Application of RS/GIS Techniques for Land Use Mapping Land Suitability Studies of a National Forest Reserve, Thailand

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ABSTRACT

A study for environmentally sustainable development planning for rural and agricultural resources was conducted in the Pa Wang Phloeng-Muang Khom-Lam Narai National Forest Reserve in Lop Buri Province, Thailand. Remote Sensing and GIS technologies were applied to arrive at appropriate land use and land suitability for various agricultural crops.

The results of the remote sensing and GIS studies integrated with the socio-economic and biophysical dimensions served as inputs for decision making in the environmental and sustainable development plan envisaged for the forest reserve in question.

1. INTRODUCTION

1.1 Background :

Rural and agricultural development, especially in developing countries of Asia, like Thailand faces serious problems such as water shortage, environmental and land degradation, declining yields, increasing population, and migration, etc. There are many questions that could be asked which may lead to some solution to the above problems. From the perspective of natural resources development and management, and with the various disciplines involved, and under the frame work of sustainable development, a team from the Asian Institute of Technology undertook a study in a National forest Reserve area in Lop Buri Province, Thailand.

1.2 Statement of the Problem :

A tract of land of 48,918 rais (7,827 hectares), after a period of time under concession to a private company was turned over to the Royal forest Department, who in turn authorized Kasetsart University in Bangkok to develop into some useful area for rural agricultural development program to be managed by the University and some other interested provincial agencies, etc. There are however, conflicting interests in the use of land in the area. Through are long span of time, there have been illegal migration and settlement of people in side this piece of land, who also put up resistance to the development plan of Kasetsart University. The fear that this illegal encroachment of land without proper and adequate measure may lead to an eventual environmental degradation and destruction without possibility for remedy.

1.3 Study Objectives :

(1) To establish the baseline information on biophysical and socio-economic condition by applying remote sensing mapping techniques, supported by ground truth and ancillary data collection.
(2) To establish geo-information database based on the input from remote sensing as well as other ancillary data, and
(3) To apply combination of RS and GIS techniques to arrive at land suitability classification to support the sustainable development planning.

2. THE STUDY AREA AND ITS VICINITY

2.1 General Description :

The study area is a part of Khok Charoen District, Lop Buri Province in the upper central region of Thailand. Specifically, it is located in the Yang Rak Sub-district with latitude 15°15′ to 15°27′ and 100°52′ to 101°00′ (figure 1).

2.2 Climate of the Study Area :

Based on the 11 year climatic record from the Meteorological Department, (1983-1993) it was indicated that the average annual rainfall varies from 1,053.9 mm to 1,324 mm. The rainy season lasts from May through October, and during November to April the dry season. High amount of precipitation usually falls during the months of August, September and October. The average annual raindays varies from 66.5 to 101.0 days.

2.3 Slope and Topography :

The study area has a slope gradient raging from 0% to more than 40%. The villages are usually occupying the flatter areas (about 0-9%). Farmlands are in the 0-16% slope category. The mountain areas have slope gradient of more than 40%. Majority of the study area (45.4%) has a slope category of 0 to 2% while areas of more than 40% covers only about 4.7% of the total area. The elevation of the study area ranges between 80 to 560 meters from mean sea level (msl).

2.4 Soils and Geology :

Soils in the study area are residual which developed from granitic materials. Soil depth varies from shallow to very deep. Textural profiles are clay, loam, clay loam, sandy clay loam, silty clay loam, silt loam, fine loamy loam, sandy loam, and gravelly clay loam. Large areas exhibit color profile of very dark grayish brown to very dark brown over very dark grayish brown to dark brown.

Large portion of the study area have drainage characteristics of moderately well-drained to well-drained while small portions exhibit a somewhat poorly drained characteristic. Permeability is generally moderate to slow while surface run off is medium to rapid. Large portions of the area have ground water table at several meters all year round. Few areas have ground water above 1.5 meters for 2-3 months during the rainy season while the paddy fields are usually saturated for 3-4 months in a year.

2.5 Sources of water and use :

The sources of water in the study area are rain, ground water, reservoir and springs. for majority of the villagers, rain is the major source of water for drinking. Each house in all the villages has several big water tanks which are filled with water during the rainy season, enough to meet the requirement in the dry season. A number of reservoirs also exist in the study area to meet partial water requirement in farming and household. During the dry season, however, these reseroirs contain little water, some dried up, and cannot meet the water requirements, so most of the farmlands are idle in the dry season.

2.6 Wildlife :

A variety of wildlife are still present in the area. Many different species of insects had also been observed. Some detailed list of amphibians, reptiles, birds and mammals which can be found in the study area is documented by the study group.

2.7 Vegetation :

Vegetation in the villages and vicinities are of the types of forest and fruit trees. Fruit trees belonging to the family Leguminosae are common. Mango and coconut trees are also growing in some villages. In the northern part of the study area, tree plantations exist. Species of

eucalyptus and Casuarina are commonly planted in these tree plantations. Big-sized trees of Pterocarpus indicus are usually growing far apart in the farmlands of most villages.

3. METHODOLOGY

The main project of this study involved interdisciplinary team approach in order to determine the existing situation in the study area to identify the development issues, biophysical and socio-economic conditions, and the relationship between people and their environment.

The interdisciplinary team work consisting of three functional groups were employed, consisting of biophysical and institution, socio-economic, and environmental remote sensing and geoinformation groups. It is the work of the environmental remote sensing and geoinformation group that is being presented in this paper.

STEPS OF WORK PERFORMED IN THE STUDY

1. Data Collection

This activity involved the collection of all the major and ancillary data required to meet the above stated objectives. Soil map, hydrological map, reservoir map, aerial photographs (1983) and land use map dervied from the landsat TM image taken in July 1993 and January 1994 were considered as the major sources of data. Crops requirements and the limitations of crops selected were also gathered.

2. Map Preparation

Using the available topographic map of Lop Buri Province sheet no. 5139 I, dated 1969, base map of the study area were prepared prior to digitization. Different coverages of the study area were prepared separately but each had the same boundary of the area, following the boundary provided by Kasetsart University. These coverages included :

(1) the boundary map of the study area derived from the topographic map provided by Kasetsart University ;
(2) the transportation map, i.e. road network in 1983 and in 1993 ;
(3) the drainage patterns (main stream and its tributaries, canals or klongs) ;
(4) reservoir map ;
(5) land use maps in 1983 and 1994 ;
(6) slope range map ;
(7) geological map ; and
(8) village location map

The preparation involved some from of ground reference data. Eight (8) Ground Control Points (GCPs) were marked on all maps. For image processing purposes (with use of CCTs), GCPs are essential for computing a transformation matrix for use in rectifying an image (ERDAS Field Guide 1991). The GCP values were converted into Universal Transverse Mercator (UTM) values for the purpose of digitization.

3. The Global Positioning System (GPS)

Global Positioning System (GPS) is a satellite based navigation and positioning system that can accurately georeference and type of spatial information in almost any place of the earth. GPS is able to provide map coordinates of either latitude/longitude or the Universal Transvers Mercator (UTM), the elevation of the observation point, the time when the record was taken, the prescribed zone value of the point location and others.

4. Basemap Preparation using ARC/INFO-GIS

Geographic Information System (GIS) are computer-based systems that are used to store and manipulate geographic information (Aronoff, 1989). These systems are powerful sets of tools for collection, storing, retrieving at will, transforming, and displaying spatial data from the world for a particular set of purpose (Burrough, 1986).

5. Digital Image Processing

ERDAS software was employed to assist in the following digital image processing steps :

* Image rectification and restoration
* Image enhancement
* Image classification

- Unsupervised classification :
The type of image classification which the use of CLUSTER program in ERDAS software. The classified output is useful for field checking and for choosing the training samples in the supervised classification.

- Supervised classification :
The type of image classification to which classes identified was based on the a priori information i.e. information gathered in the field, and is considered as the best technique in identifying land use/land cover on the image through the digital analysis process where the training samples was established.

6. Slope Classification

The output of the digital elevation model (DEM) process in ERDAS TOPO module is a slope map which was developed for further use.

7. Land suitability analysis for crops

The FAO Framework for Land Evaluation (1976) served as the basis for the land suitability studies undertaken by the team.

To facilitate in the processing of data in the ARC/INFO GIS software using linear combination method, important decisions were first determined. These included the following : a) parameters considered, b) crop requirements, c) score/ranking of the condition in the parameters used, and d) assigning weights to each parameters for final analysis.

4. RESULTS AND CONCLUSION

4.1 Land use/Land cover maps : The land use/land cover maps of the study area were compiled for two different periods, namely, for 1983 and that of 1993/4. The 1983 land use/land cover map was originally compiled by Kasetsart University based on aerial photographs, taken on November 22, 1983 at a scale of 1:13,000. The land use classes were then normalized to be conformed to the land use/land cover classification scheme for use with remote sensor data adopted by the US Geological Survey (Lillesand and Kiefer, 1987).

(1) The land use/land cover classes of 1983 were determined to be as follows :

Classes	Hectare	%
Mixed Deciduous Forest	2,195.15	27.97
Dry Dipterocarp Forest	499.71	6.37
Brush and Shrubs	530.20	6.75
Plantation	6.45	0.08
Other Agricultural Areas	4,130.28	52.62
Paddy Fields	431.18	5.50
Villages	14.78	0.19
Water Bodies	12.18	0.16
Kasetsart Research Station	28.49	0.36
Roads		
Streams		
TOTAL	**7,849.04**	**100.00**

(2) Land use/land cover classes for 1994 are determined to be as follows :

Classes	Hectare	%
Dense Forest	734.49	9.37
Less Dense Forest	783.90	9.99
Bushes	1,862.19	23.75
Shrubs	1,103.58	14.07
Paddy Fields	621.36	7.92
Plantation	194.76	2.48
Other Agricultural Areas	2,508.30	31.98
Water Bodies	33.12	0.42
Roads		
Streams		
Settlements		
TOTAL	**7,841.70**	**100.00**

4.2 Land Suitability maps :

Various land suitability analysis were undertaken to output various land suitability maps. These maps served as input to the strategy formulation phase. The processes involved called for land suitability requirements for various crops, for example, corn and sorghum, pasture, paddy, mango, cassava and other root crops. The FAO Framework for Land Evaluation, 1976 was adopted based on crop requirement parameters for each crop, and the four suitability classes were defined, namely, "S1", the highly suitable "S2", the moderately suitable, "S3", the marginally suitable, and "N", the not suitable. Soil suitability maps for each of the dominant crops in the area were produce for further use as part of strategic planning of the main project.

5. CONCLUSION AND RECOMMENDATIONS

Remote sensing and geographic information systems technologies were used over a typical forest and agricultural area aiming at a sustainable development planning of the area under study. An interdisciplinary team effort was employed and RS/GIS techniques were used as one of the input into strategic planning process. The contribution of these technologies is indispensable, especially when dealing with spatial information over a large geographic area. And, the manipulation of a large spatial database can only be effectively done by means of GIS.

There are a few recommendation points to be made regarding the use of RS/GIS in this study. Firstly, the classification scheme adopted after US Geological Survey which attempted to normalize airphoto interpretation result and digital classification of landsat TM data may not be accurate enough to be accepted as final result. A more acceptable common means should still be sought. The use of FAO Framework may be straight forward, but the parameters used as input into the process should be carefully picked, and weighting or scoring of each parameter should be carefully adjusted. A disciplinary understanding of specific processes would be required in this matter.

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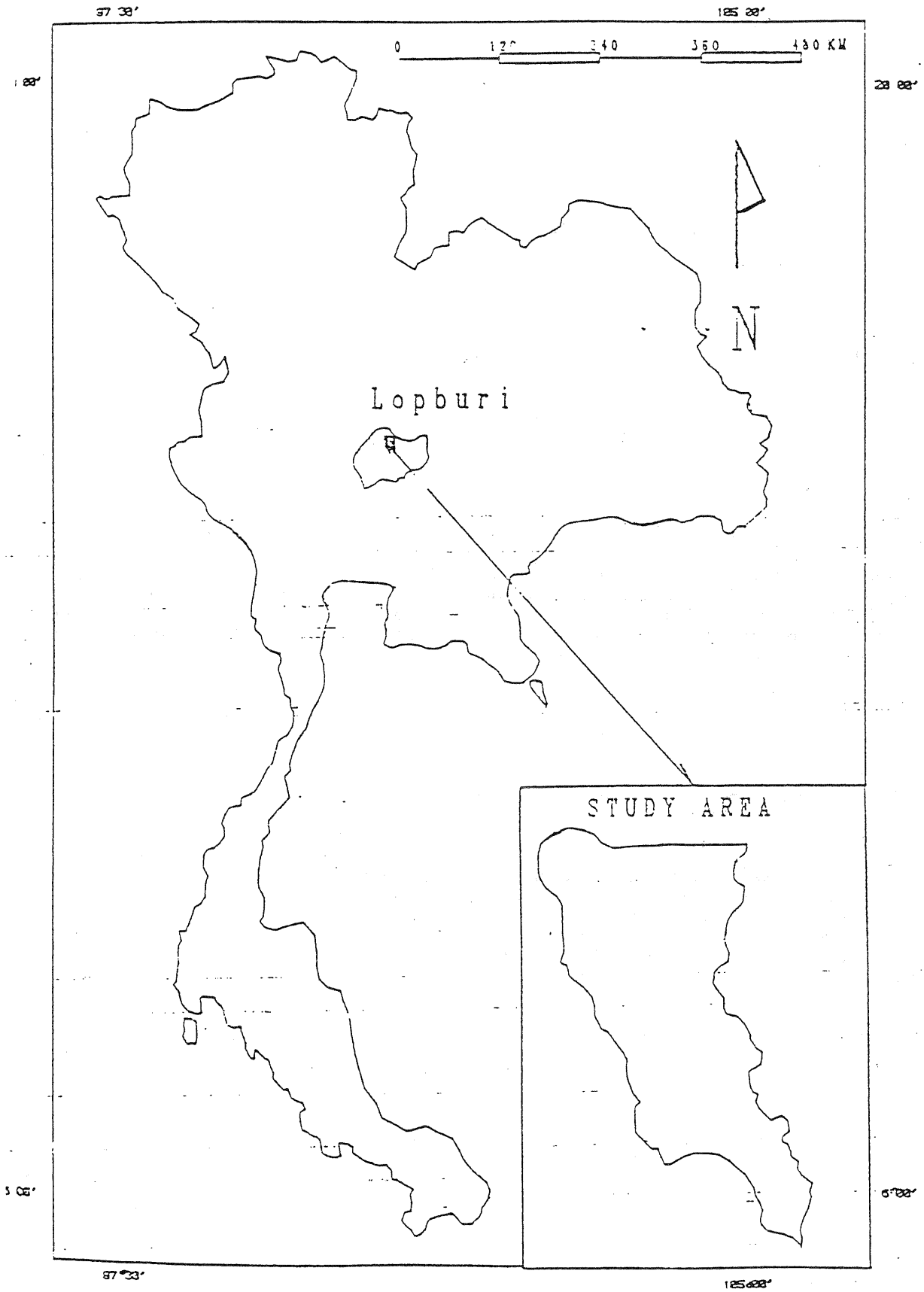

Figure 1. Location Map of the Study Area