UNIVERSITI PUTRA MALAYSIA

LAND SUITABILITY AND FERTILITY CAPABILITY EVALUATION FOR LAND REFORM AREA IN MAHA SARAKHAM, PROVINCE, THAILAND

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By

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Land suitability evaluation is one of the most effective methods for proper agricultural land use planning as it evaluates the suitability of land for a specific crop. Soil clusters were obtained using cluster analysis which groups soils according to similar characteristics. Fertility Capability Classification of Soil (FCC) groups soils according to the kind of limitations present for agronomic management of the physical and chemical properties. For any particular soil, the FCC is presented as a code such as *Lek*, a soil which is loamy for topsoil and subsoil (L) having high leaching potential and low nutrient capital reserves. The fertility constraints were high leaching potential (e), and low nutrient capital reserves (k). The interpretation of the code provides information that guides the user in choosing the right practices for the classified soil. By knowing soil clusters, FCC, and the land suitability, farmers can identify the fertility and the limitations of their land and the most suitable crop to cultivate.

The study was conducted in Khok Phuk Kut and Pong Deang Forest, Maha Sarakham Province, Northeast Thailand, which are both located within a land reform area that was allocated by the Thai Government to landless farmers for agricultural purposes. The study area was 2,915.81 ha. The study entailed creation of FCC unit and land suitability maps using Global Positioning System (GPS) and Geographic Information System (GIS) as well as grouping soil series into soil clusters based on their physical and chemical properties (by cluster analysis). Conformity of land suitability and present land use was also considered. The base maps of administrative boundary, topography, climate, soil series, and present land use were collected.

GIS was used to digitize the boundary of study area based on a map of the administrative boundaries of Maha Sarakham Province, Thailand. The boundary of the study area was overlaid with the soil series map using GIS. GPS was used to locate soil sampling points and features. The number of soil samples was based on the size of the area. Soil samples were analyzed based on important physical and chemical properties relevant to cluster analysis, FCC, and the Land Development Department's land quality of land use requirement for major economic crops. FCC is based on quantitative topsoil and subsoil parameters (termed soil type and substrata type) and condition modifiers, directly relevant to plant growth. Soil series were grouped into soil clusters by cluster analysis based on physical and chemical properties.

Using cluster analysis, the soil series were grouped into three clusters as follows: (i) Ban Phai and Phra Thongkhom series (Bpi and Ptk), (ii) Ubon series (Ub) and (iii) Maha Sarakham and Non Deang series (Msk and Ndg). Based on the

identification of FCC units, the soils of the study area for both topsoil and subsoil were loamy sand (S) or sandy loam (L). Their fertility constraints were high rate of infiltration, low water-holding capacity, low nutrient capital reserves (k), and Al-toxicity (a). Land suitability classification of the study area for major economic crops such as rice (transplanted, direct seeded), upland rice, cassava and sugarcane was based on soil series. An area of 2,905.67 ha was found not suitable (N) for rice (transplanted, direct seeded) and upland rice. The same area was marginally suitable (S3) for cassava. It was marginally suitable for sugarcane (2,882.24 ha), and only 23.43 ha was not suitable. The fertility constraints were soil texture or structure.

This study can contribute to the generation of information useful in characterizing the soil into classes, group of soils, as well as evaluating the fertility of the land and also land suitability for the above-mentioned crops. The conformity of land suitability and present land use can ensure the proper use of land. The proper land-use planning management can be practiced in the land reform area.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Master Sains

PENILAIAN KEUPAYAAN KESUBURAN DAN KESESUAIAN TANAH UNTUK KAWASAN PEMULIHAN TANAH DALAM WILAYAH MAHA SARAKHAM, THAILAND

Oleh

SOONTAREE BOONME

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Penilaian kesesuaian tanah adalah salah satu kaedah yang paling efektif bagi perancangan guna tanah pertanian dimana ia menilai kesesuaian sesuatu bidang tanah untuk sesuatu tanaman. Kelompok tanah diperolehi dengan menggunakan kaedah analisis kelompok yang menggunakan sifat-sifat yang sama. Pengkelasan Keupayaan Kesuburan Tanah (FCC) mengkelaskan tanah berdasarkan kepada masalah yang sedia ada dari segi ciri-ciri fizik dan kimia tanah. Bagi sesuatu tanah, pengkelasan ini ditunjukkan dengan kod [contoh: Lek di mana tekstur tanah atas dan sub-tanah adalah lom (L), mempunyai potensi larutlesap tinggi (e) dan keupayaan simpanan nutrien rendah (k)]. Interpretasi kod memberi maklumat sebagai panduan untuk memilih amalan pertanian yang sesuai. Dengan mengetahui kelompok tanah, FCC dan kesesuaian tanah, petani dapat dibantu mengenalpasti kesesuaian sesuatu tanah dan memilih tanaman yang sesuai.

Kajian ini telah dijalankan di Khok Phuk Kut dan hutan Pong Deang, dalam wilayah Maha Sarakham, utara timur Thailand yang dikhaskan untuk pemulihan tanah oleh kerajaan Thai kepada petani yang tidak bertanah untuk pertanian. Luas kawasan adalah 2,915.81 hektar. Kajian ini menggunakan unit FCC, peta kesesuaian tanah dengan bantuan sistem kedudukan global (GPS) dan sistem maklumat geografi (GIS). Siri tanah dikumpulkan kepada kelompok berdasarkan ciri kimia dan fizik tanah. Perbandingan kesesuaian tanah dengan guna tanah terkini juga diambil kira. Peta asas meliputi sempadan pentadbiran, topografi, iklim, siri tanah dan guna tanah.

GIS digunakan untuk mendigitkan sempadan kawasan kajian berdasarkan kepada sempadan pentadbiran wilayah Maha Sarakham, Thailand, dan GPS digunakan untuk menentukan lokasi pensampelan tanah dan penunjuk yang penting. Bilangan sampel tanah adalah berdasarkan kepada saiz kawasan. Sampel tanah dianalisis berdasarkan sifat kimia dan fizik yang penting yang diperlukan untuk analisis kelompok, FCC dan kualiti tanah mengikut Jabatan Pembangunan Tanah bagi tanaman berkepentingan ekonomi. FCC adalah berdasarkan parameter kuantitatif tanah atas dan sub-tanah dan keadaan pengubah yang berkait terus dengan pertumbuhan tanaman. Siri tanah di kumpul kepada kelompok tanah melalui analisis kelompok berdasar kepada sifat kimia dan fizik tanah yang sama.

Keputusan analisis kelompok menunjukkan siri tanah di kawasan kajian telah dikumpulkan kepada 3 kelompok: kelompok 1 mengandungi siri Ban Phai dan Phra Thongkhom (Bpi dan Ptk), kelompok 2 siri Ubon (Ub), dan kelompok 3 mengandungi siri Maha Sarakham dan Non Deang (Msk dan Ndg). Berdasarkan unit FCC, tanah di kawasan kajian adalah, pasir berlom atau lom berpasir (L) bagi tanah

lapisan atas dan sub-tanah. Masalah kesuburan tanah adalah kadar larut lesap yang tinggi, keupayaan pegangan air rendah; keupayaan simpanan nutrien (k) rendah potensi larutlesap tinggi (e), dan keracunan-Al (a). Kesesuaian tanah dikawasan kajian untuk tanaman ekonomi seperti padi, padi bukit, ubikayu dan tebu adalah tidak sesuai (N) untuk padi dan padi bukit dengan keluasan 2,905.67 ha. Kawasan adalah yang sama berkesesuaian marginal (S3) bagi ubi kayu. Manakala untuk tebu keluasan 2,882.24 ha adalah berkesesuaian marginal (S3) dan 23.43 ha tidak sesuai (N). Faktor penghad adalah tektur atau struktur tanah.

Kajian ini boleh menyumbang kepada penjanaan informasi yang berguna untuk pencirian tanah mengikut kelas, kelompok tanah, penilaian terhadap kesuburan tanah dan juga kesesuaian tanah untuk tanaman. Penyesuaian terhadap kesesuaian tanah dan guna tanah akan dapat memastikan penggunaan tanah yang betul. Perancangan tanah yang betul boleh dilaksanakan di kawasan pemulihan tanah ini dengan menggunakan kaedah-kaedah yang diutarakan dalam kajian ini.

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LIST OF ABBREVIATIONS

Bpi	Ban Phai series
%BS	Percentage of base saturation
C	Clayey (>35% clay)
CA	Cluster analysis
cm	Centrimeter
%C	Percentage of carbon
CEC	Cation Exchange Capacity
DGPS	Differential Global Positioning System
ECEC	Effective Cation Exchange Capacity
FCC	Fertility Capability Soil Classification
GIS	Geographic Information System
GPS	Global Positioning System
ha	Hectare
ISRIC	International Soil Reference and Information Centre
K	Potassium
km	Kilometer
km^2	Kilometer square
L	Loamy
LDD	Land Development Department
LRA	Land Reform Area
LRAs	Land Reform Areas
LR	Land Reform
m	Meter

mm	Millimeter
Msk	Maha Sarakham series
N	Nitrogen
N1	Land that is unsuitable for a particular use at present but which might be useable in future
N2	Land that offers no prospect of being so used
NASIS	National Soil Information System
Ndg	Non Deang series
NRCS	Natural Resource Conservation Service
O	Organic (>30% O.M. to at least 50 cm)
%OM	Percentage of Organic Matter
P	Phosphorus
Ptk	PhraThongkham series
R	Rock or other hard root-restricting layer within 50 cm
RCAR	Remote Sensing Center of Agricultural Resources
RS	Remote Sensing
S	Sandy (USDA sand and loamy sand)
S1	Highly suitable
S2	Moderately suitable
S3	Marginally suitable
SC	Sandy topsoil underlain by clayey subsoil
Ub	Ubon series
USDA	United States of Department of Agriculture
WISE	World Inventory of Soil Emission Potentials

CHAPTER I

INTRODUCTION

1.1 Background

The total land area of Thailand is 51.31 million ha or 513,115 km^2 (Office of Agricultural Economics, 1994). The Agricultural Land Reform Area (LRA) is 8.2 million ha (http://www.alro.go.th, 2004). Chirapanda (1998) referred to Land Reform in the 1975 Agricultural Land Reform Act as "redistribution of land for farming and residential to farmers who are landless or do not have sufficient land for cultivation, and to farmers' institutions by means of lease and sale". The state will provide support services such as development and marketing facilities.

Agriculture is the main occupation within the LRA. The problems of land resources in the LRA are misuse of land for residential and industrial and construction purposes on agricultural land. Land use for agriculture was tremendously increased through deforestation, encroachment into the watershed conserved area, and cultivation of areas not suitable. Infertile soil is a major factor hampering agricultural production (Yamamoto and Sukchan, 2001). Land degradation is one of the consequences of mismanagement of land and results frequently from a mismatch between land quality and land use (Beinroth et al., 1994).

According to the Land Development Department, Ministry of Agriculture and Cooperatives, Thailand, about 70% of the agricultural land is deteriorating and low

fertility of soil limited its production potential, and 25% is affected by severe or very severe soil erosion (Duced and Sluse, 2000).

More often than not, the land reform farmers are ill-advised in production planning and lack supporting services to carry it out. They have been sustaining fertility at a higher level by applying chemical fertilizers. Land development policy, therefore put emphasis on accelerating land reform, improving productivity, and conservation. Looking beyond the administrative problems facing agricultural development, the Thai government is faced with a more serious development issue whether land reform can contribute substantially to renewable natural resources replenishment.

Land evaluation is an assessment of man's possible use of land for agriculture, forestry, engineering, recreation, and other activities which involve the collection and interpretation of large amounts of data (FAO, 1983). In general, the principal objective of land evaluation is to select the optimum land use for each defined land unit, taking into account both physical and socio-economic considerations and the conservation of environmental resources for future use (FAO, 1976).

FAO guidelines on the land evaluation system are based on defined land quality as related to individual crop (FAO, 1983). Establishment of land unit is typically based on its suitability. Sys et al. (1991) applied the FAO concept and developed the crop requirements based on the experiences in tropical areas.

Land suitability assessment for agriculture is meant to evaluate the ability of a piece of land to provide the optimal ecological requirements of crops. This evaluation

needs a specification of the respective crop requirements and calibrating them with the terrain and soil variables, therefore the identified limiting factors could be managed to suit the various crop requirements and improve crop productivity. This is a pre-requisite to productivity maximization in the agricultural sector (FAO, 1983).

Within the planning area, an assessment of crop combinations is needed in order or to lessen a price risk. The new technology that is available for land evaluation consists mainly of the use of remote sensing and geographic information system (GIS). Land suitability evaluation was then formulated with the objective of classifying units of land to their suitability for combining economic crops using GIS and remotely sensed data (Jimenez, 1995).

Cluster analysis is a general term for a family of statistical classification methods that group objects. The idea is to statistically minimize within-group variability while maximizing among group variability in order to produce relatively homogeneous groups that are distinct from one another (Young and Hammer, 2000). Cluster analysis has been used to develop conceptual schemes for grouping soils. Langohr et al. (1976) used the similarities among particle-size distributions to cluster soils, showing that the cluster classes approximated existing series.

Fertility Capability Classification of Soil (FCC) system was developed over 25 years ago for interpreting soil taxonomy and additional soil attributes in a way that is directly relevant to plant growth (Buol et al., 1975; Buol and Couto, 1981; Sanchez et al., 1982). The FCC system has been incorporated into FAO's Framework for

Land Evaluation (FAO, 1976) and guidelines are being prepared for rainfed and irrigated agriculture.

Barry and Glenn (2000) reported that the global positioning system (GPS) technique permits the collection of data on specified profile, cross section, and boundary locations. A GIS is the most widely used tool to draw maps based on geo-referenced information. This will enable input applications at variable rates within a field (Kandasamy et al., 2001). Data gathered using GPS can be used to create a map of a farm (in either vector or raster format) that is linked to a GIS (Phillips et al., 1998). Several computer software packages (i.e. MapInfo, ArcView, ArcInfo) are available that can download the GPS data and overlay the boundaries on an aerial photograph of a field.

Remote sensing is a rapid method of constructing base maps in the absence of detailed land surveys (Jimenez, 1995). Data captured using these techniques can be added to mapping or directly plotted to scale using a digital plotter (Barry and Glenn, 2000). Remote Sensing Center of Agricultural Resources (RCAR) has been using Remote Sensing techniques to gather timely data on crop production and using GIS for Agricultural Planning (Karnchanasutham and Amarakul, 1991).

In accordance with the specific objective of land reform of Thailand was to increase agricultural production and improve delivery systems of supporting services so as to ensure better living standard among farmers, and to reduce social and economic inequalities among the populace (Chirapanda, 1990). For this study, with soil cluster can be used for soil classification. From FCC units map and land suitability maps,

they are expected to be useful in efficient planning and designing of land resources for sustainable land use and this will provide the decision maker or planner the opportunity to select the suitable crop that matches the area and then can provide advice to farmers for proper land use management.

1.2 Statement of the Problems

Currently, the farmers within the LRA of Maha Sarakham Province, have a low level ability and knowledge in the process of rapid change and the development of agriculture with regards to land use. The destruction of the natural habitat and the depletion of natural resources in this area are mainly due to the farming practices such as shifting cultivation or slash-and-burn agriculture. In addition to the traditional agricultural land use, forests have been cleared indiscriminately for illicit timber. Besides, this region has infertile soil that limits agricultural production. There are four types of problem soils which are widely distributed, namely; sandy, skeletal, saline, and Vertisols (Mitsuchi et al., 1986). These soils have caused serious degradation problem, e.g. erosion and salinity (Imaizumi el at., 1999). Therefore, agricultural productivity is low (Yamamoto and Sukchan, 2001).

These conditions and problems suggest the need for land-use planning to systematically allocate land resources for major land use types. The goals of land use planning should be related to sustainable agriculture so as to ensure that the resources may be used for future generation.

1.3 Objectives of the Study

The main objective of this study was to group soils according to the similarity of their physical and chemical properties, and then evaluate the fertility of these soils using FCC and land suitability for major economic crops through the integration of remote sensing, GPS and GIS.

1.4 The Specific Objectives of the Study were to:

1. To group soils based on the similarity of their physical and chemical properties,
2. To create the FCC units map, and the land suitability classification maps of rice (transplanted, direct seeded), upland rice, cassava and sugarcane.