III-4.3 Land Use Plan

1) Methodology : GIS Application

GIS has been utilized for analysis as stated below. This GIS survey has been executed under cooperation among JICA-Sida (Sweden International Development Agency) and the National Agriculture and Forestry Research Institute (NAFRI) of Lao PDR with advice obtained from the Watershed Classification Project (WSCP) of the Mekong River Commission (MRC).

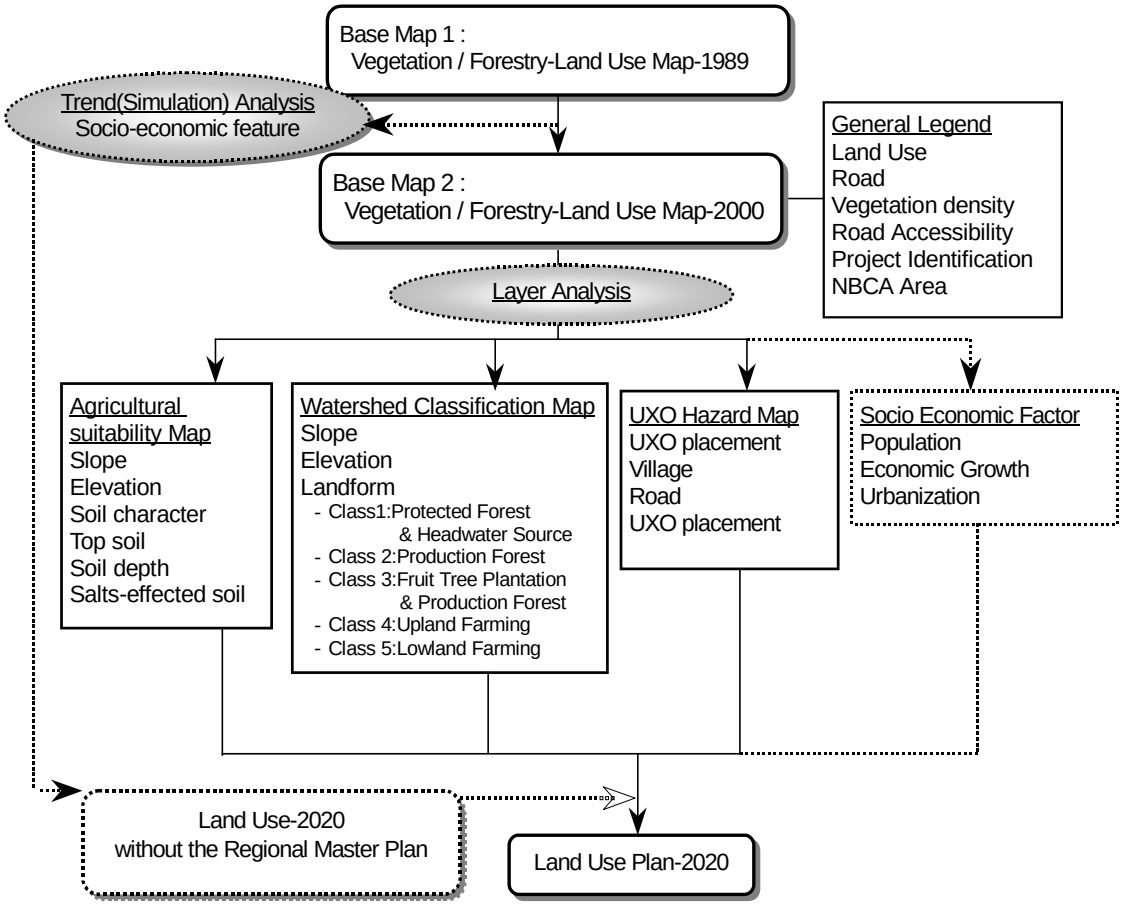

Figure III4-13 Flow of Land Use Planning

2) Watershed and Forestry Analysis

(1) Method of Analysis

Watershed classification has been based on the method used in Thailand in the late 1980's. Watershed classification by MRC aims at giving an indication of the

sensitivity of watersheds with regard to water resources degradation mainly by soil erosion.

Digital Terrain Model (DTM)

Based on the contours, rivers and spot heights taken from the 1:50,000 American topographic maps, a Digital Terrain Model (DTM) was calculated for more than 750 mapsheets with a GIS software (Arc/Info). A DTM is a computer based continuous representation of the topography, or in other words, of the landscape. The elevation information in DTM is not measured in reality but calculated from altitude information (contours and spot heights), and often by adding the river network. Through interpolation, DTM attributes elevation information to each and every point, or cell of the area, which it covers. DTM thus digitally stores topographic information, which contains such parameters as slope, landform, aspect, and shape. In order to overcome the correction problems with the standard algorithms of Arc/Info (terrace effects and over-exaggeration of terrain surface) a sophisticated program package was developed, which helped minimize such undesired effects.

Watershed Classification parameters

From the resulting DTM, which had a resolution of a 50-meter cell size, three parameters of elevation, slope and landform were derived and fed into a generalized and easy-to-read format with the help of filter operations.

Slope

The slope is the relation between vertical and horizontal distance. Slope was divided into 7 ranges, from 1 (flat – below 2%) to 7 (steep – over 60%). Values are deduced from distances between adjacent elevation contours on topographic maps, using a mapping approach. The distances between the contours are measured with a scaled template.

Landform

The value for landform ranges from 1 for very steep and very dissected landform, to 22 for flat and only slightly dissected landforms. They are artificial values that cannot be measured directly on the landscape. The process of assigning numerical values to landforms was necessary to include this parameter in the WSC equation. The landform is the most complex among three topographic parameters. It is composed of the slope, the curvature of the terrain, and the roughness or dissection of the terrain, whereby each of these secondary parameters is given a specific weight in the landform value equation. The fact that slope appears as an independent parameter and as a secondary parameter in the

landform equation shows the importance that is attributed to the slope for the calculation of WSC.

The curvature indicates whether a slope projects outwards (convex), inwards (concave), or not at all (indifferent). Convex landforms indicate a more erosion-resistant formation than concave landforms. Water gathers in concave landforms, where its erosive power can lead to soil degradation. Convex landforms are generally more sensitive to wind erosion, but this kind of erosion is irrelevant in the climatic zone of the Lower Mekong Basin.

The third component of the landform is the roughness. The roughness of a slope is equivalent to the number of dissections in every kilometer of the slope. The higher the number of dissections in a particular slope length, the higher the roughness value.

Elevation

The Elevation is the altitude of a given spot measured in decameters (10 meters) above sea level. Elevation was introduced into the WSC equation to simulate climatic influences on WSC. Areas in higher locations usually have higher average annual rainfall. Higher rainfall, in turn, has a greater erosive potential on comparable soils, so that the risk of soil and water degradation increases with the amount of rainfall ands also with the elevation of the considerable area.

Elevation was divided into ranges of 100 meters (0-100; 101-200; etc), with one elevation value given to areas located within the same range. Elevation values are directly reported from the elevation contours found on topographic maps. The method applied a multivariate statistical analysis for establishing relationships between a number of variables and watershed class numbers.

WSC calculation

The resulting 3 layers of the parameter calculation (slope, landform and elevation) are supposed within GIS and an initial WSC is calculated using an equation which takes account of the values of the topographic parameters described above. The equation used for the Lower Mekong Basin is :

WSC = a + (b x slope) + (c x landform) + (d x elevation)

The values used for Laos are :

a = 1.709
b = - 0.035
c = 0.136
d = - 0.002

Hence, for Lao PDR, the equation is :

WSC = 1.709 - (0.035 x slope) + (0.163 x landform) - (0.002 x elevation)

The resulting WSC values are assigned to the actual WSC classes (1 to 5). The range values used for WSC are indicated below.

Table III4-4 WSC Values

WSC Class	Lower limit of WSC Values	Upper limit of WSC Values
1	All negative values	Up to 0.8
2	>0.8	Up to 2.1
3	>2.1	Up to 3.4
4	>3.4	Up to 4.7
5	>4.7	All values greater than 4.7

<Example>

A landscape unit with the following parameter values

Slope = 50%
Landform = 10 (moderate slope with less than 3 dissections per kilometer of slope length)
Elevation = 700 meters above sea level (70 decameters)

Is given WSC value of

1.709 – (0.035 x 50) + (0.163 x 10) – (0.002 x 70) = 1.449

This value falls within the range of values for class 2 (>0.8 up to 2.1). Therefore after classification, this landscape unit is assigned to “class 2”.

(2) Watershed Classification

On the basis of the topography of the landscape (parameter: slope, elevation, landform), five watershed classes are calculated by means of a watershed equation and are depicted on the watershed classification maps at the scale of 1:250,000. Watershed Class 1 is the most sensitive, and Watershed Class 5 the least sensitive to water resource degradation by erosion. For each watershed class, general recommendation for sustainable land uses are given as follows:

- Watershed Class 1: Protection Forest
  Areas with very steep slopes and rugged landforms, commonly uplands and headwater areas. Critical areas for water and soil resources management. *Recommended land use*: as a rule, these areas should be under permanent forest cover. Other existing land uses based on traditional rights and practices should be considered carefully with regard to their impact on water and soil conversion.

- Watershed Class 2: Production Forest
  Areas with steep slopes, usually at higher elevation. Landforms are in general less susceptible to water and soil degradation than under WSC Class 1.
  Recommended land use : forest (conservation and production forests), agro-forestry and grazing, if accompanied by strict conservation measures.

- Watershed Class 3: Agro-Forestry
  Areas with moderate to steep slopes and less erosive landforms. Includes uplands and foot zones of slopes. Wider range of land use tolerable than in WSC Class 1 and 2 from point of view of water and soil conservation.
  Recommended land use : production forest, grazing and combinations of trees and agricultural crops, if appropriate conservation measures are applied.

- Watershed Class 4: Upland Farming
  Gently sloping lands. Moderate need for water and soil conservation depending on local conditions.
  Recommended land use : Wide range of land use from point of view of water and soil conservation : paddy rice, other agricultural uses and forest.

- Watershed Class 5: Lowland Farming
  Gently sloping land and flat areas. Suitable for a wide range of land use form point of view of water and soil conservation.
- *Recommended land use* : paddy rice, other agricultural uses and forest.

(3) Watershed and Forestry Classification in SKR

As mentioned in the Environmental and Resource Management (Section III-1.2), the Mekong river forms the western border of SKR (about 350 km in length). Major catchments areas in Khammouan are Nam Theun, Nam Hinboun and Xe Don, and those in Savannakhet are Xe Bang Heing, Xe Bangfay and, Nam Thahao and Xe Bang Nouane. Two provinces share the major catchment areas of the Xe Bangfay. Most of these river systems rise on the border with Vietnam and run from east to west before entering into the Mekong river.

Two provinces show different features as illustrated below. Class 1, which is areas with very steep slopes and rugged land forms, commonly uplands and headwater area and critical for water and soil resources management, accounts for 15% in Khammouan, and 2% in Savannakhet. Classes 1 and 2, which need the consideration for the protection and the sustainable use of forestry, account for 40% in Khammouan, and 10% in Savannakhet.

Table III4-5 Watershed Classification in SKR

Watershed Classification : SKR				
	Khammouan (ha)	(%)	Savannakhet (ha)	(%)
Classification 1	244,214	14.64	44,360	2.07
Classification 2	421,317	25.26	200,479	9.37
Classification 3	307,993	18.46	313,327	14.64
Classification 4	409,497	24.55	744,559	34.79
Classification 5	284,978	17.09	837,275	39.13
	1,668,000	100.00	2,140,000	100.00

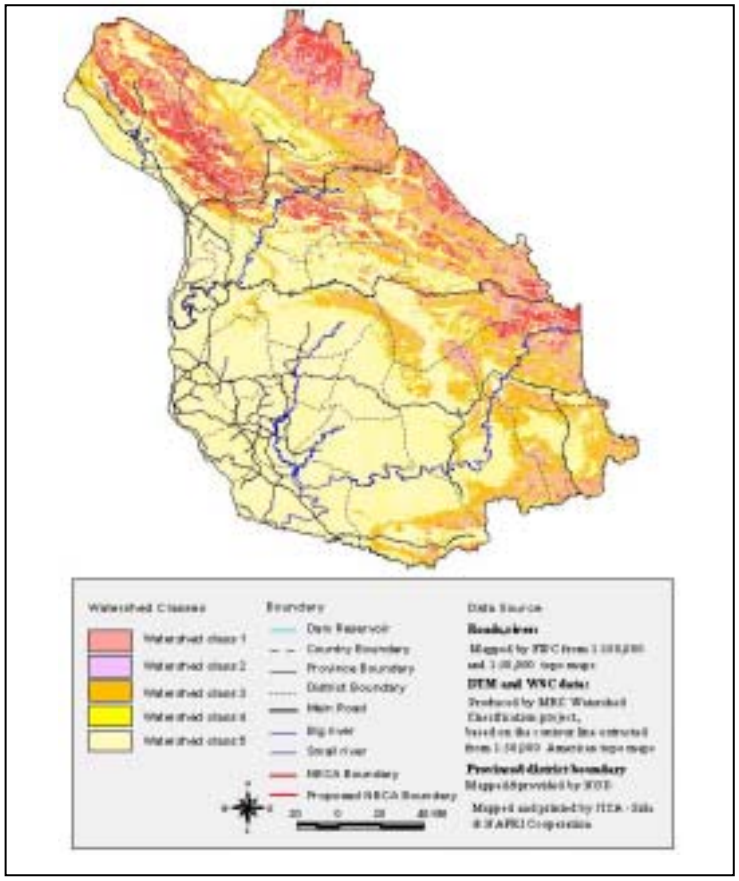

Figure III4-14 Watershed Classification Map of SKR

3) Agricultural Suitability Analysis

Over the next 20 years, the population in SKR is projected to grow by approximately 0.6 million. If nothing is done to increase agricultural productivity and appropriate use of land for agriculture, then about 170,000 ha of new agricultural land will be required to feed these additional people. Without doubt, land is and will be cleared for agriculture along the improved transportation routes such as routes 8b, 9, 12 and 13. However, this should be done so as to ensure that the land is put to the appropriate use. In many cases, land is abandoned because of low fertility or it may erode through bad land choice and/or poor farming practices.

(1) Methodology and Criteria :

Soil study

The system of soil classification used by the Soil Survey and Land Classification center (SSLCC) is derived from the FAO/UNESCO's legend soil map of the world, 1989-revised legend. There are two categories: soil groups and subgroups (units). Classification is based on soil properties (diagnostic horizons and properties) observed in the field or inferred from those observation or on laboratory measurements.

A soil group consists of soils that are developed from similar materials and similar environment conditions (physiography, topography, and slopes and drainage condition). Soil subgroups are differentiated from one to another according to the chemical-physical properties of soils and/or soil diagnostic properties.

The treatment of materials from field survey and from laboratory for map compilation includes the delineation of soil unit boundary (on a topographical map at 1/100.000 scale, produced by Russia with Gauss projection) by transferring the interpretation unit and elements of the interpretative situation of each aerial photograph and the result of field survey on to the base map. Each mapping unit should bear the index of mapping unit featuring soil group, soil subgroups, etc.

The soil pattern of Khammouan and Savannakhet includes 12 soil groups: Leptosols, Fluvisols, Solonchack, Arenosols, Regosols, Solonetz, Alisols, Acrisols, Luvisols, Lixisols, Gleysols, and Cambisols. Land mapping units are presented by soil profile code which refers to dominant soil group in capital letters, as shown on the following maps.

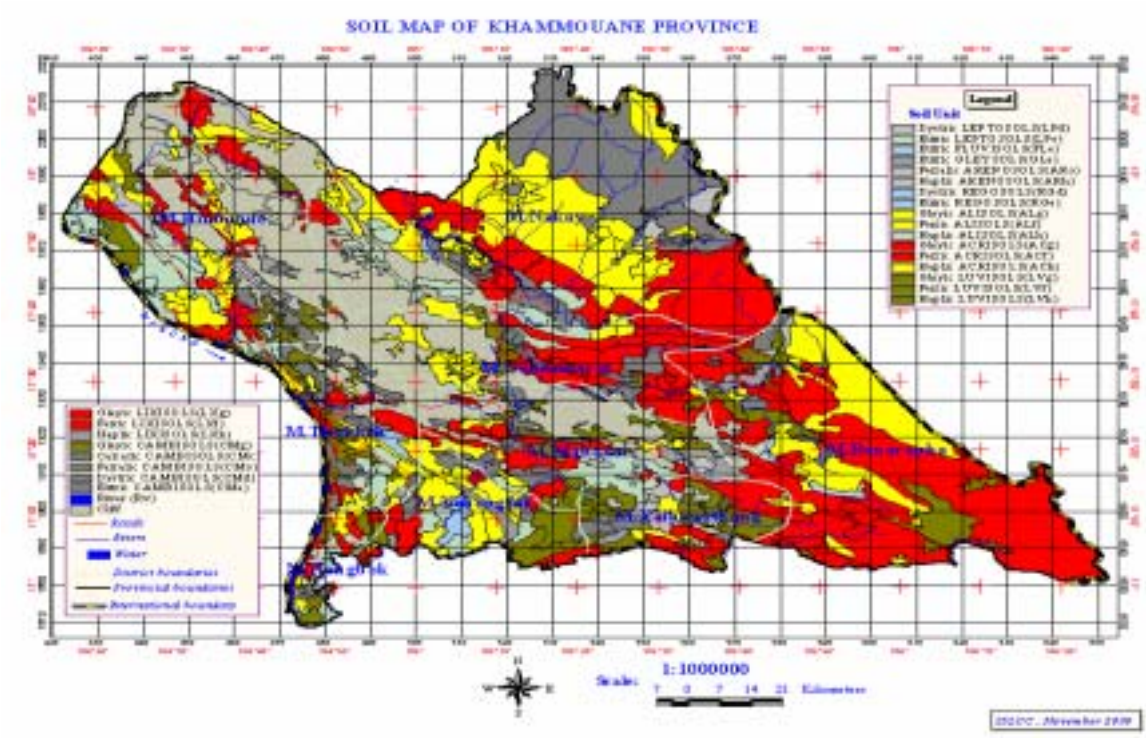

Figure III4-15 Land Mapping Units Identified in Khammouan Province

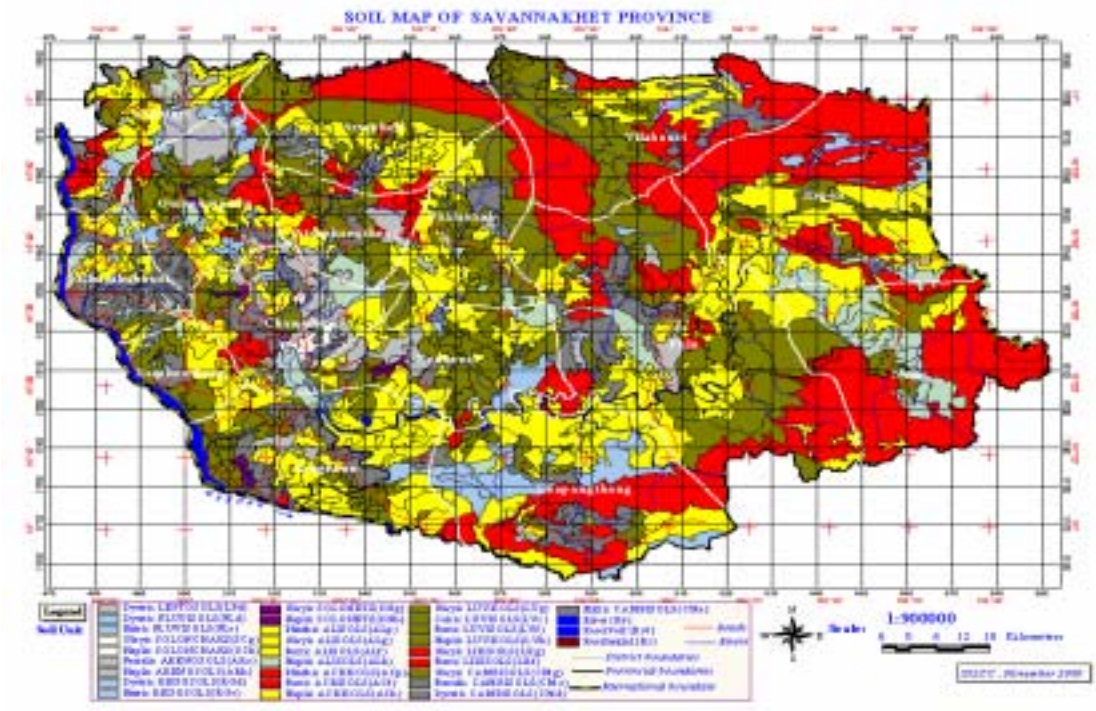

Figure III4-16 Land Mapping units Identified in Savannakhet Province

(2) Application to Land Suitability Evaluation for Cropping System

This land evaluation methodology proceeds by converting land characteristics or primary land attributes that are recorded by a soil survey, into a set of land qualities that are relevant for the land utilization type. Land qualities are important for determining the physical land suitability for growing crops; these are nutrient availability, nutrient retention, rooting condition, salt-affected, erosion hazard, moisture availability, and flood hazard. These land qualities can be ranked according to the following classes:

- S1- Lands very well suited for crop production; having no significant limitations that restrict their use for this land use alternative.
- S2- Land well suited for crop production; having slight limitation that restrict their use for this land alternative.
- S3- Land moderately well suited for crop production; having moderate limitations that reduce the choice of crops and/or require special land management for this land use alternative.
- N- Lands not suited for crop production, having very severe limitations that preclude their use for this land use alternative.

Each land quality is defined by specific combination of selected land characteristics. Nutrient availability; nutrient retention and salt-affected can be derived directly from the soil properties. The rooting condition and erosion hazard can be considered from soil information. The moisture availability referring to the water requirement in a growing period and flood hazard can be derived from rainfall and temperature regime can be derived from mean temperature in a growing period.

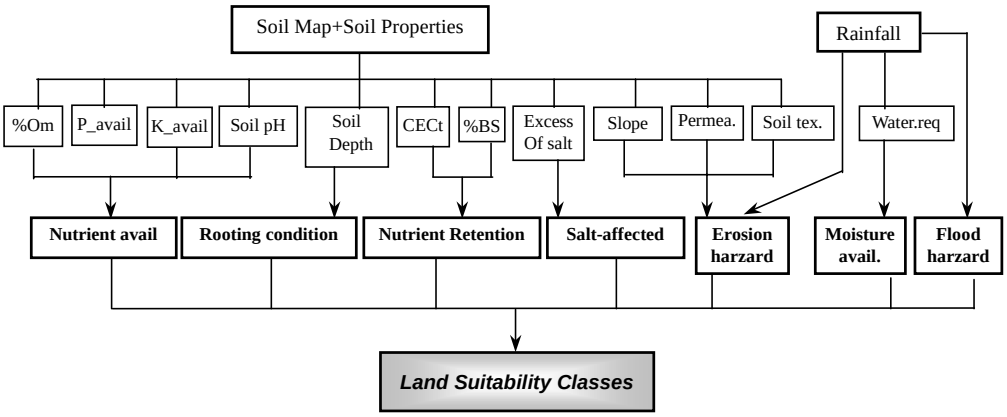

Figure III4-17 Crop Suitability Map Preparation Flowchart

The tabulated land use requirements for a list of crops (Qualitative Land Evaluation 1995; SSLCC) have been used for specific suitability rate for each crop.

Table III4-6 Land Use Requirement of Some Land Use Types

Land use types	Land Quality	Diagnostic factor	Suitability rate				
			Units	S1	S2	S3	N
Rice	– Temperature	– Mean temp. in growing period	C	22-30	30-33	33-35	>35
	- Moisture avail.	– Av.annual rainfall	mm	>1500	1200-1500	800-1200	<800
	- Nutrient avail.	– %organic matter	%	>3	1-3	<1	
		- P(available)	ppm	>25	10-25	<10	
		- K2O(available)	mg/100g	>6	3-6	<3	
		– Soil_pH (Soil Reaction)	Reaction	5.5-7.5	7.5-8.0	8.0-8.5	>8.5
					5.0-5.5	4.0-5.0	<4.0
	- Nutrient reten.	- CEC.total (meq/100g)	meq/100g	>15	5-15	<5	
		- Base saturation(%)	%	>50	35-50	<35	
	- Rooting Condi.	- Effective soil depth	cm	>50	25-50	15-25	<15
	- Erosion hazard	– Slope	class	a	b	c	>c
		– Soil texture		Sc,C,Cl	Scl,Sil,Si	Ls,Sl	gravels, sand
	-Oxygen avail.	- Soil drainage	class	1,2,3	4	5	6
Corn	– Temperature	– Mean temp. in growing period	C	23-25	25-30	30-35	>35
					23-20	16-20	<16
	-Moisture avail.	– Water requirement in growing period	mm	500-800	400-500	300-400	<300
	- Nutrient avail.	– %organic matter	%	>2.5	1.0-2.5	<1.0	
		- P(available)	ppm	>25	6-25	<6	
		- K2O(available)	mg/100g	>6	3-6	<3	>8.5
		– Soil_pH (Soil Reaction)	Reaction	5.5-7.5	7.5-8.0	8.0-8.5	<4.5
					5.0-5.5	4.5-5.0	
	- Nutrient reten.	- CEC.total (meq/100g)	meq/100g	>15	3-15	<3	
		- Base saturation(%)	%	>50	<50		
	- Rooting Condi.	- Effective soil depth	cm	>100	50-100	25-50	<25
	- Erosion hazard	– Slope	class	ab	c	d	>d
		– Soil texture		Sl,L,Sil,Cl			
	-Oxygen avail.	- Soil drainage	class	5,6	4	3	1,2
Citrus	– Temperature	– Mean temp. in growing period	C	25-30	30-33	33-35	>35
					25-18	18-13	<13
	-Moisture avail.	– Av.annual rainfall	mm	1500-200	2000-2500	2500-3000	>3000
				0	1200-1500	1100-1200	<1100
	- Nutrient avail.	– %organic matter	%		1.0-2.5	<1.0	
		- P(available)	ppm	>2.5	6-15	<6	
		- K2O(available)	mg/100g	>15	3-6	<3	
		– Soil_pH (Soil Reaction)	Reaction	>6	6.5-7.5	7.5-8.5	>8.4
				5.5-6.5	5.0-5.5	4.5-5.0	<4.5
	- Nutrient reten.	- CEC.total (meq/100g)	meq/100g		5-10	<5	
		- Base saturation(%)	%	>10	<35		
	- Rooting Condi.	- Effective soil depth	cm	>35	50-100		
	- Erosion hazard	– Slope	class	>100	d	e	>e
		– Soil texture		a,b,c			
	-Oxygen avail.	- Soil drainage	class	Sl,L,Sil,Si, vfSl 5,6	4	3	1,2

A decision tree is a basic component of the model. The decision tree can be a severity level or a subclass decision tree. The severity level decision trees allow one to place each land unit into one of the defined suitability classes, based on how good the LURs of each LUT are met by the prevailing land characteristics. The subclass decision tree assigns specific physical suitability subclasses as a final output of the decision procedure, indicating the major limitations.

- Example of a severity level decision tree for land uses type of low land rice and land use requirement of nutrient retention.

> CECe-c (CEC by sum of bases + extr. acidity, topsoil)

1. 0-4 meq/100g]..... : 3 (Moderate)
2. 4-5 meq/100g]..... : =1
3. 5-10 meq/100g] > Bases/c(Basaturation)------1.vl (Very Low) [0-25 %].. : 3(Moderate)
   2.sl [25-35 %]..... : =1
   3.l (Low) [35-50 %]..... : =2(Slightly)
   4.m (Medium) [50-75 %].. : =1
   5.h (High) [75-100 %]..... : =1
4. 10-15 meq/100g]..... : =2(Slightly)
5. 15-20 meq/100g] > Bases/c (Basaturation)----1.vl (Very Low) [0-25 %].. : 3 (Moderate)
   2.sl [25-35 %]..... : =1
   3.l (Low) [35-50 %]..... : 2(Slightly)
   4.m (Medium) [50-75 %]. : none
   5.h (High) [75-100 %]..... : none
6. 20-100 meq/100g] > Bases/c (Basaturation)--1.vl (Very Low) [0-25 %].. : 3 (Moderate)
   2.sl [25-35 %]..... : 2(Slightly)
   3.l (Low) [35-50 %]..... : 2(Slightly)
   4.m (Medium) [50-75 %].. : none
   5.h (High) [75-100 %]..... : none

The land use requirement " Nutrient Retention" is evaluated through an assessment of cation exchange capacity by sum of bases plus extr. Acidity (CECe) and basaturation (Bases). The first level decision is made on the basis of the cation exchange capacity by sum of bases plus extr. acidity, with additional subdivisions related to the amount of basaturation (Bases).

(3) Agricultural Suitability in SKR

The land suitability for each one of the lands mapping units of Khammouan and Savannakhet Provinces are demonstrated in the tables below. These tables show land suitability code and approximate extent of those mapping units suitable for rainfed lowland rice, corn, upland rice, leguminous (soy bean, Mungbean), cash crops (cotton, coffee, tobacco, tea, kenaf, sugar cane), vegetable (onion) and fruit crops (citrus- orange, tangerine, grape fruit, lemon and lime).

Table III4-7 Land suitability code and approximate extent of the mapping units for Khammouan Province.

Land Suitability Rating Code	Land Utilization Types	Land suitability Rating
Cliff	Cliff	Cliff
LSR-01	S1(Citrus,Cot,Sb,Sug,Tob);S2(Cof,Corn,Mb,Upr);S3(Kenaf,Lowr,Tea); N(Onio)	S1;S2(tex/m/ph/t);S3(m/t);N(t)
LSR-02	S1(Citrus,Tob);S2(Corn,Cot,Kenaf,Mb,Sb,Sug,Upr);S3(Cof,Lowr); N(Onio,Tea)	S1;S2(tex/m/ph/t);S3(tex/m/t);N(t)
LSR-03	S2(Citrus,Cof,Corn,Cot,Kenaf,Mb,Sb,Sug,Tob,Upr);S3(Lowr,Tea);N(Onion)	S2(tex/m/ph/t);S3(tex/m/ph/t);N(t)
LSR-04	S1(Cot);S2(Citrus,Corn,Lowr,Mb,Sb,Sug,Tob,Upr);S3(Cof,Kenaf); N(Onio,tea)	S1;S2(m/ph/t);S3(tex/t);N(t)
LSR-05	S2(Citrus,Corn,Cot,Kenaf,Mb,Sb,Sug,Tob,Upr);S3(Cof,Lowr);N(Onio,Tea)	S2(tex/m/ph/t);S3(m/r/tex/t);N(t)
LSR-06	S2(Citrus,Corn,Cot,Mb,Sb,Sug,Tob,Upr);S3(Cof,Kenaf,Lowr);N(Onio,Tea)	S2(e/m/ph/t/w);S3(m/tex/t/w);N(t)
LSR-07	S2(Citrus,Mb,Tob,Upr);S3(Corn,Cot,Kenaf,Lowr,Sb,Sug);N(Cof,Onio,Tea)	S2(tex/m/ph/t/r);S3(tex/m//r);N(t/m/r)
LSR-08	S2(Sug,Upr);S3(Citrus,Cof,Corn,Cot,Kenaf,Lowr,Mb,Sb,Tea,Tob);N(Onion)	S2(tex/ph/t/r);S3(tex/ph/m/r);N(t)
LSR-09	S2(Sug,Upr);S3(Citrus,Cof,Corn,Cot,Kenaf,Lowr,Mb,Sb,Tob);N(Onio,Tea)	S2(tex/ph/t/r);S3(tex/ph/t/m/r);N(t)
LSR-10	S3(Citrus,Cof,Corn,Cot,Kenaf,Lowr,Mb,Sb,Sug,Tea,Tob,Upr);N(Onion)	S3(tex/ph/t/m/r/e);N(t)
LSR-11	S3(Citrus,Cof,Corn,Cot,Kenaf,Lowr,Mb,Sb,Sug,Tob,Upr);N(Onio,Tea)	S3(tex/ph/t/m/r/e);N(t)
LSR-12	S2(Sug,Upr);S3(Citrus,Cof,Corn,Cot,Kenaf,Mb,Sb,Tob);N(Lowr,Onio,Tea)	S2(tex/ph/t/w/e/r);S3(ph/t/w/r);N(t/w)
LSR-13	S2(Sug,Upr);S3(Citrus,Corn,Cot,Kenaf,Lowr,Mb,Sb,Tob);N(Cof,Onio,Tea)	S2(tex/ph/t/m/r);S3(tex/ph);N(m/t)
LSR-14	N(Citrus,Cof,Corn,Cot,Kenaf,Lowr,Mb,Onio,Sb,Sug,Tea,Tob,Upr)	N(ph/t/f/e/w)
river	River	River

Note: rainfed lowland rice, corn, upland rice, leguminous (soy bean, Mungbean), cash crops (cotton, coffee, tobacco, tea, kenaf, sugar cane), vegetable (onion) and fruit crops (citrus- orange, tangerine, grape fruit, lemon and lime).

Table III4-8 Land Suitability Code and Approximate Extent of Mapping Units for Savannakhet Province.

Land Suitability Code	Land Utilization Types	Land Suitability Rating
LSR-01	S1(Citrus,Cot,Sb,Sug,Tob); S2(Corn,Cof,Kenaf,Mb,Upl r); S3(Lowr,Tea,); N(Onio)	S1;S2(m/ph/t);S3(m/t);N(t)
LSR-02	S1(Citrus;Tob); S2(Cof,Corn,Cot,Kenaf,Mb,Sb,Sug,Upr); S3(Low r,Tea,Up r); N(Onio)	S1;S2(m/ph/t/tex/w);S3(m/t/tex);N(t)
LSR-03	S1(Citrus); S2(Corn,Kenaf,Mb,Sb;Sug,Tob,); S3(Cof,Cot,Low r,Up r); N(Onio;Tea)	S1;S2(m/ph/t/tex);S3(m/t/tex);N(t)
LSR-04	S1(Citrus); S2(Corn,Kenaf,Mb,Sb,Sug,Tob) ;S3(Cof,Cot,Low r,Tea,Up r); N(Onio)	S1;S2(m/ph/t/tex);S3(m/t/tex);N(t)
LSR-05	S1(Citrus;Cot,Sb,Tob); S2(Corn,Kenaf,Mb,Sug,Upr); S3(Low r,Tea,Up r); N(Onio;Cof)	S1;S2(m/ph/t);S3(m/t);N(t/m)
LSR-06	S1(Citrus,Tob); S2(Corn,Cot,Kenaf,Mb,Sb;Sug,Upr); S3(Low r,Tea); N(Onio;Cof)	S1;S2(m/ph/t/tex);S3(m/t/tex/ph);N(t/m)
LSR-07	S1(Citrus,Tob); S2(Corn,Cot,Kenaf,Mb,Sb;Upr) ;S3(Low r,Sug,Tea); N(Onio;Cof)	S1;S2(m/ph/t/tex);S3(m/t/tex/ph);N(t/m)
LSR-08	S1(Citrus); S2(Corn,Kenaf,Mb,Sb;Sug,Tob); S3(Low r,Sug,Tea,Upr); N(Onio;Cof)	S1;S2(m/ph/t/tex);S3(m/t/tex/);N(t)
LSR-09	S1(Citrus); S2(Corn,Kenaf,Mb,Sb,Tob) ;S3(Low r,Sug,Tea,Upr,Cot,); N(Onio;Cof)	S1;S2(m/ph/t/tex);S3(m/t/tex/);N(t)
LSR-10	S2(Citrus,Cof,Corn,Cot,Kenaf,Mb,Sb;Sug,Tob,Upr); S3(Low r,Tea); N(Onio)	S2(m/ph/t/tex);S3(m/t/tex);N(/t)
LSR-11	S2(Citrus,Cof,Corn,Cot,Kenaf,Mb,Sb;Sug,Tob,Upr); S3(Low r,Tea) ;N(Onio)	S2(m/ph/t/tex);S3(m/t/tex);N(/t)
LSR-12	S2(Citrus,Cof,Corn,Cot,Mb,Sb;Sug,Tob,Upr); S3(Kenaf,Low r,Tea); N(Onio)	S2(m/ph/t/);S3(m/t/tex);N(/t)
LSR-13	S2(Citrus,Cof,Mb,Sug,Tob,Upr); S3(Corn,Sb,Cot,Kenaf,Tea); N(Lowr,Onio)	S2(e/m/ph/t/w/tex);S3(w);N(t)
LSR-14	S1(Tob); S2(Citrus,Corn,Cot,Kenaf,Mb,Sug,Upr); S3(Cof,Corn,Tea,Lowr); N(Onio)	S1;S2(r/m/ph/t/tex);S3(m/t/ph/r);N(t)
LSR-15	S2(Citrus,Corn,Cot,Kenaf,Mb,Sb,Sug,Upr); S3(Cof,Tea,Lowr,); N(Onio)	S2(e/r/m/ph/t/tex);S3(m/t/r);N(t)
LSR-16	S2(Citrus,Corn,Cot,Mb,Sb,Sug,Tob,Upr); S3(Cof,Kenaf,Lowr,Tea); N(Onio)	S2(r/m/ph/t);S3(m/r/t);N(t)
LSR-17	S2(Citrus,Corn,Mb,Sb,Sug,Kenaf,Tob,Lowr); S3(Cof,Cot,Tea,Uplr); N(Onio)	S2(m/ph/t/tex);S3(m/t/tex);N(t)
LSR-18	S2(Citrus,Corn,Mb,Sb,Sug,Kenaf,Tob,Lowr); S3(Cof,Cot,Tea,Uplr); N(Onio)	S2(m/r/ph/t/tex);S3(m/t/tex);N(t)
LSR-19	S2(Citrus,Corn,Mb,Sb,Sug,Kenaf,Tob); S3(Cof,Cot,Lowr,Uplr); N(TeaOnio)	S2(m/ph/t/tex);S3(r/m/t/tex);N(t)
LSR-20	S2(Citrus,Mb,Sug,Kenaf,Tob,Uplr); S3(Corn,Cof,Cot,Sb,Tea,Lowr,Uplr); N(Onio)	S2(e/r/m/ph/t/tex);S3(r/m/t/w);N(t/w)
LSR-21	S2(Citrus,Mb,Sug,Kenaf,Tob,Uplr); S3(Corn,Cot,Sb,Tea,Lowr,); N(Cof,Onio)	S2(t/r/m/ph/tex);S3(r/t/m/tex);N(t)
LSR-22	S1(Tob); S2(Citrus,Corn,Cot,Mb,Kenaf,Tob,Sb,Uplr); S3(SugTea,Lowr,); N(Cof,Onio)	S1;S2(t/r/m/ph/tex);S3(r/t/m/tex/ph)N(m/t)
LSR-23	S2(Citrus,Corn,Cot,Mb,Kenaf,Tob,Sb,Uplr);S3(SugTea,Lowr,);N(Cof,Onio)	S2(t/m/ph/tex);S3(t/m/tex);N(t/m)
LSR-24	S2(Citrus,Corn,Mb,Kenaf,Tob,Sb,Sug,Uplr); S3(Cot,Tea,Lowr,Uplr); N(Cof,Onio)	S2(t/r//m/ph/tex);S3(t/m/tex);N(e/w/t)
LSR-25	S2(Citrus,Corn,Mb,Kenaf,Tob,Sb,Uplr); S3(Cot,Sug,Tea,Lowr,Uplr); N(Cof,Onio)	S2(t/r//m/ph/tex);S3(t/m/tex);N(t/m)
LSR-26	S2(CitrusTob,Uplr); S3(Corn,Kenaf,Cot,Mb,Sb,Lowr); N(Sug,Tea,Cof,Onio)	S2(r/t/m/t/ph/tex);S3(m/tex/r);N(t/r)
LSR-27	S2(CitrusTob); S3(Corn,Kenaf,Cot,Mb,Sb,Lowr,Sug,Upl); N(Tea,Cof,Onio)	S2(r/m/t/ph/tex);S3(m/tex/r);N(m/t/r)
LSR-28	S2(Citrus); S3(Corn,Tob,Kenaf,Cot,Mb,Sb,Lowr); N(Sug,Tea,Cof,Onio,Upl)	S2(ph/tex);S3tex);N(t/tex)
LSR-29	S1(Cot);(Cof,Sug); S2(Citrus,Corn,Tob,Kenaf,Cot,Mb,Sb,Lowr,Tea,Upl); S3(Onio)	S1;S2(m/t/x);S3(x/m/ph/t);N(t/m)

Land Suitability Code	Land Utilization Types	Land Suitability Rating
LSR-30	S1(Tob);S2(Cof,Sug); S3(Citrus,Corn,Kenaf,Cot,Mb,Sb,Lowr,Tea,Upl); N(Onio)	S1;S2(m/ph/t/tex);S3(x/t);N(t/x)
LSR-31	S2(Tob,Cof,Cot,Sug);S3(Citrus,Corn,Kenaf,Mb,Sb,Lowr,Tea,Upl);N(Onio)	S2(m/ph/t/tex);S3(m/tex/x/t);N(t/x)
LSR-32	S2(Sug,Uplr);S3(Citrus,Cof,Cot,Corn,Kenaf,Mb,Sb,Lowr,Tea,Tob);N(Onio)	S2(ph/t);S3(m/tex/ph/t);N(t)
LSR-33	S2(Sug,Tob);S3(Citrus,Cof,Cot,Corn,Kenaf,Mb,Sb,Lowr,Tea,Uplr);N(Onio)	S2(ph/tex/r/x);S3(m/tex/ph/t/x);N(t/x)
LSR-34	S2(Sug,Uplr);S3(Citrus,Cof,Cot,Corn,Kenaf,Mb,Sb,Lowr,Tea,Tob);N(Onio)	S2(ph/tex/t);S3(m/tex/ph/t);N(t/x)
LSR-35	S2(Sug);S3(Citrus,Cof,Cot,Corn,Kenaf,Mb,Sb,Lowr,Tea,Tob,Uplr);N(Onio)	S2(ph/tex/r);S3(m/tex/ph/t/x);N(t)
LSR-36	S2(Sug,Uplr);S3(Citrus,Cof,Cot,Corn,Kenaf,Mb,Sb,Lowr,Tea,Tob);N(Onio)	S2(ph/tex/t);S3(m/tex/ph/t);N(t)
LSR-37	S2(Sug);S3(Citrus,Cof,Cot,Corn,Kenaf,Mb,Sb,Lowr,Tea,Tob,Uplr);N(Onio)	S2(ph/tex/t/r);S3(m/tex/ph/t/r/x);N(t/x)
LSR-38	S3(Citrus,Cof,Cot,Corn,Kenaf,Mb,Sb,Lowr,Tea,Tob,Sug,Uplr);N(Onio)	S3(e/m/tex/ph/t/r/w);N(t)
LSR-39	S2(Tob,Sug);S3(Citrus,Cot,Corn,Kenaf,Mb,Sb,Lowr,Tea,Uplr);N(Onio,Cof)	S2(ph/m/tex/x);S3(m/ph/tex/x);N(m/x)
LSR-40	S2(Tob,Uplr);S3(Citrus,Cot,Corn,Kenaf,Mb,Onion,Tea,Sb,Lowr,Sug);N(Cof)	S2(ph);S3(t);N(m/r)
LSR-41	S2(Tob,Sug,Uplr);S3(Citrus,Cot,Corn,Kenaf,Mb,Tea,Sb,Lowr);N(Onion,Cof)	S2(m/ph/tex);S3(t/m/tex/x);N(t/x)
LSR-42	S2(Sug,Uplr);S3(Citrus,Cot,Corn,Kenaf,Mb,Tea,Sb,Lowr,Tob);N(Onion,Cof)	S2(m/ph/tex/t/r);S3(t/m/ph/tex/r);N(m/t)
LSR-43	S2(Sug);S3(Citrus,Cot,Corn,Kenaf,Mb,Tea,Sb,Lowr,Tob,Uplr);N(Onion,Cof)	S2(m/ph/tex/t/x);S3(m/ph/tex/x);N(m/t/x)
LSR-44	S2(Uplr);S3(Citrus,Cot,Corn,Kenaf,Mb,Tea,Sb,Lowr,Tob,Sug);N(Onion,Cof)	S2(ph/tex/t/x);S3(m/ph/tex/r/t);N(m/t)
LSR-45	S3(Citrus,Cot,Corn,Kenaf,Mb,Tea,Sb,Lowr,Tob,Sug,Uplr);N(Onion,Cof)	S3(m/ph/tex/r/t);N(m/t)
LSR-46	S1(Tob);S2(Cot,Sug); S3(Cof,Corn,Kenaf,Lowr,Mb,Sb,Uplr); N(Citrus,Onion,Tea)	S1;S2(t/tex/x)S3(m/tex/x/t);N(t/r/x)
LSR-47	N(Citrus,Cof,Corn,Cot,Kenaf,Lowr,Mb,Sb,Onion,Tea,Tob,Sug,Uplr)	N(e/w/t)
Swamp	996	Swamp
River	995	River

Note: rainfed lowland rice, corn, upland rice, leguminous (soy bean, mungbean), cash crops (cotton, coffee, tobacco, tea, kenaf, sugar cane), vegetable (onion) and fruit crops (citrus- orange, tangerine, grape fruit, lemon and lime).

Land mapping units are grouped into classes according to degree of limitation in use or risk of damage when used. Thus, the most serious degree of limitation determines the suitability classes, and classes is indicated by numeric 1(S1) to 4(Not suitable) increasing order of suitability and each class is subdivided into subclasses according to dominant kinds of limitation. The small case letter following the class number indicates the dominant limitation.

The overall suitability of land in SKR for rainfed lowland rice, corn, upland rice, leguminous (soy bean, mungbean), cash crops (cotton, coffee, tobacco, tea, kenaf, sugar cane), vegetable (onion) and fruit crops (citrus-orange, tangerine, grape fruit, lemon and lime) is shown on the following page.

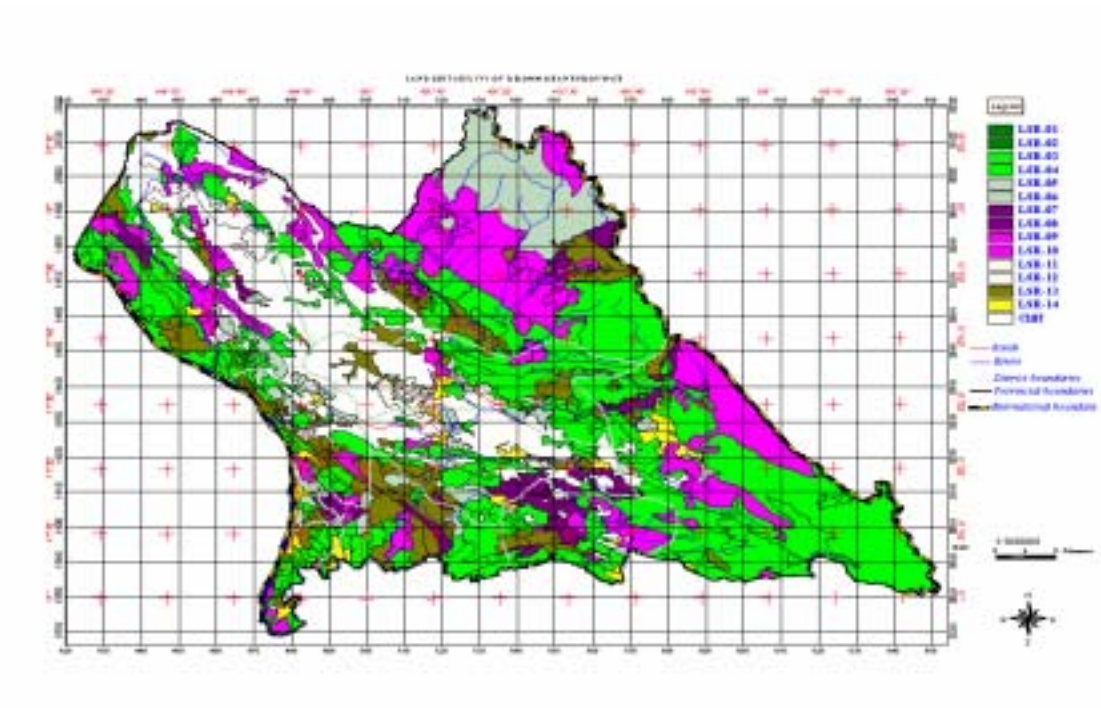

Figure III4-18 Suitability map of Khammoune Province

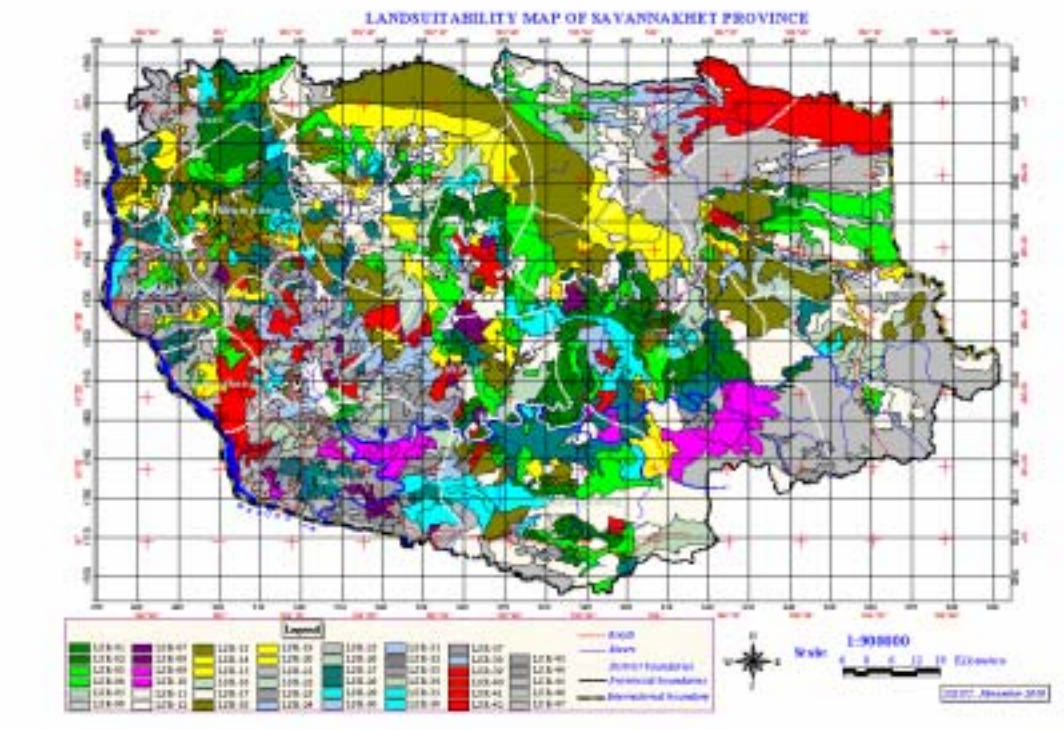

Figure III4-19 Suitability map of Savannakhet Province.

4) Land Use Suitability Map

The land use suitability mapping analysis for the SKR area with regards to the potential and constraints of the land, is a process of selecting the type of land use which gives the high sustainable yield and at the same time minimizes the environmental consequences. The sustainable yield is concerned with the stable climatic condition and the soil fertility. Both variables are influenced by forest cover status and intensity of forest destruction. Protecting the forest from being destroyed and identifying the areas for permanent forest cover are of great concern, in order to maintain the environment in SKR.

The land use suitability mapping analysis for the SKR area is based on the two main analysis; i.e., the watershed classification and the agricultural suitability. The Land Use Sustainability Map will show the following points:

- The area of the particular categories of forestry cover, forest activities and other land use : Protection forest, Production forest, and others.
- The area of the certain agricultural crops which could suitably be grown.

(1) Classification Rules 1

Areas for Protecting Watershed
The main objectives of watershed protection are:

- to maintain a regular flow in the river and stream during the wet and dry season, and
- to prevent soil erosion, which leads to other consequences such as soil and mineral losses resulting in low soil fertility, sedimentation or river bed and reservoir.

The criteria for the area identification for watershed protection is therefore based on the following variables.

- Land cover : Current forest including bamboo
- Watershed classes : WSC 1 or WSC 2

Reforestation Areas for Protecting Watershed
The main objective of reforestation is to increase forest cover at the areas of high risk of soil erosion.

- Land cover : Current unstocked forest, savannah, scrub, shifting cultivation areas and grass land
- Watershed classes : WSC 1 or WSC 2

Forest Areas for Timber Production and Local Uses
These forest areas will be used for logging and as sources for fuel wood and construction materials for local community.

- Land cover : Current forest including bamboo
- Watershed classes : WSC 3 or WSC 4 or WSC 5

Potential Rice Paddy Expansion
These areas will mainly be used for future paddy field development as to meet the rice requirement of increasing population. The criteria for identification of these areas is therefore based on the following variables:

- Land cover : Current unstocked forest, shifting cultivation areas
- Watershed classes : WSC 5

Potential Crop Areas
These areas will be used for growing cash crops like corn, bean, coffee, tea, etc. The criteria for identification of these areas is therefore based on the following variables:

- Land cover : Current unstocked forest, shifting cultivation areas
- Watershed classes : WSC 4

Potential Fruit Trees and Forest Plantation
These areas will be used for growing fruit trees like mango, orange, etc. and forest industrial plantation. The criteria for identification of these areas is therefore based on the following variables:

- Land cover : Current unstocked forest, shifting cultivation areas
- Watershed classes : WSC 3

Grazing Land
This is an area for grazing cattle and other animals for the local community. The criteria for identification of this area is based on the following variables:

- Land cover : Glass land, savannah and scrub forest
- Watershed classes : WSC 3 or WSC 2 or WSC 5

(2) Classification Rules 2

These classification rules are used for further analysis of the areas which were classified in step 1 as potential areas for paddy field and cash crops. The following are the areas derived from the analysis:

Potential Paddy Areas

The classified potential paddy will be integrated with the optimal land suitability. The areas of paddy suitability 1, 2 and 3 will be designated for paddy expansion, and the remaining areas will be assigned to cash crops.

- Land cover : Classified potential paddy
- Agricultural suitability : Paddy suitability 1, 2 and 3

Potential Areas for Cash Crops

The classified potential cash crops areas from step 1 will be integrated with optimal land suitability. The areas of suitability 1, 2 and 3 for priority crops will be designated for priority crops expansion, and the remaining areas will be assigned for other secondary crops.

- Land cover : Current potential crops areas
- Land suitability : Priority crop suitability 1, 2 and 3

(3) Identification of Land Use Category

In this process, the current land use (2000) and watershed classification data have been integrated first. By applying the Classification Rules 1, the following land use categories are derived.

- Protection forest
- Reforestation for protecting WS
- Production forest
- Potential fruit & forest plantation areas
- Potential rice paddy
- Potential crop areas
- Grazing land
- Existing land use:
    - Rice Paddy
    - Other Agricultural land
    - Urban
    - Water
    - Swamp

(4) Assessment of Crop Suitability

In this process, the areas of potential rice paddy and potential crop identified in the previous process are integrated with the land suitability produced by SSLCC. As many crop types can be grown in the same areas, six priority crops are identified for this study; i.e., Rice, Citrus, Tobacco, Sugar, Soy bean, and Kernaf. For these crops, only suitability class 1 to class 3 are selected, the remaining areas are assigned for other cash crops.

Table III4-9 Land Use Suitability in SKR

Land Suitability	Khammouan		Savannakhet	
	(ha)	(%)	(ha)	(%)
Protection Forest	359,483	21.55	129,322	6.04
Reforestation for protecting WS	137,952	8.27	112,422	5.25
Production Forest	460,663	27.62	943,479	44.09
Grazing Land	24,506	1.47	37,922	1.77
Potential Fruit&Forest Plantation	74,550	4.47	144,524	6.75
Potential Rice Paddy	79,174	4.75	136,403	6.37
Potential Area for CtTbSgSbKn	154,041	9.24	61,167	2.86
Potential Area for Other Cashcrop	15,468	0.93	35,513	1.66
Potential Area for TbSgSbKn	0	0.00	194,015	9.07
Potential Area for TbSbKn	0	0.00	10,682	0.50
Potential Area for Sugarcane	0	0.00	12,946	0.60
Existing Rice Paddy	131,987	7.91	286,042	13.37
Existing Other Agriculture Land	1,926	0.12	2,202	0.10
Barren land & Rocks	197,163	11.82		
Urban Area	1,260	0.08	3,443	0.16
Water	10,530	0.63	16,352	0.76
Swamp	19,298	1.16	13,565	0.63
Total	1,668,000	100.00	2,140,000	100.00

Source: JICA/Sida-NAFRI GIS Survey

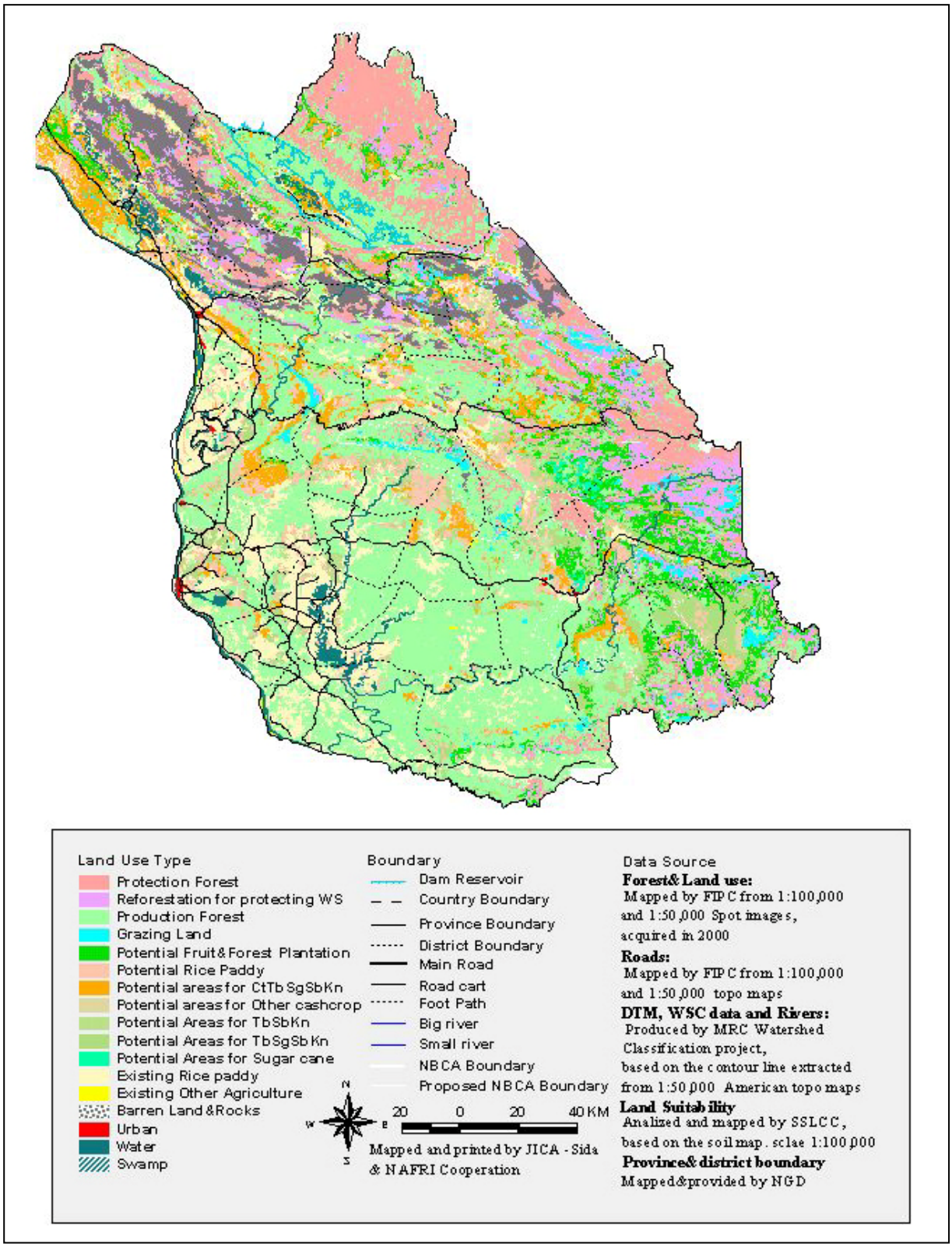

Figure III4-20 Land Suitability Map

4) Land Use Plan for 2020

Based on the Land Use Suitability Map, the Land Use in 2020 is planned under the following principles:

- To keep the forestry area over 60% in SKR
- To propose the new protection forests for the watershed management
- To secure the agricultural production as planned in this study (refer to Chapter IV for details)

Forestry Management

The forestry area is to be kept for the sustainable resource utilization, in pursuit of the government policy.

The protection area and the reforestation area for watershed protection, excluding NBCA, in the Land Use Suitability Map is proposed to be the new protection area, called “the Protection Forest”. This is to assure the area definition of the protection forest that the central and each provincial government has been trying to set up. The protection Forestry Area of land use in 2020 is composed of

- Protection forest,
- Reforestation for protecting watershed,
- Some area of current production forest, and
- Reforested area of some of potential agricultural area and grazing land in the land use suitability analysis, that are currently unstocked area, ray (including shifting cultivation area), savanna, scrub, and grass land.

Agricultural Development

According to the agricultural development plan (refer to Chapter IV), the target rice paddy area planned for 2020 is 62,000 hectares in Khammouan and 143,000 hectares in Savannakhet. In line with the government policy, the abandoned shifting cultivation area will be converted to the reforestation area and grazing land for livestock. The grazing land for livestock will be planned to be 406,000 hectares in total in 2020 (about 125,000ha in Khammouan and 281,000ha in Savannakhet).

To secure the agricultural development plan as planned in this study under close coordination with forestry management, some areas will be converted from other land in the land suitability analysis, which are surplus for the purpose of future agricultural development plan.

- Rice/paddy area is defined from potential rice paddy area in the land use suitability analysis,
- Cashcrop area is defined from the potential cashcrop area in the suitability analysis,
- Fruit tree/tree crop is defined from the potential fruit and forest plantation area in the suitability analysis
- Grazing land for livestock is defined from grazing land in the land use suitability analysis, which used to be current unstocked area, ray (including shifting cultivation area), savanna, scrub, and grass land.

As noted previously, elimination of UXO is critical to any development in the future. The heavily contaminated area is mostly covered by forests. The activity in forest should therefore be secured when any development and management program is to be planned therein.

Table III4-10 Land Use Plan for 2020

(Unit: Ha and %)

Land Use in 2020 :	Khammouan Province		Savannakhet Province	
Forestry	**1,107,759**	**66.41**	**1,355,960**	**63.36**
Protection Forest	780,073	46.77	666,300	31.14
Production Forest	244,336	14.65	517,597	24.19
Fruit&Forest Plantation	83,350	5.00	172,063	8.04
Agricultural Land	**287,638**	**17.24**	**747,543**	**34.93**
Rice Paddy	133,500	8.00	295,256	13.80
Grazing Land	125,500	7.52	282,030	13.18
Other Agriculture Land	28,638	1.72	170,257	7.96
Other Area	**272,602**	**16.34**	**36,497**	**1.71**
Barren land & Rocks	197,546	11.84	2,989	0.14
Swamp	14,292	0.86	13,607	0.64
Urban Area	1,213	0.07	3,516	0.16
Water	59,551	3.57	16,385	0.77
Total	1,668,000	100.00	2,140,000	100.00

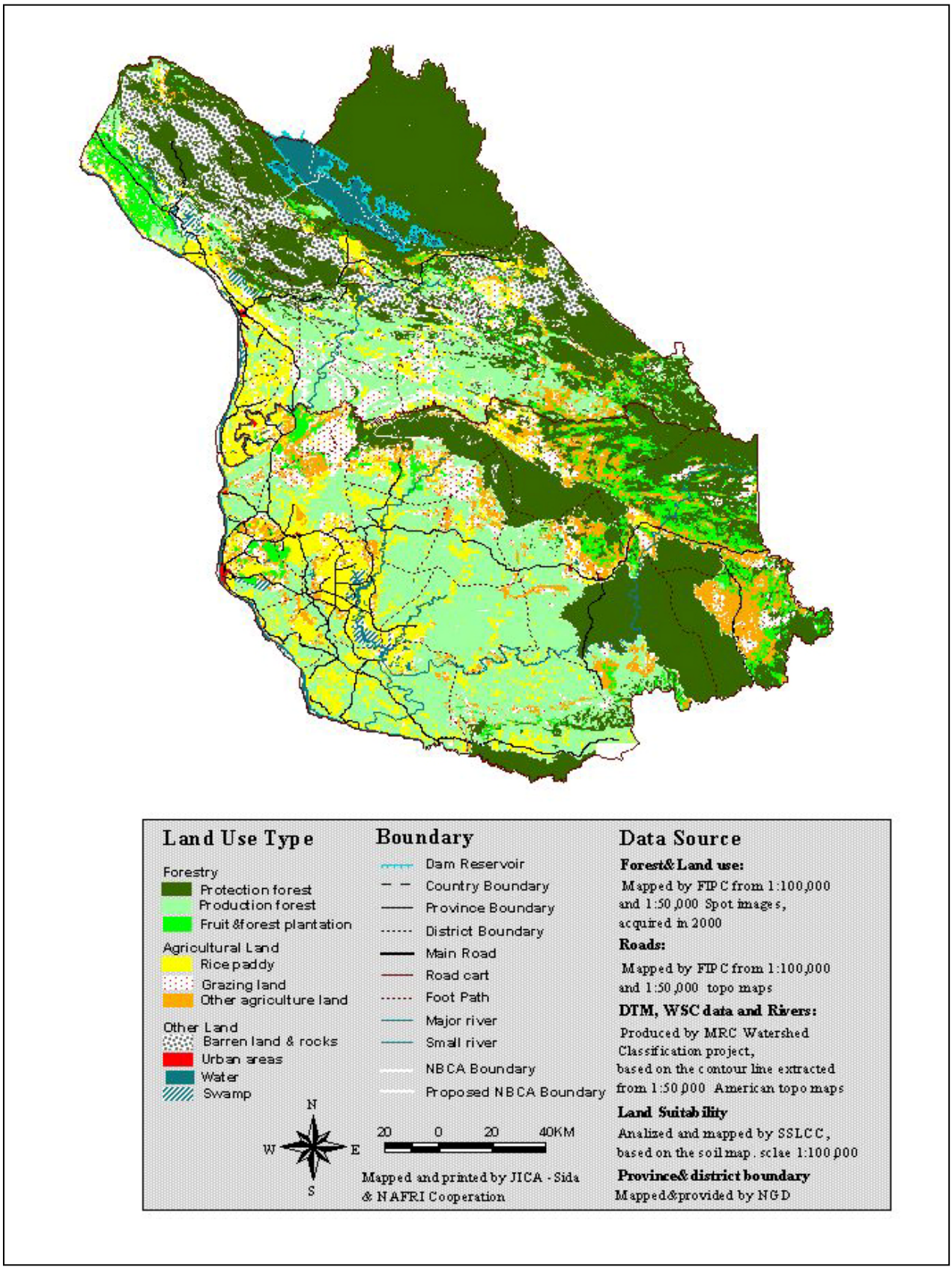

Figure III4-21 Land Use Plan for 2020