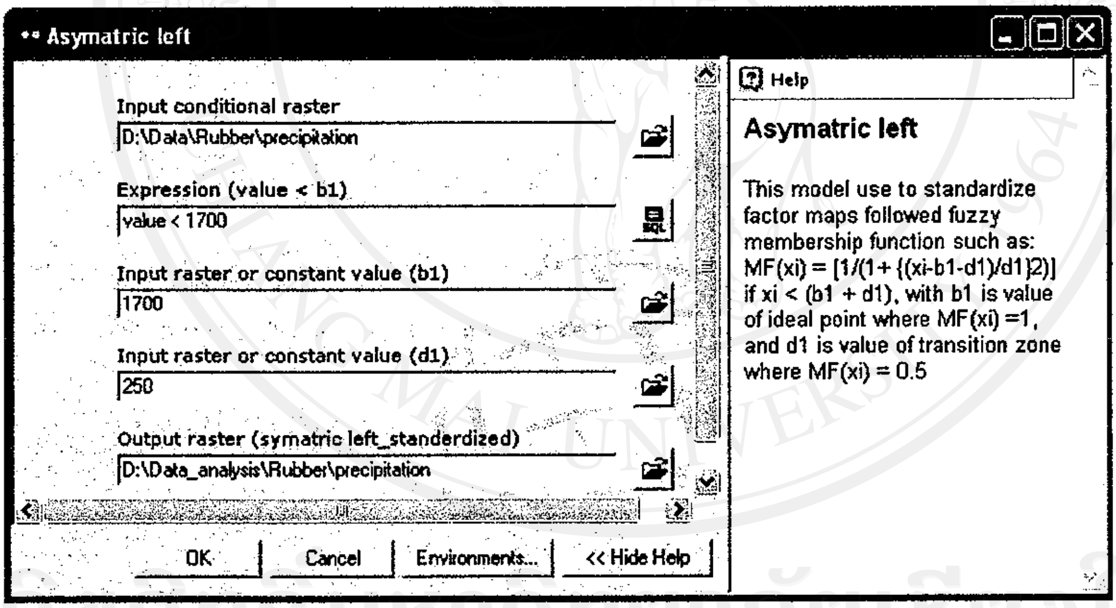

Figure 5.2 The window to enter parameters in asymmetric left model (Model 3).

The window in Figure 5.2 shows the factor maps to be standardized using "Input conditional raster". The value of ideal point (b_1) would be placed in "Expression (value < b_1)". The value of LCP (d_1) would be assigned in "Input raster or constant value (d_1). And the location and the name of the output map will be assigned then click OK. The standardized map would be created.

5.1.3 Asymmetric Right for Standardize Factor Model

For asymmetric right model (Model 4, Equation (4.4)), the factor maps would also be divided in to two parts, less than and greater than ideal point by using Less Than Frequency and Greater Than Frequency tools. If the value of the factor map was less than the value of ideal point, it would be assigned with the value of 1. While the value of factor map was greater than the value of ideal points would be assigned with the asymmetric right by using Singe Output Algebra tools. Model was built by using Singe Output Algebra tools, to carry-out the equation $MF(x_i) = [1/(1 + \{(x_i - b_2 + d_2)/d_2\}^2)]$. The model was used to standardize factor maps in case of asymmetric right was built. All factor maps need to standardize with asymmetric right can be accomplished by entering parameters in the model represented in Figure 5.3.

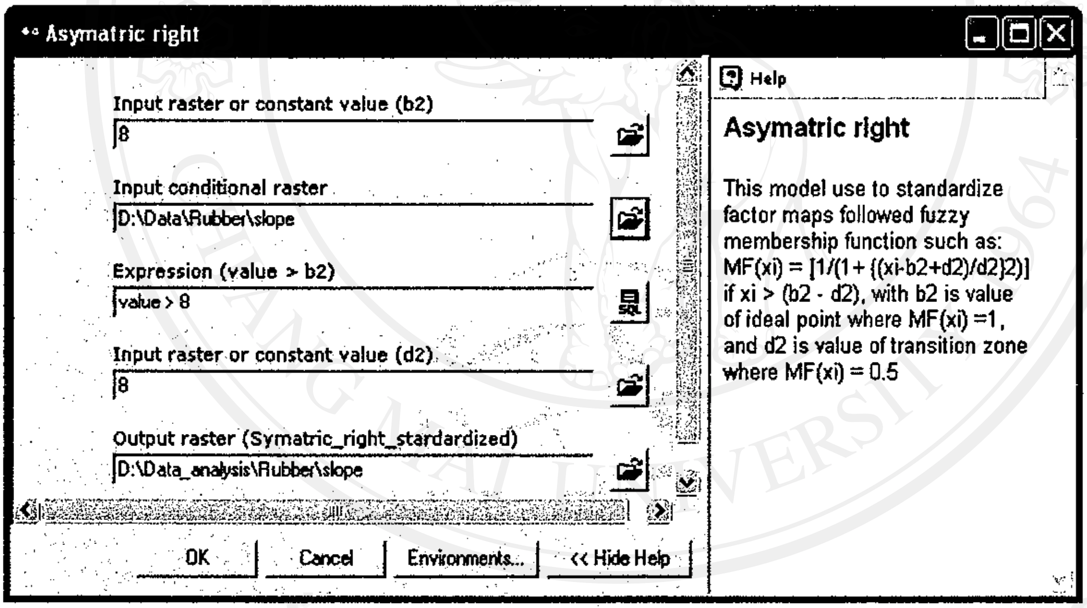

Figure 5.3 The window to enter parameters in asymmetric right model (Model 4).

Asymmetric right for standardize factors model (Figure 5.3) shows that the factor maps need to standardize to be assigned to the "Input conditional raster". The value of ideal point (b_2) would be placed in "Expression (value > b_2)". In the "Input raster or constant value (d_2)", the value of LCP (d_2) would be assigned. And the location and the name of the output map will be assigned then click OK. The standardized map would be generated.

5.1.4 Joint Membership Crop Suitability Index Model

Eight parameters maps of crop suitability, mean of annual temperature, mean of annual precipitation, soil depth, soil drainage, cation exchange capacity, pH, organic matter, and slope were used to combine with their corresponding weight by using simple function of Times, and Plus in Arc Toolbox. The model in Figure 5.4 shows eight parameter maps and their weights to be entered in the model. When all necessary information of factors has been entered and the model was executed the crop suitability index would be attained.

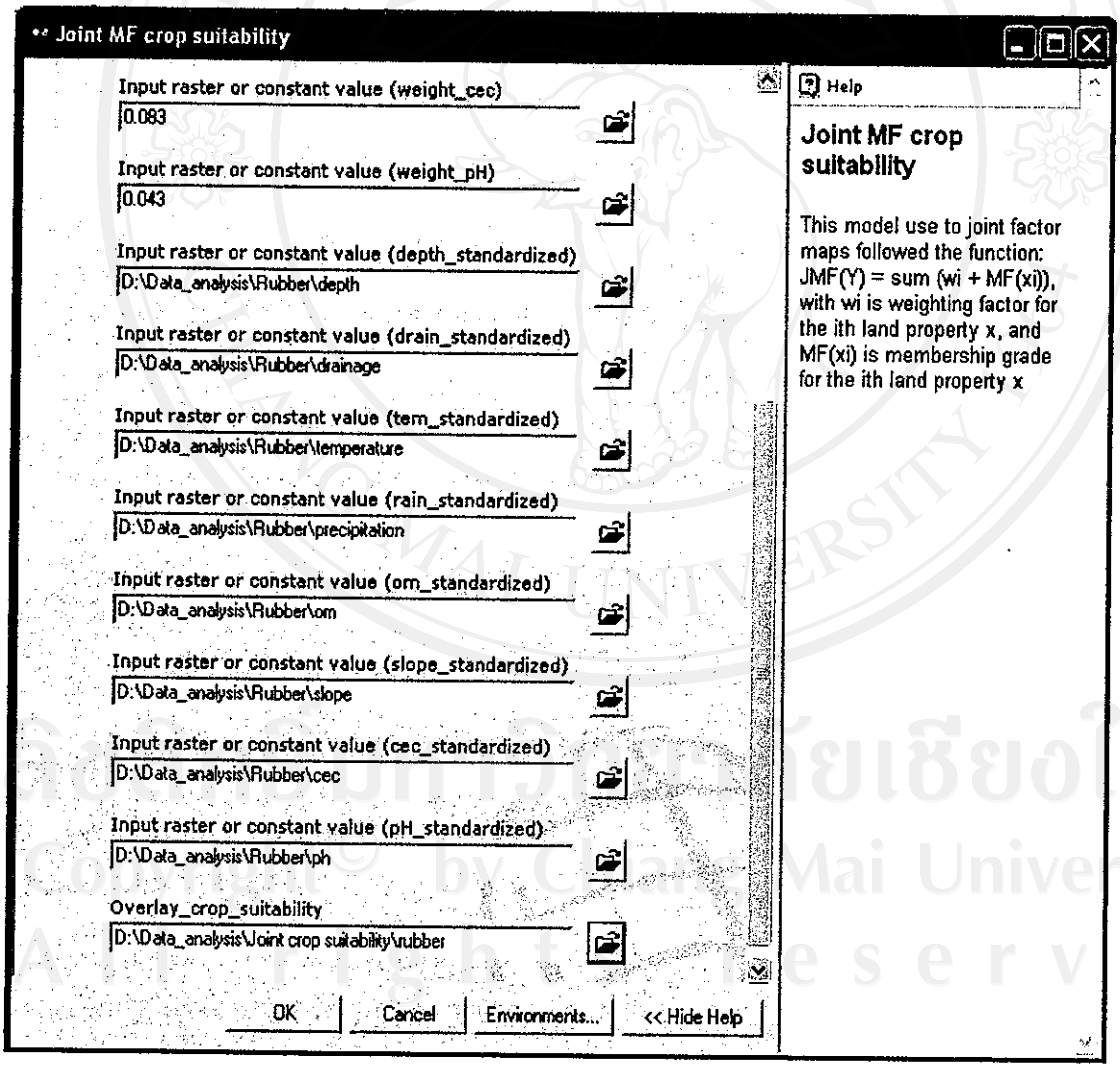

Figure 5.4 The window to enter parameters in joint MF crop suitability model.

5.1.5 Annual Soil Loss Estimation Model

In this model, the rainfall erovisity factor (R) was set following Equation (4.9) by using Times and Minus command in Arc Toolbox. The Soil erodibility (K) was set following Equation (4.10) by using Single Output Algebra tools with Times, Plus, Minus, Power command. The topography factors (LS) was derived from DEM. All of these factors were multiplied by using Times command in Arc Toolbox (Figure 5.5).

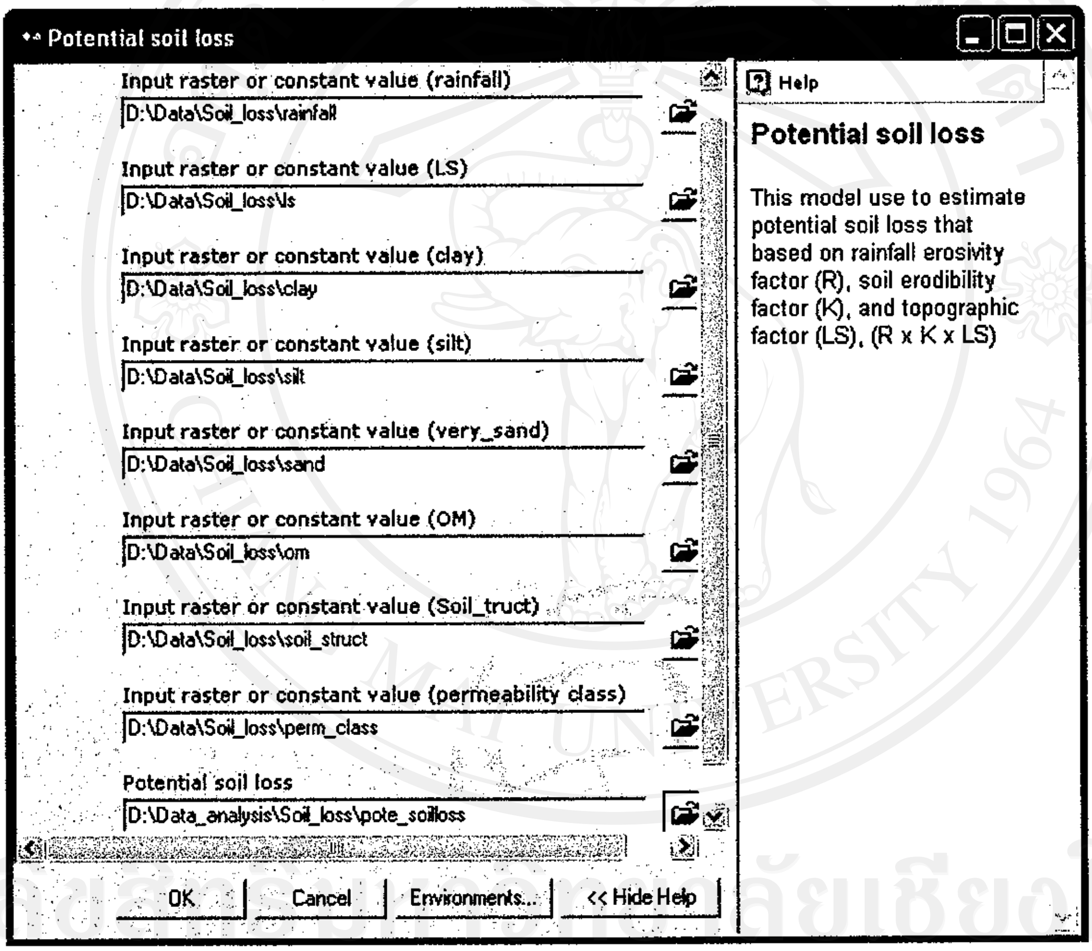

Figure 5.5 The window to enter parameters of potential soil loss estimation model.

The output of this model would be used to multiply with land cover management factor (C-factor), and conservation practice factors (P-factor) by using Times command in Spatial Analysis Tools in Arc Toolbox (Figure 5.6). By using this model, annual soil loss map would be created.

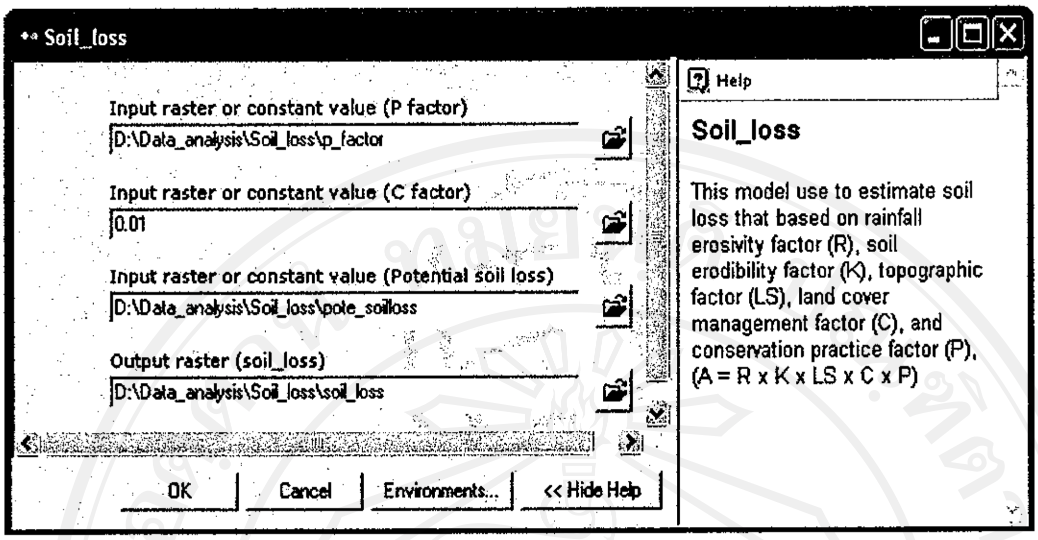

Figure 5.6 The window to enter parameters for soil loss estimation model.

5.1.6 Joint Membership Physical Suitability Index Model

The crop suitability index, and soil loss index would be combined by using Plus command. Before those factors to be combined, they have to multiply with their corresponding weights. The window to enter parameters in joint MF of physical suitability model is presented in Figure 5.7. When all of factors are set, click OK, the physical suitability index map would be accomplished.

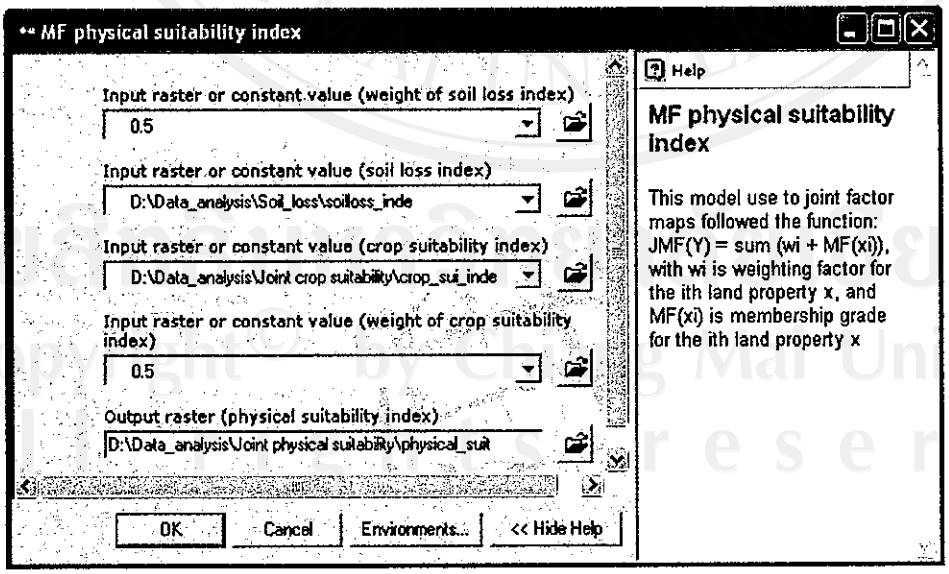

Figure 5.7 The window to enter parameters in joint MF of physical suitability model.

5. 2 Determination of Physical Suitability

5.2.1 The Constraint Map of the Study Area

The constraint map of the study area was defined as the area that could not be used for the cultivation. These areas will not be used for physical suitability evaluation. It composed of construction sites, water bodies and the area that cover by forest (Figure 5.8).

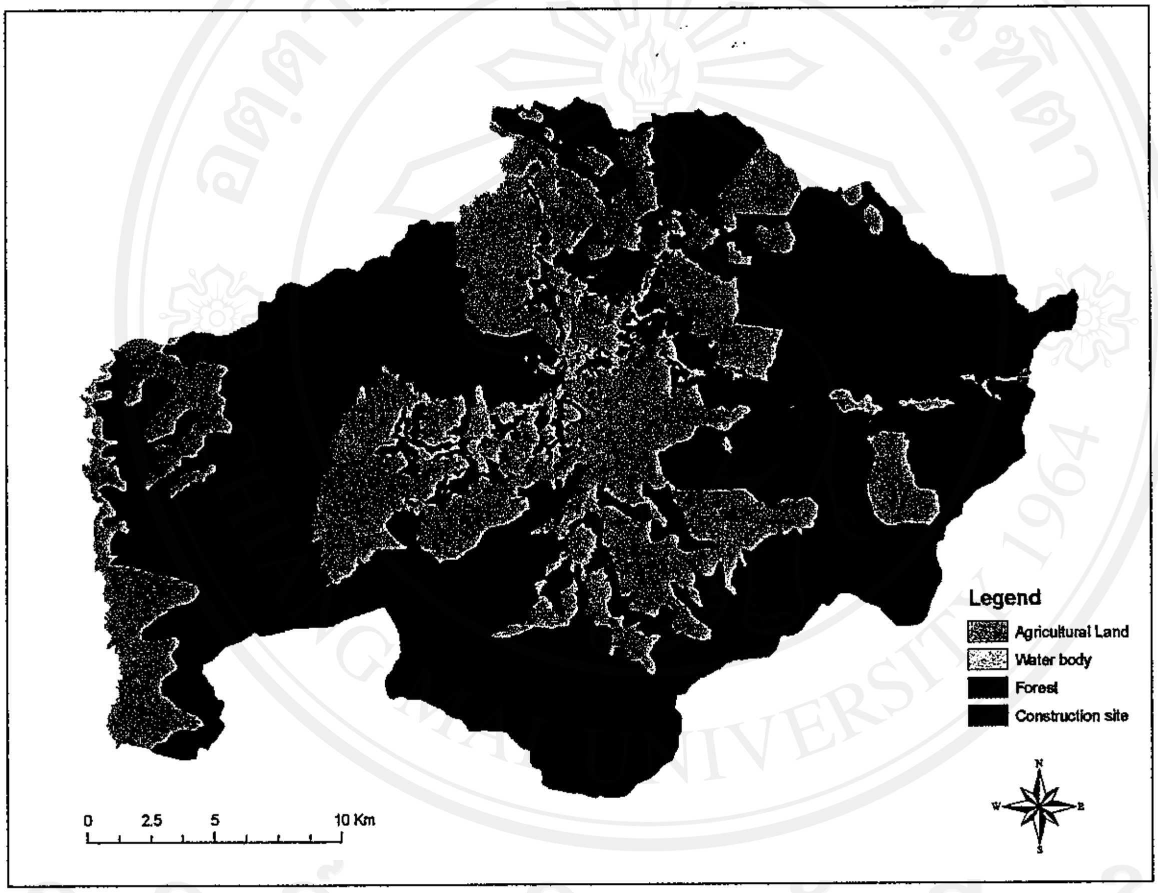

Figure 5.8 The constraint map in Nam Dong district.
Source: Nam Dong Cadastral Department, 2005.

5.2.2 Soil Loss Estimation

As mention in section 4.6.5, the Revised Universal Soil Loss Equation (RUSLE) developed by Renard *et al.* (1997) (Equation (4.8)) was used to estimate the annual soil in the study area. The annual soil loss in the study area was calculated based on rainfall, soils, land use and DEM (Figure 4.4).

The rainfall erosivity (R-factor) was estimated by using equation that was developed by Xiem and Phien (1999) using linear regression between rainfall erosivity index and set of 30 year annual rainfall data in Vietnam, annual rainfall from study area was used to estimate rainfall erosivity index by assigning amount of annual rainfall in Equation (4.9). The erosivity index in the study area is equal to 1,830.32 $MJ.mm.ha^{-1}.h^{-1}.yr^{-1}$.

The soil erodibility factor is soil-loss rate per erosion index unit for a specified soil as measured on a standard plot, which is defined based on regression equation was built by Wischmeier and Smith (1978). The equation required soil texture, soil structure, soil permeability, and soil organic matter information which derived from soil map. The value of soil erodibility in the study area varied from 0.041 to 0.131 $t.ha^{-1}.MJ^{-1}.ha.mm^{-1}.h$ (Figure 5.9).

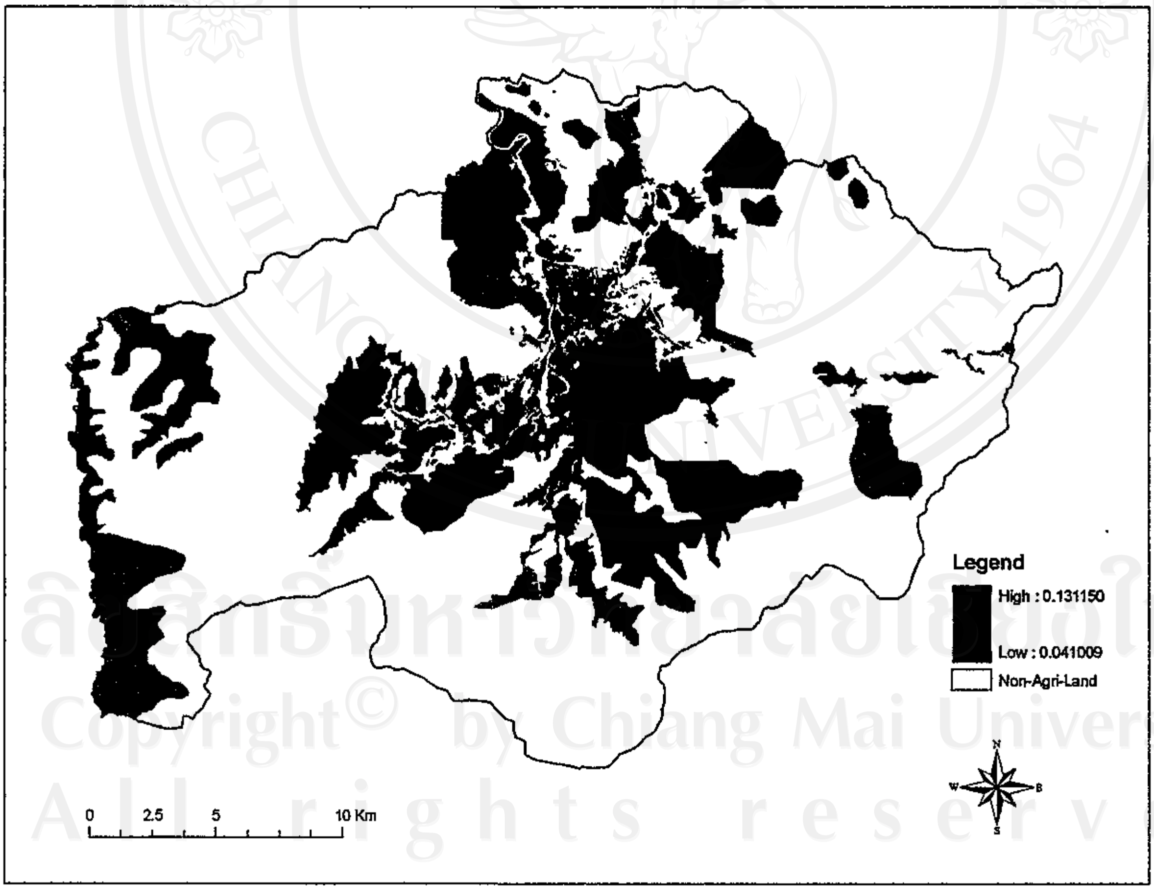

Figure 5.9 The soil erodibility in Nam Dong district.

The topographic factors represents the ratio of soil loss on a given slope length and steepness to soil loss. Topographic factor were calculated by using the equation proposed by Moore and Burch (1986) from unit stream-power theory and a variant used in place of the topographic factor in RUSLE (Equation (4.11)). The result of the topographic factor map in the study area showed in Figure 5.10 is range from 0.0 to 71.7.

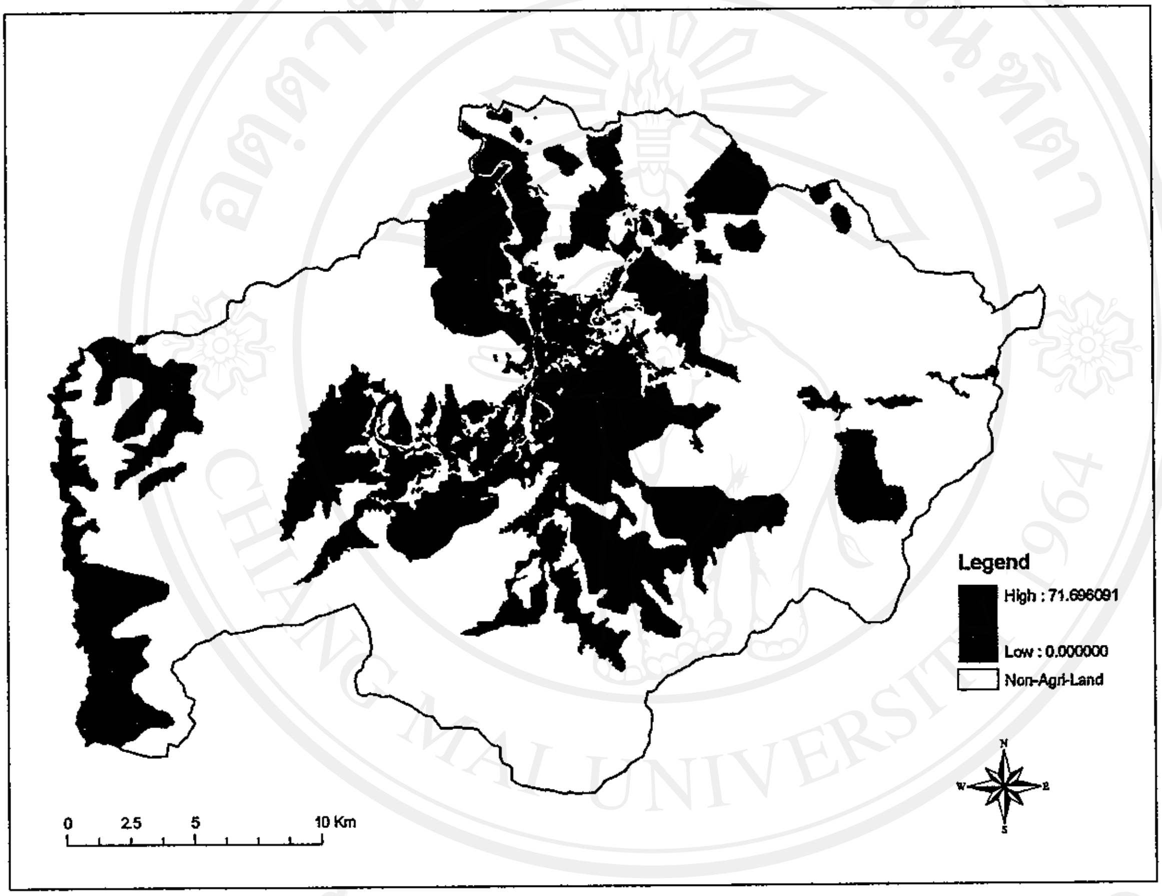

Figure 5.10 The topographic factors in Nam Dong district.

The annual soil loss in the study area also depending on the land cover management factor (C-factor), and the conservation practice factor (P- factor). The C-factor will be defined by using the previous works of Wischmeier and Smith (1978) and Mongkolsawat *et al.*, (1994), which based on the land use in the study area (Section 4.6.5.4). The P-factor reflects the impact of support practices. It is the ratio of soil loss with contouring and/or stripcropping to that with straight row farming up-and-down slope. In this study the contouring was suggested for soil conservation practice, so the P-factor value was calculated based on the previous works of Wischmeier and Smith (1978) (Section 4.6.5.5). The annual soil loss correlate with each crops in the study area are represented in appendices D.

The models to calculate potential soil loss was constructed and run in ArcMap environment. The result of potential soil loss in the study area showed that rate of soil erosion in this area varies from 0.0 to 11,349.93 tons per hectare per year (Figure 5.11).

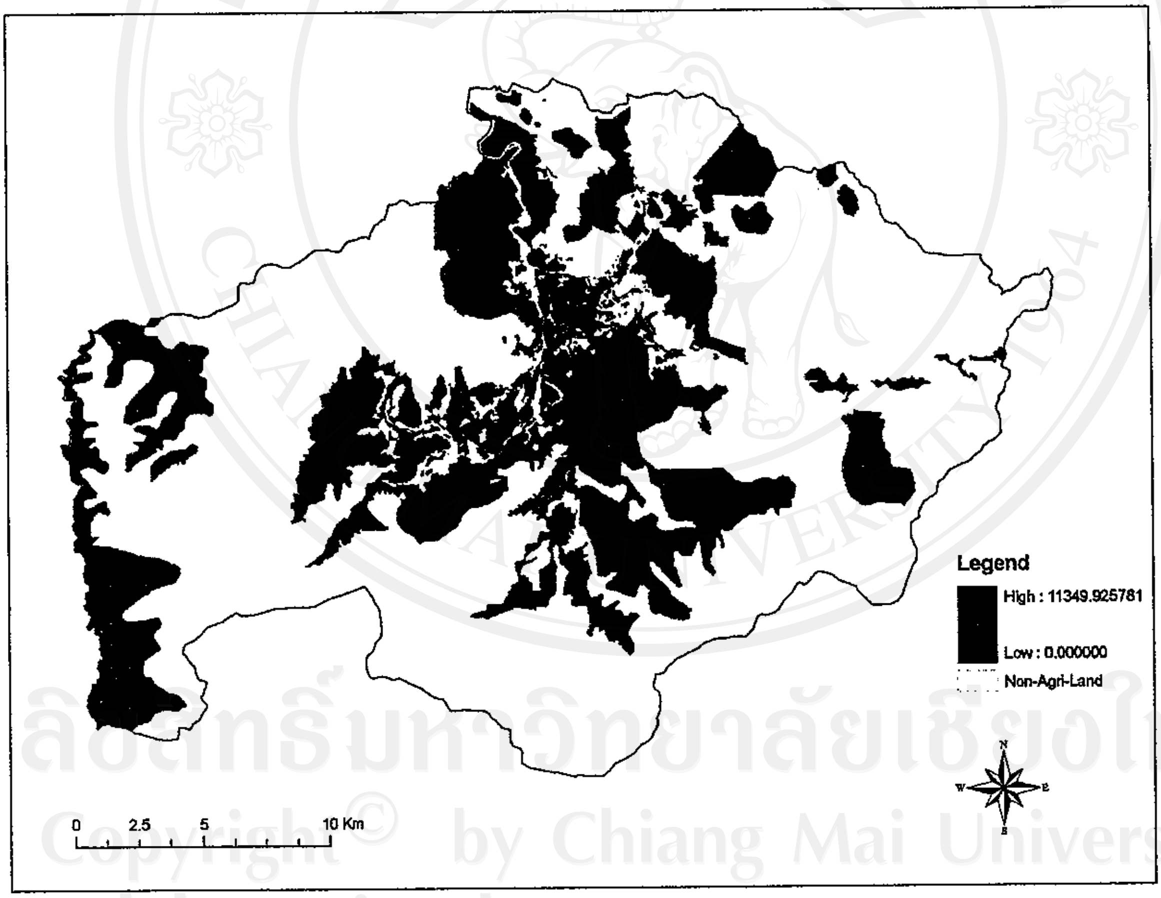

Figure 5.11 The potential soil loss in Nam Dong district.

Annual soil loss was calculated and it was standardized to obtain soil loss index that was used to determine physical suitability index by using joint membership function (Equation (4.5)) with crop suitability index, and the weight factors.

5.2.3 Model Parameters Definition

As mention in section 4.4, this approach factors standardized with fuzzy method by selecting suitable membership function with MF values of individual land characteristics that consists of two basic functions: symmetric and asymmetric. The first function, also called an 'optimum range', distinguishes two variants: one that uses a single ideal point (Model 1, Equation (4.1)), while the other employs a range of ideal points (Model 2, Equation (4.2)). For instance, with regard to the temperature, precipitation, etc, may higher or lower is less better. The second function, an asymmetric model, is used where only the lower and upper boundary of a class has practical importance. This function consists of two variants: asymmetric left (Model 3, Equation (4.3)) and asymmetric right (Model 4, Equation (4.4)). For example, with consider to soil depth 'more is better,' so that it is appropriate to use an asymmetric left model. A similar concept applies to organic carbon content, cation exchange capacity, etc. With a similar rule, an asymmetric right, which is 'less is better' is appropriate for slope, erosion, etc.

In this modelling process, computation of criterion membership functions was based on equation (4.1), which applies to Model 1. In addition to that, the following forms also apply to Model 2, Model 3, and Model 4.

In the computation, it is crucial to examine an appropriate model parameter to suit each decision criterion. The choice depends on the 'trend of performance' of the respective land attribute in accommodating a favourable condition for a selected land use type. Model parameters include LCP (lower crossover point), b (central concept), UCP (upper crossover point), and d (width of transition zone). LCP and UCP represent the situation where a land attribute examined is at a marginal level for a given purpose, while *b* is for an ideal level. For example, soil depth takes an *asymmetric left* function (Model 3, Equation (4.3)) or *more is better,* because the quality function of land performs better, as the soil depth level increases. The optimum soil depth value (ideal, *b*) for rubber was set at 150 centimeter, following the highly suitable, while LCP (marginal suitable) was set at 100 centimeter (Appendix C, Table C-1).

Furthermore, the property of soil pH for rubber takes the form of a symmetric model, which presents an optimum level as a range of values (Model 2). The optimum level (b_1 and b_2) was specified in the range between 5.0 and 6.0 (Appendix C, Table C-1), while LCP and UCP values were set at 4.5 and 6.5.

Likewise, slope angle which was derived from a DEM takes an *asymmetric right* function (Model 4), or *less is better*. An optimum slope gradient for cropping was set at 8% or less, while the UCP threshold value was specified at 16% (Appendix C, Table C-1) for rubber.

The model parameters for membership function of eleven crops in the study area are presented in Appendix C.

As well, annual soil erosion takes an *asymmetric right* function (Model 4), the ideal value *b* and UCP was adopted Baja *et al.* (2002), which was set to 5 t/ha/y for ideal value and 20 t/h/y for upper crossover point. This means that the membership grade of soil loss will be dramatically decreased at the points where erosion rate exceeds 20 t/ha/y.

5.2.4 Weight Definition

As mention in chapter 4, the weighting factors have been derived using pairwise comparison method, eleven workshops by local people's perceptions, and agricultural extension were carried out to provide its best judgment as to the importance of evaluation criteria. After debated and careful analysis of the set of evaluation criteria the criterion weights were calculated (Appendix F). The criterion weights are showed in Table 5.1 and Table 5.2.

Table 5.1 The weight factors of LCs for eleven crops in the study area.

Crops / Factors	Rubber	Cassava	Maize	Bean	Sweet-potato	Irrigated-rice	Citrus	Banana	Sugar-cane	Pine-apple	Rainfed upland-rice
Temp.	0.162	0.150	0.098	0.043	0.156	0.026	0.065	0.141	0.294	0.215	0.022
Rainfall	0.083	0.055	0.098	0.199	0.265		0.118	0.256		0.115	0.261
Sunshine									0.124		
Depth	0.381	0.263	0.098	0.043	0.156	0.104	0.289	0.141	0.294	0.115	0.151
Drainage	0.043	0.032	0.275	0.333	0.265	0.104	0.289	0.256	0.124	0.215	0.022
CEC	0.083	0.055	0.051	0.199	0.035	0.191	0.027	0.034	0.036	0.041	0.151
pH	0.043	0.263	0.051	0.043	0.035	0.041	0.065	0.020	0.036	0.041	0.048
OM	0.162	0.150	0.275	0.113	0.065	0.344	0.118	0.076	0.064	0.215	0.261
Slope	0.043	0.032	0.051	0.026	0.022	0.191	0.027	0.076	0.038	0.041	0.084

Source: Synthesizing from stakeholder workshop, 2006.

Table 5.2 The weigh factors for crop suitability and soil erosion of eleven crops in the study area.

Crops \ Factors	Crop suitability	Soil erosion
Rubber	0.50	0.50
Cassava	0.67	0.33
Maize	0.75	0.25
Bean	0.75	0.25
Sweet potato	0.67	0.33
Irrigated rice	0.75	0.25
Citrus	0.67	0.33
Banana	0.67	0.33
Sugarcane	0.67	0.33
Pineapple	0.50	0.50
Rainfed upland rice	0.25	0.75

Source: Synthesizing from stakeholder workshop, 2006.

5.2.5 Physical Suitability

The procedure for physical suitability assessment followed the multicriteria evaluation represented in Figure 4.1. That model consists of two sub-models: which are crop suitability index model; and soil loss index model. Both were modeled based on fuzzy set methodology in a GIS, and incorporated farmers' perceptions as well as their preferences into the decision-making process by using AHP.

Crop suitability index for each crop was result of model that run based on the joint membership function, LCs and the weight factor of each LC that derived from AHP workshops. And the annual soil loss was defined, and it was standardized based on an *asymmetric right* function (Model 4) for obtaining the soil loss index. After that crop suitability index and soil loss index was used to determine physical suitability index by using joint membership function with the weight factors.

The results of physical suitability index based on the fuzzy set methodology in a GIS ranging from 0 (very poor or not suitable) to 1.0 (excellent or highly suitable). The continuous value of physical suitability was classified based on guideline for definitions of classes for each crop according to Dent and Young (1981) and FAO (1983).

The results of physical suitability analysis in the study area showed that 6.26% of total arable area was highly suitable for banana production (1,298.34 ha). About 55.64% (11,543.40 ha) and 38.1% (7,903.98 ha) was moderately and marginally suitable, respectively (Figure 5.12).

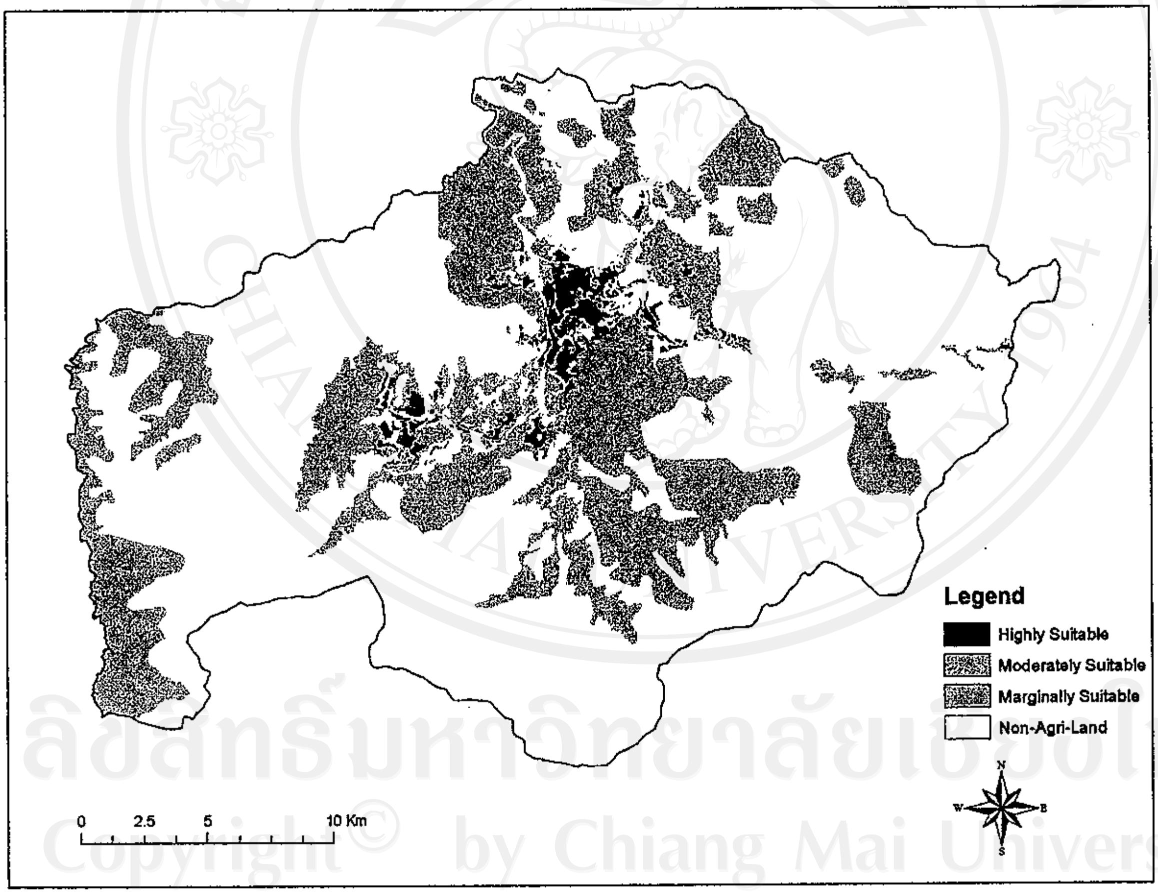

Figure 5.12 The physical suitability of banana in Nam Dong district.

Physical suitability of bean crop (Figure 5.13) showed that the number of percentage available to each suitability class for bean. The highly suitable area for bean was 1,416.24 ha, and its proportion was 6.83%, moderately suitable area was 18,672.03 ha, marginally suitable area was 657.45 ha, and its proportion was 90% and 3.17%, respectively.

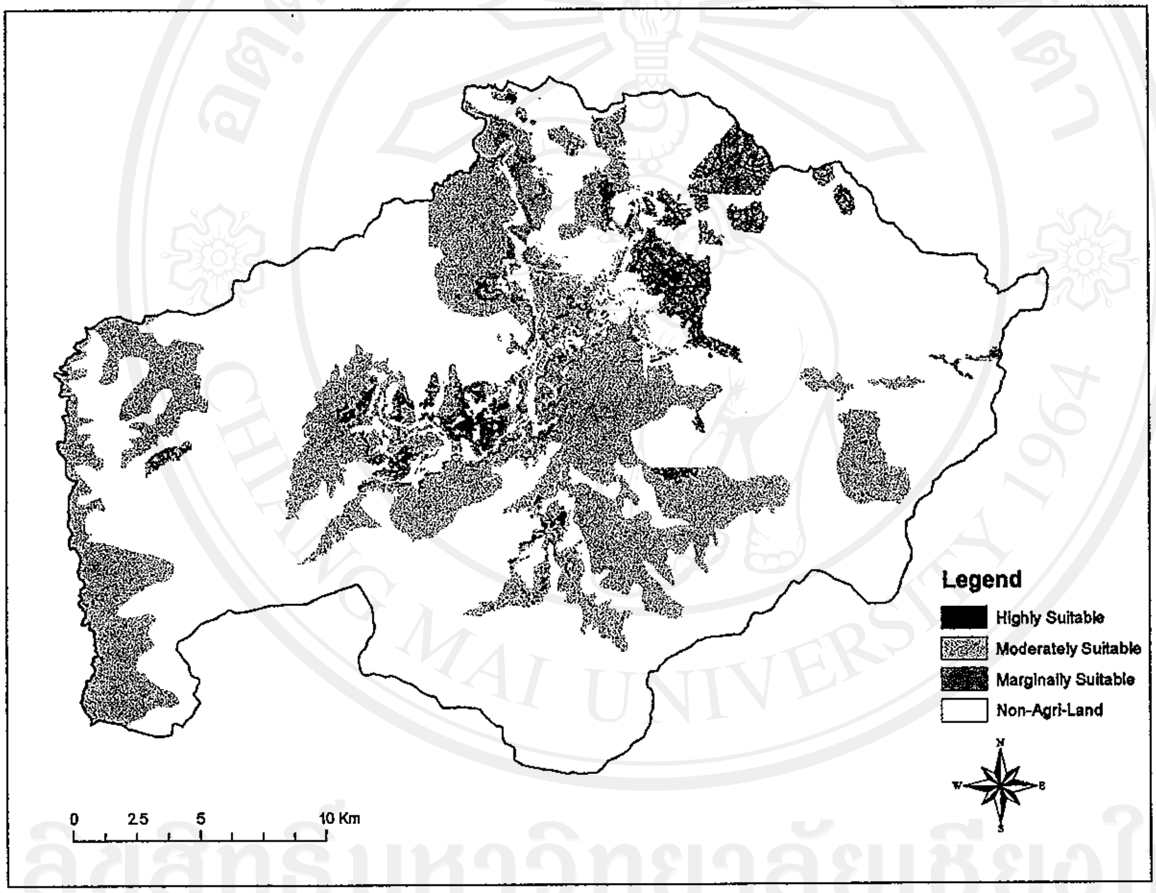

Figure 5.13 The physical suitability of bean in Nam Dong district.

The spatial analysis physical suitability of cassava showed that as much as 6.24% (1,293.66 ha) of total arable area was highly suitable, while 52.06% (10,800.54 ha), 38.1% (7,170.12 ha) and 7.14% (1,481.4 ha) are moderately, marginally and non suitable for cassava production, respectively (Figure 5.14).

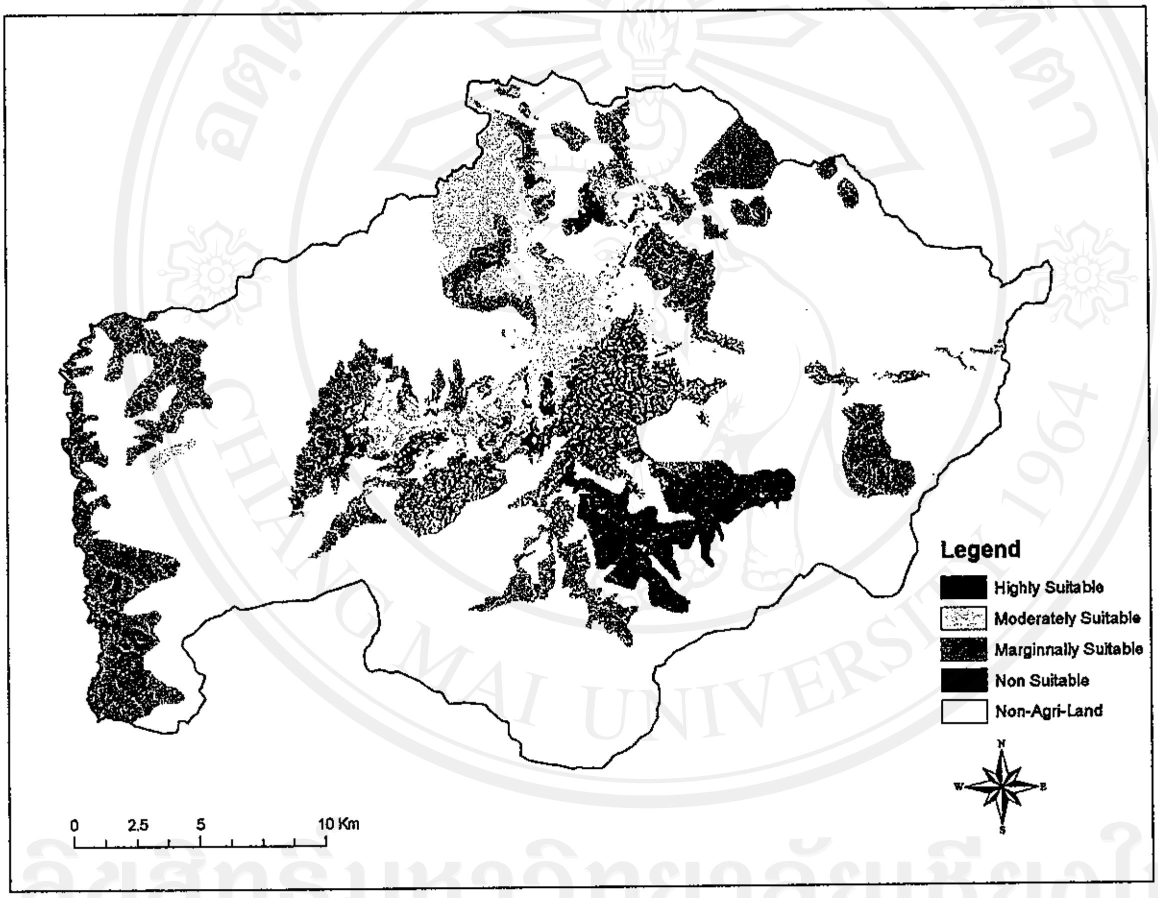

Figure 5.14 The physical suitability of cassava in Nam Dong district.

The results of spatial analysis physical suitability of citrus in the Figure 5.15 showed that there was non area is highly suitable, the highest percentage was belong to the marginally suitable which was 11,057.04 ha (53.30%), and following by moderately suitable with area of 11,057.04 ha (46.37%), while the non suitable was 0.34% (69.57 ha).

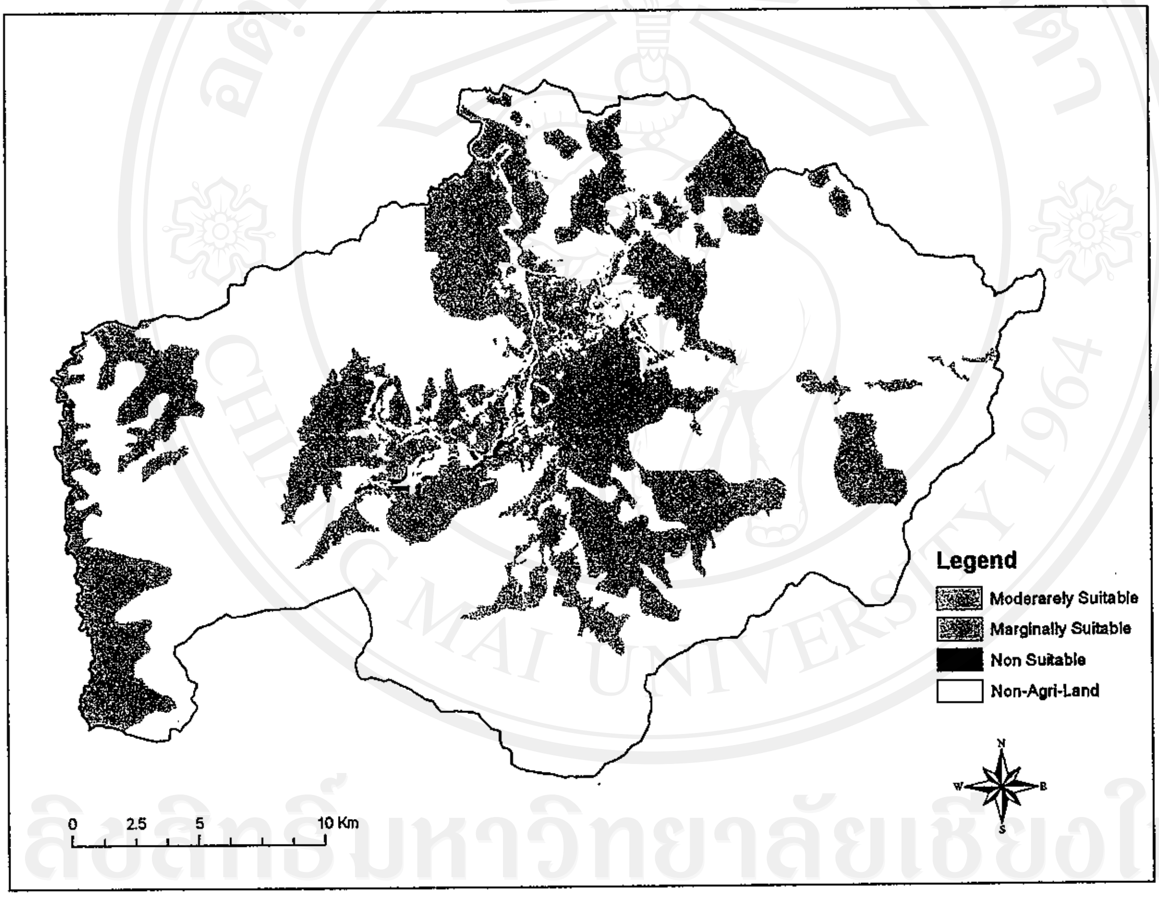

Figure 5.15 The physical suitability of citrus in Nam Dong district.

From the physical suitability map of irrigated-rice that showed in Figure 5.16 found that the extent for the highly suitable area was about 48.96 ha, and its proportion was 0.24%, while moderate suitability area was 2.62% (5.42.88 ha); marginal suitability area was 0.19% (39.06 ha), and non suitable area was 11.34 ha, and its proportion of 0.05%.

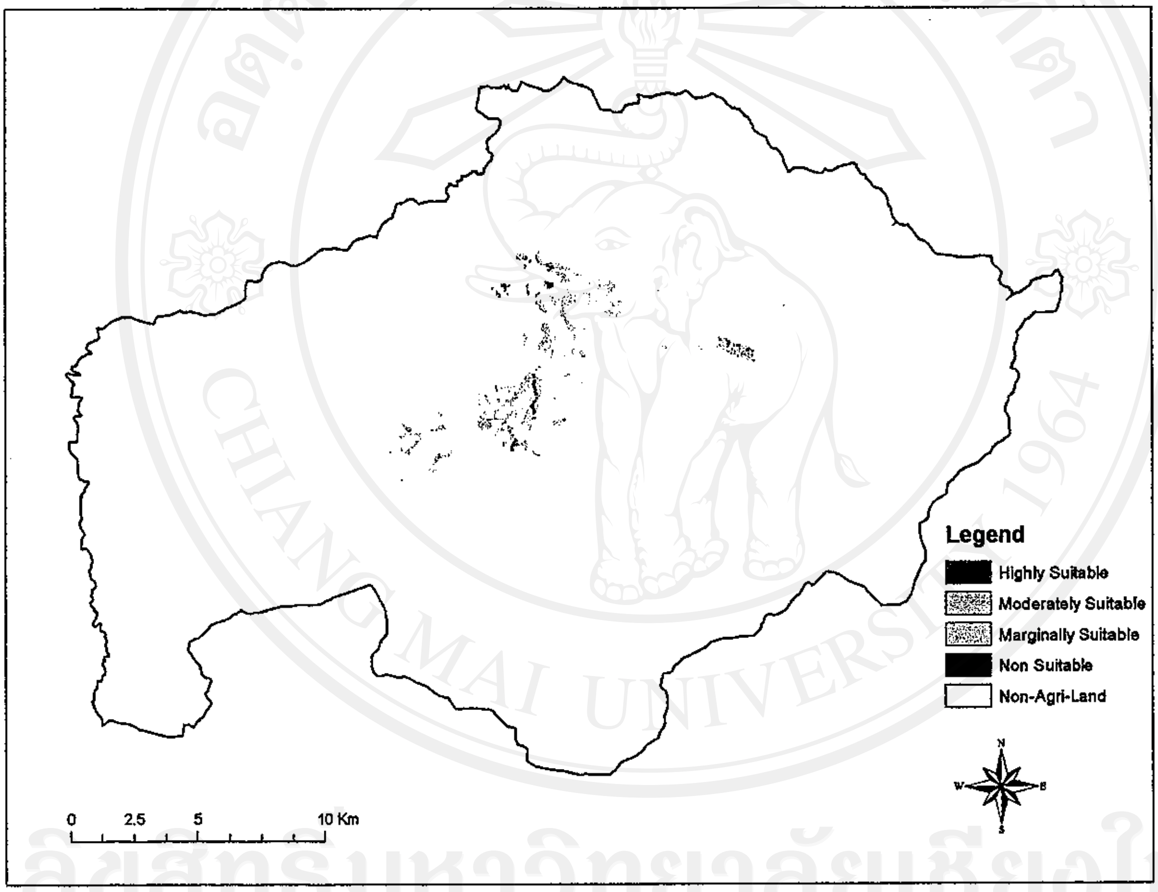

Figure 5.16 The physical suitability of irrigated-rice in Nam Dong district.

The results of physical suitability of maize also indicated that 81.04% (16,813.26 ha) of total arable area was moderately suitable, at a highly suitable occurred only 6.62% (1,372.86 ha), and marginally suitable was 12.34% (2,559.60 ha) for Maize production (Figure 5.17).

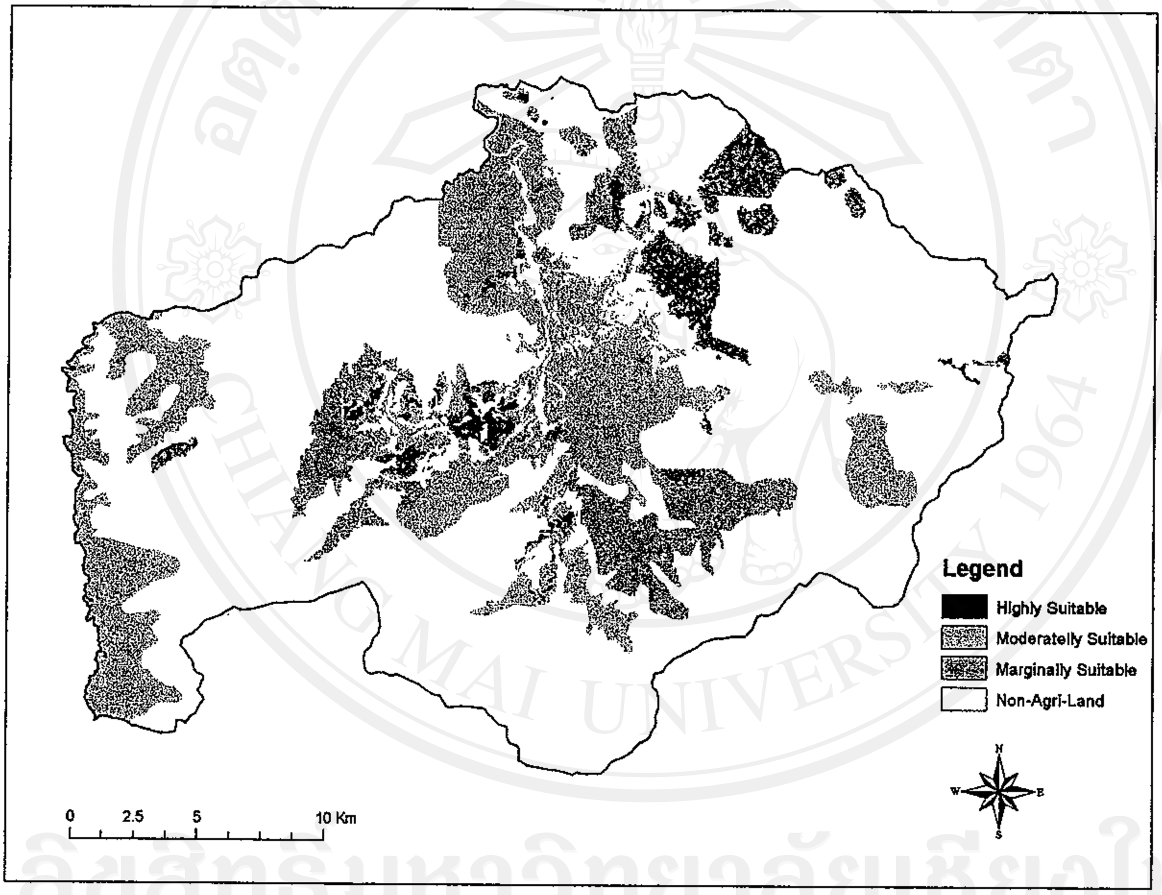

Figure 5.17 The physical suitability of maize in Nam Dong district.

The results of physical suitability of pineapple (Figure 5.18) showed that all arable area were suitable for pineapple of which 17.57% was highly suitable (3,645 ha). While 72.93 % was moderately suitable (15,129.63 ha), and 9.5 % was marginally suitable (1,971.09 ha).

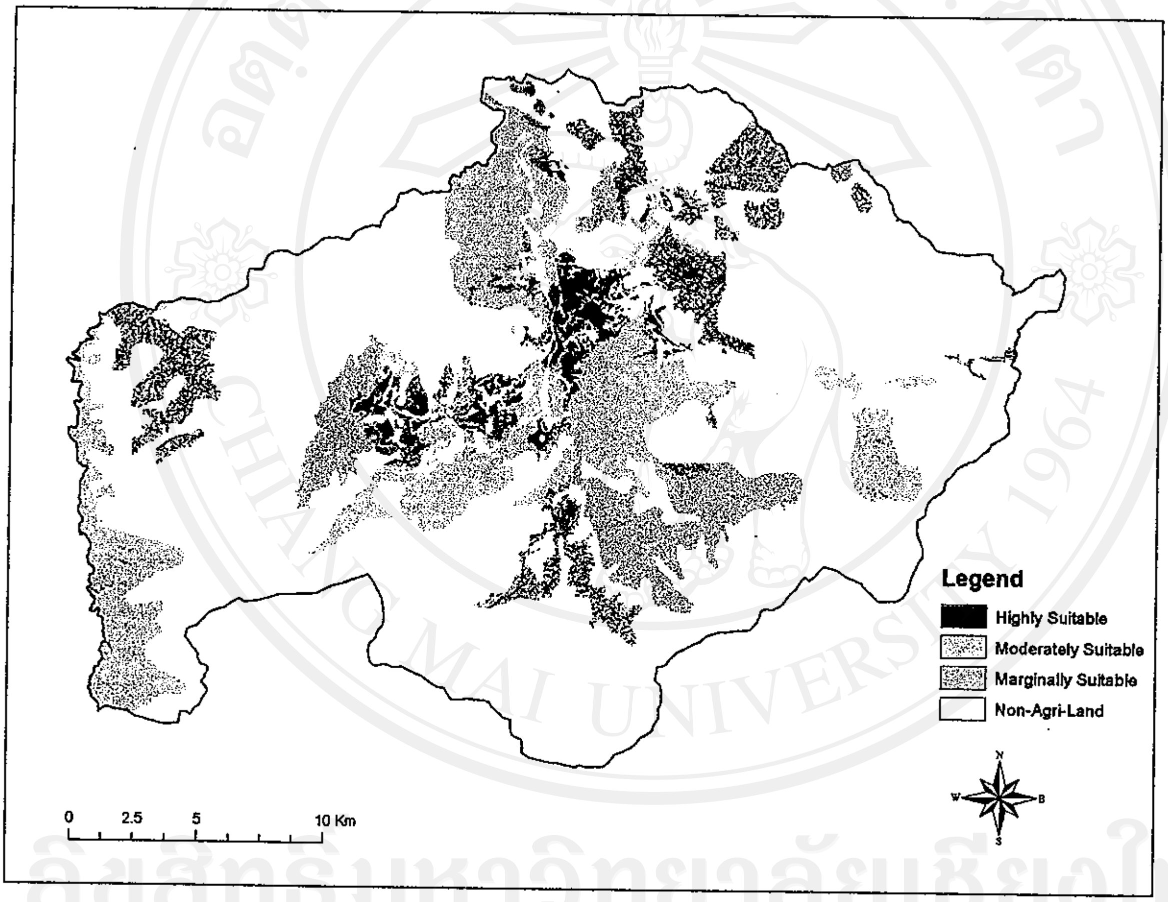

Figure 5.18 The physical suitability of pineapple in Nam Dong district.

About 77.55 % (16,087.59 ha) of arable area was defined moderately suitable for rubber, whereas highly suitable area was 15.85% (3,287.97 ha), and 1,370.16 ha was marginally suitable, and its proportion was 6.60%, respectively (Figure 5.19).

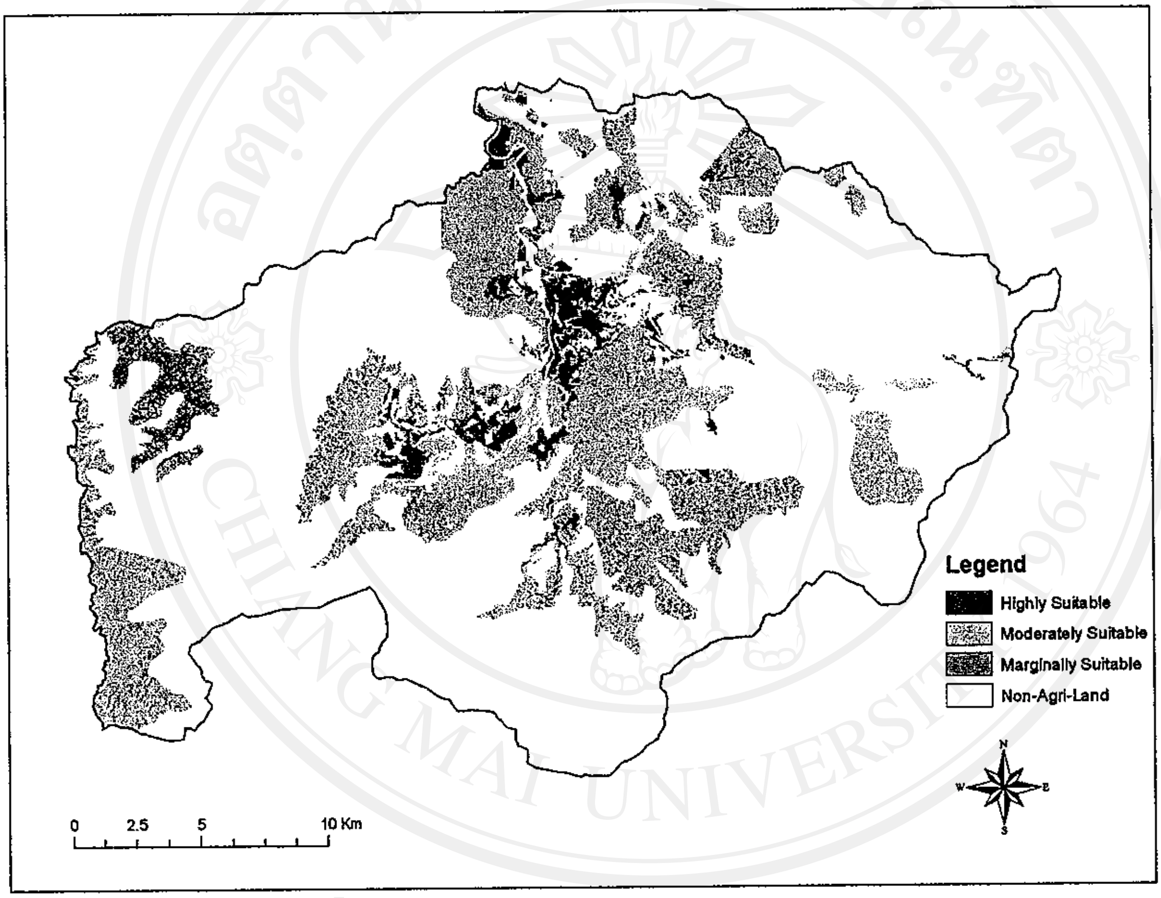

Figure 5.19 The physical suitability of rubber in Nam Dong district.

The result for physical land suitability for sugarcane in Figure 5.20 showed that the area of highly suitable was about 2,334.33 ha with the proportion was 11.25%. While moderately suitable area was about 7,905.33 ha with its proportion at 38.11%, marginally suitable area was 8,990.73 ha with its proportion of 43.34%; and non suitable area was 1,515.33 ha and its proportion of 7.30%.

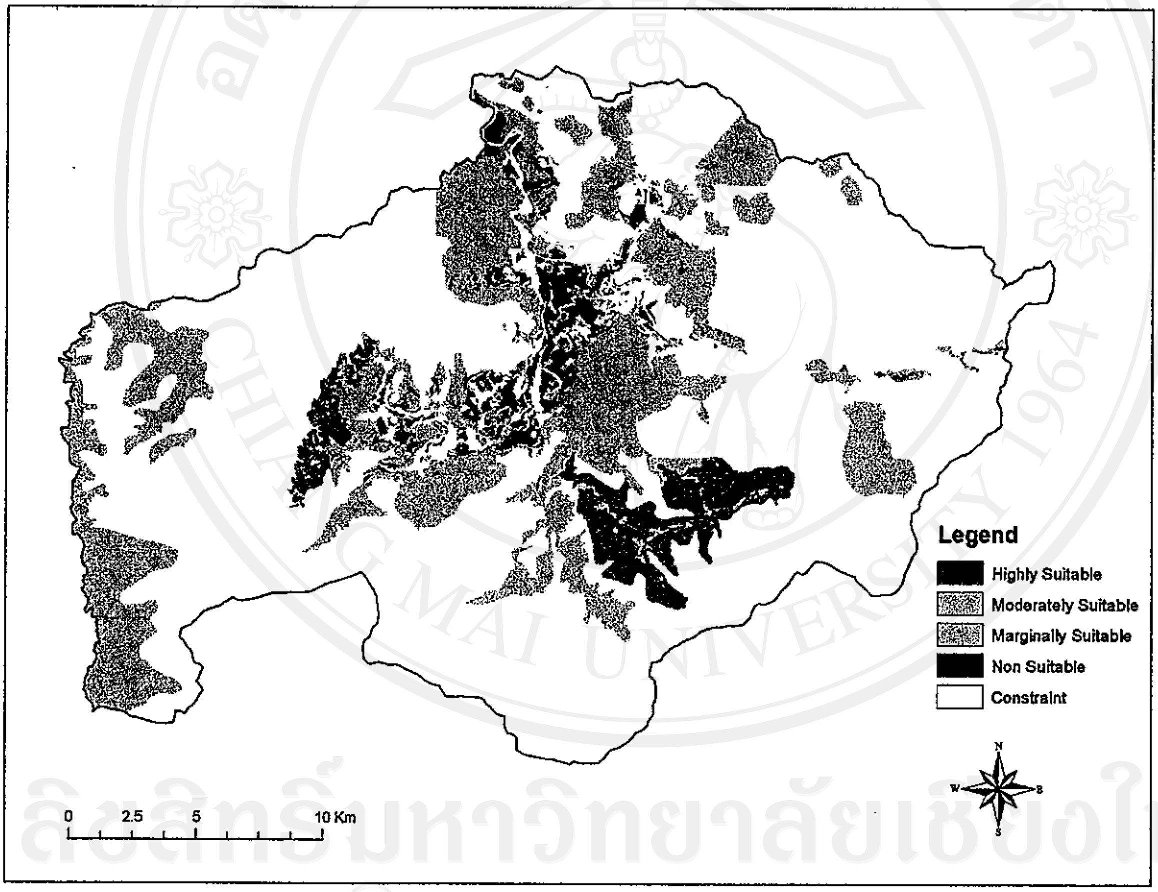

Figure 5.20 The physical suitability of sugarcane in Nam Dong district.

The proportion of physical suitability of sweet-potato represented in the Figure 5.21 showed that the highest proportion was moderately suitable with 68.72% (14,257.08 ha), and second rank was marginal suitability with 30.80% (6,389.10 ha), and only 0.48% (99.54 ha) of arable area was highly suitable.

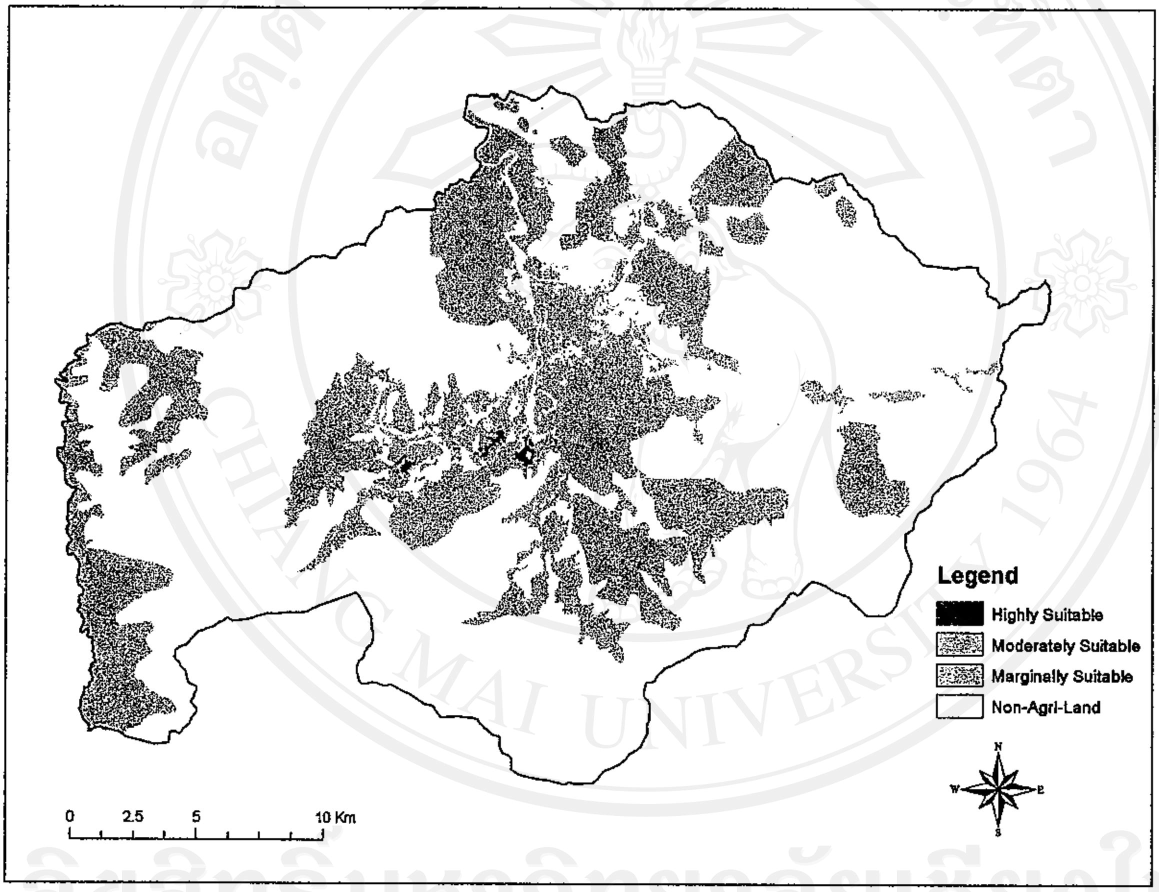

Figure 5.21 The physical suitability of sweet potato in Nam Dong district.

The physical suitability of the rainfed upland rice showed that there was no percentage of highly suitable area. While 17.27% (3,582 ha) of total arable area was non suitable, 43.07% (8,935.83 ha) was marginally suitable, and 7,585.65 ha (36.56%) was moderately suitable (Figure 5.22).

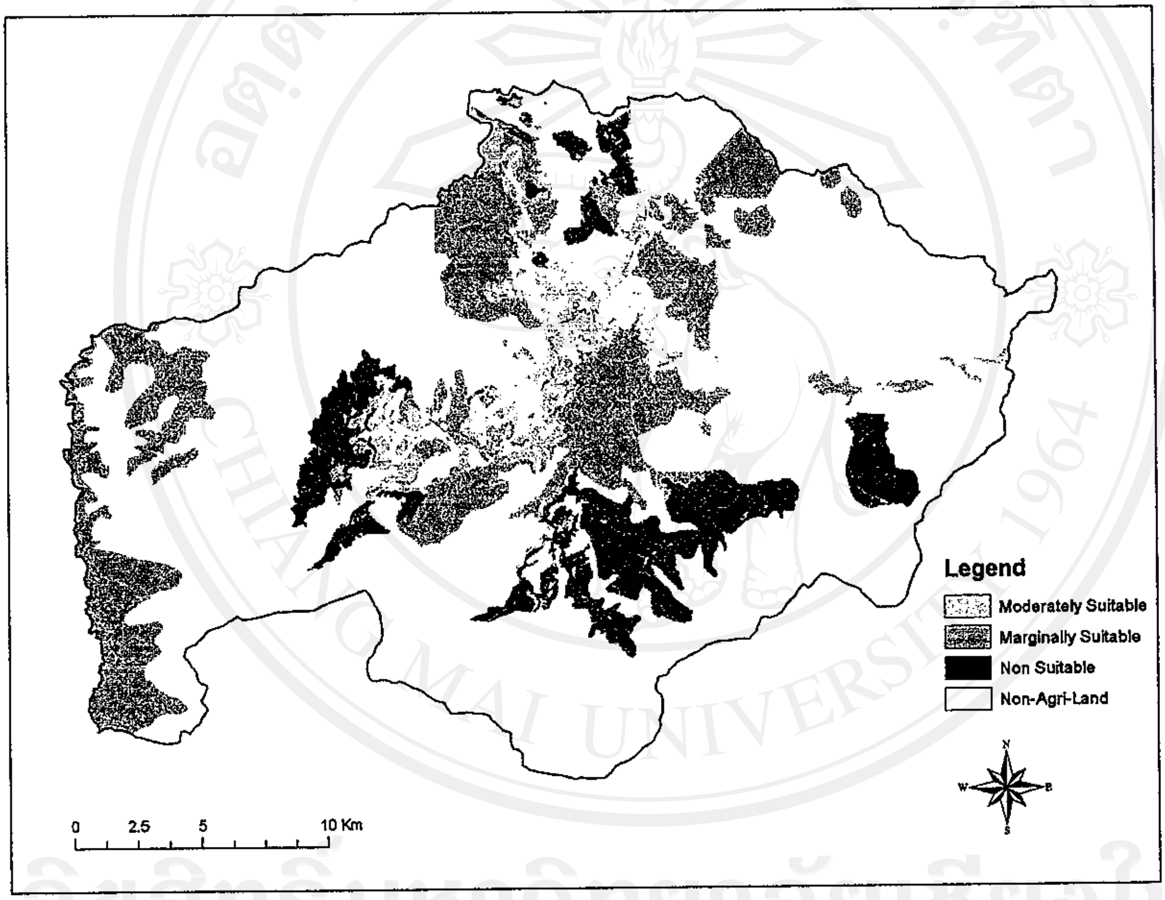

Figure 5.22 The physical suitability of raifed upland-rice in Nam Dong district.

5.3 Relative Crop Suitability

The relative crop suitability map was generated as shown in Figure 5.23. The areas allocated for each crop were summarized in Table 5.3.

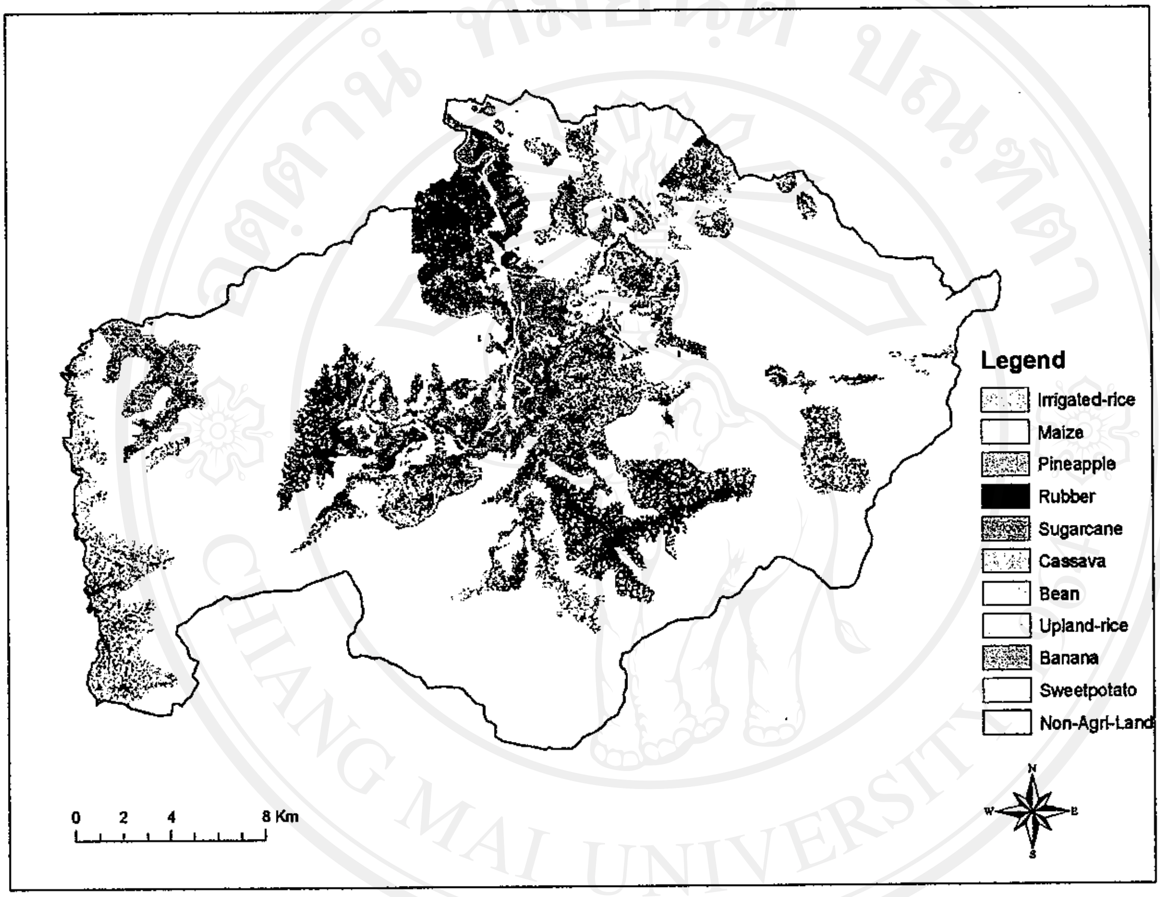

Figure 5.23 The relative crop suitability in Nam Dong district.

The results of relative crop suitability map showed that the arable land was suitable for ten crops namely banana, bean, cassava, irrigated-rice, maize, pineapple, rubber, sugarcane, sweet potato and rainfed upland rice. The citrus crop could not compete with other crops based on physical suitability. The highest suitable area was rubber (6,412.9 ha, 30.9%), the second (4689.7 ha, 22.6%) and the third ones (4139.7 ha, 20%) were suitable for bean and pineapple. The suitable area for sugarcane, cassava, maize, banana, sweet-potato, irrigated-rice and upland-rice were 2,377.6 ha (11.5%), 2,089.5 ha (10.1%), 939.6 ha (4.5%), 59.3 ha (0.2%), 36.8 ha (0.2%), 0.4 ha (0.0%) and 0.2 ha (0.0%), respectively.

Table 5.3 The relative crop suitability area and its proportion in Nam Dong district.

Suitable class / Crops	Suitable Area (ha)	Proportion of suitable area (%)
Banana	59.31	0.29
Bean	4,689.72	22.61
Cassava	2,089.53	10.07
Irrigated-rice	0.36	0.00
Maize	939.60	4.53
Pineapple	4,139.73	19.96
Rubber	6,412.86	30.91
Sugarcane	2,377.62	11.46
Sweet-potato	36.81	0.18
Upland-rice	0.18	0.00
Sum	20,745.72	100.00

5.4 Comparison between Relative Crop Suitability with Existing Land Use Maps

The existing land use map in the study area published in 2005 was encoded (each type of land use was encoded with unique value), and used to overlay with relative crop suitability map. The error matrix of existing land use in 2005 and relative crop suitability was produced (Table 5.4).

The results in Table 5.4 showed that 76.3% (22.86 ha) of existing land use of banana was located in high suitability. While 13.8% (4.14 ha), 8.1% (2.42 ha), 1.8% (0.54 ha) of existing land use of banana may be allocated to bean, pineapple and sweet potato, respectively as suggested by their relative suitability.

Table 5.4 Classification error matrix of existing land use in 2005 and relative crop suitability in Nam Dong district.

Unit: ha

	Banana	Bean	Cassava	Citrus	Irrigated rice	Maize	Pine-apple	Rubber	Sugar-cane	Sweet potato	R.Upland rice	Sum
Banana	**22.86**	4.14	-	-	-	-	2.42	-	-	0.54	-	29.96
Bean	-	**34.02**	-	-	-	-	-	-	16.02	-	-	50.04
Cassava	-	13.77	**13.95**	-	-	222.75	67.05	102.69	-	4.77	-	424.98
Citrus	-	-	-	-	-	-	-	57.96	39.06	-	-	97.02
Irrigated-rice	-	88.38	-	-	**0.36**	65.70	-	-	135.73	-	-	290.17
Maize	-	-	-	-	-	**37.35**	-	-	28.62	-	-	65.97
Pineapple	-	4.32	-	-	-	-	**8.28**	53.28	-	20.25	0.09	86.22
Rubber	-	-	-	-	-	-	242.37	**2,381.40**	102.24	-	-	2,726.01
Sugarcane	-	25.11	-	-	-	1.08	6.21	-	**27.27**	0.36	-	60.03
Sweet-potato	-	45.27	-	-	-	-	-	75.51	12.15	**0.99**	-	133.92
R.upland-rice	-	8.91	-	-	-	-	-	37.89	-	-	**0.09**	46.90
Unused land	36.45	4,465.71	2,075.58	-	-	612.72	3,813.39	3,704.04	2,016.54	9.90	-	16,747.60
Sum	59.31	4,689.63	2,089.53	-	0.36	939.60	4,139.72	6,412.77	2,377.63	36.81	0.18	20,745.72

For the total existing land use of bean (50.04 ha), 34.02 ha (68%) was cultivated in the suitable area, while 16.2 ha (32%) of existing land use of bean may be better allocated to sugarcane.

Only 13.95 ha (3.3%) of existing land use of cassava was cultivated in the suitable area, 54.2% (222.75 ha), 24.2% (102.69 ha), 14.1% (67.05 ha), 3.2% (13.77 ha) and 1.1% (4.77 ha) of existing land use of cassava may be better allocated to other crops namely maize, rubber, pineapple, bean and sweet potato, respectively.

However, citrus could not compete with other crops, so all area of existing land use of citrus was not promising for citrus production. These area may be allocated to rubber 59.7% (57.96 ha), and 40.3% (39.06 ha) to sugarcane.

The results in Table 5.4 also showed that a majority of the existing land use of irrigated rice may replace by sugarcane (135.73 ha, 46.8%), while 88.38 ha (30.5%) and 65.7 ha (22.6%) may change to bean and maize. Only 0.9 ha (0.1%) of existing land use of irrigated rice should keep up.

About 37.55 ha (43.4%) of existing land use of maize may transform to sugarcane, which the rest of existing land use of maize (28.62 ha, 56.6%) should continue growing.

The results of comparison existing land use and relative crop suitability of pineapple showed that 9.6% (8.28 ha) was located in suitable. And 61.8% (53.28 ha), 23.5% (20.25 ha) and 5% (4.32 ha) of existing land use of pineapple may be allocated to by rubber, sweet-potato and bean, respectively.

All most area of existing land use of rubber was located in suitable area (2,381.4 ha; 87.4%). While 8.9% (242.37 ha) and 3.8% (102.24 ha) may be better allocated to pineapple and sugarcane.

The results also showed that suitable areas for sugarcane (27.27 ha, 45.4%) should continue growing this crops. And 41.8% (25.11 ha), 10.3% (6.21 ha), 1.8% (1.08 ha), and 0.6% (0.36 ha) of existing land use of sugarcane may convert to grow bean, pineapple, maize, and sweet potato, respectively.

For the existing land use of sweet- potato showed that the area of 56.4% (75.51 ha), 33.8% (45.27 ha), and 9.1% (12.15 ha) may change to rubber, bean, and sugarcane, respectively. However, 0.7% (0.99 ha) of existing land use of sweet potato was located in suitable area.

The area suitable for rainfed upland rice that only 0.2% (0.09 ha) according to the results of analysis. The area of existing land use of raifed upland rice may be allocated to rubber (37.89 ha, 80.8%) and bean (8.91 ha, 19%).

The results of comparison existing land use and relative crop suitability also showed total 16,747.6 ha unused land that suitable for eight crops. The suitable area for bean was 4,465.71 ha (26.7%), pineapple was 3,813.39 ha (22.8%), rubber was 3,704.4 ha (22.1%), cassava was 2,075.88ha (12.4%), sugarcane was (2,016.54.27 ha, 12%), maize was 612.72 ha (3.7%), banana was 36.45 ha (0.2%) and sweet potato was 9.9 ha (0.9%), respectively may be considered.