Suitable Areas for Economic Crops Based on GIS and Physical Land Evaluation Model

Teerawong Laosuwan, Satith Sangpradid, Poramate Chunpang

Abstract *- The aim of this research was to locate suitable areas for economic crops of sesame based on Geographic Information System (GIS) and Physical Land Evaluation Model in Chi watershed, North-east of Thailand. The authors used decision tools or rules to locate suitable areas for economic crops plantation by analyzing six variables from physical evaluation model (S), (W), (R), (L), (SA), and (SL). These six factors were analyzed by using overlay function technique including union and intersect scheme. The variables then were determined their score via Physical Land Evaluation Model. The results of this work found that areas for sesame plantation included high, moderate, low and non suitable areas, which accounted for 30.47%, 19.61%, 8.92% and 1.66%, respectively.*

Index Terms— Suitable Areas, Economic Crops Plantation, **GIS, Physical *Land* Evaluation.**

I. INTRODUCTION

Sesame (*Sesamum indicum* L.) is an ancient oil crop considered to be still at an early stage in breeding. The fact that sesame is a crop of mainly developing countries with limited available research funds for long term breeding programmers resulted in very few breeding efforts in research stations. Furthermore, sesame is not a mandate crop of any of the international agriculture research centers household consumption and growing farm plants [1].

Sesame is economic crops that provide high return. Thus, these crops are required to encourage more planting. As the main areas of Chi watershed have hot and dry environment, lack of abundant soils and sandy soil, it is important to locate suitable areas for economic crops plantation in Chi watershed. Especially, sesame is important economic crops. The sesame crop is considered as high economic potential crops because this is more resistant to drought than others, easy to plant and require low investment. Therefore, it has been widely used in various industries such as nutritional foods, instant noodles, medicines and cosmetics. Sesame residues from the extraction of sesame oil still contain protein and amino acid and especially, high amounts of Methionine. Sesame residues are used as animal foods. Moreover, both domestic and foreign markets demand sesame seeds and oils, representing 700-900 million baht for their export value annually. To economically important oil seed crop which is widely cultivated in many parts of the world, primarily in tropical and subtropical areas of the world, including India, China, Sudan, Burma, Tunisia, Egypt, Thailand, Mexico, Guatemala, El Salvador Afghanistan, Pakistan, Bangladesh, Indonesia, Sri Lanka, Saudi Arabia and Turkey and has recently been adapted to semi-arid regions [2].

Geographic Information System (GIS) is a computer based information system that has a capability of handling all kinds of spatially referenced land related data at all mapping scales in support of decision making. It enables the input, management, manipulation, analysis, modeling, output, and dissemination of spatially referenced land-related data [3] - [5]. Geographic Information System is the fundamental science geographic concepts and many applications *in various* fields. For example the completed development of web-based GIS application for agroforestry carbon sequestration offset project in Thailand [6]. The primary goal of the study is to apply Geographic Information System to locate suitable areas for sesame plantation in Chi watershed, Thailand.

II. THE STUDY AREA AND DATA USAGE

A. The Study Area

The study area, Chi watershed, is located in the northeast of Thailand. Chi watershed is a sub catchment of Mekong watershed and covers an area of about 9,477sq.km. (Fig.1). The Chi River drained eastwards to the Mun River which finally flows into the Mekong at the Thai Laos border in the east. Average annual rainfall varies from 1,000 mm to 1,500 mm and is higher in the west. The rainfall is unevenly distributed during the rainy season (May to October), with over 60% occurring during August and September [7]. The elevation of the basin ranges from 1,100 m in the west to 100 m in the east. Physiographical, the main area is formed by the so called Korat Plateau and characterized by small hills for the high land in the west and gently undulating alluvial plains for the lower land in the east. Geologically, the area is mainly underlain by the thick sequences of Mesozoic rocks of Maha Sarakham Formations which consist of sandstone, siltstone and interblended rock salts. The remaining forest in the area, mainly dipterocarp forest type, is found in the upper stream in the west and subsists about 15 % of the area. The majority of soil is inherently low in fertility and is salinized in lower terrace of the area where there exists rock salts. Most soil types have a

Manuscript received on May, 2013.

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relatively narrow range in landform; a given soil is generally recognized in a definite land form [8]. The main land forms in the Northeast are predominantly determined by the Mekong River and its tributaries [9] - [11].

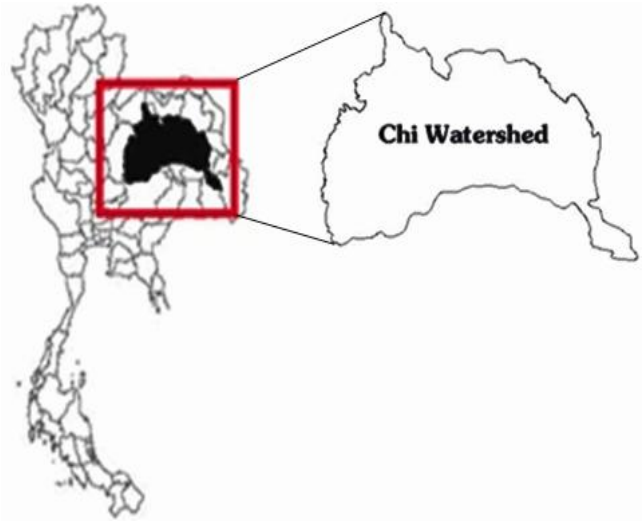


Fig.1. The study area

III. METHODOLOGY

In this work, Map Window GIS software was used to locate suitable areas for economic crops plantation in Chi watershed. Data about sesame economic crop was studied by overlay function technique of Physical Land Evaluation Model [12] - [16]. There were four proper areas namely; high, moderate, low and non suitable areas in Chi watershed. The overlay function technique on GIS and Physical Land Evaluation Model analysis of spatial data were used to locate suitable area at different levels from highest to lowest level [16]. Such analysis is beneficial for administrator's decision making and planning to locate and select the most suitable area. In this study, GIS was applied to locate suitable areas for supporting economic crops plantation in Chi watershed, Thailand. Research methods consisted of data layer analysis overlay function technique including union and intersect scheme. Variables then were determined their score via Physical Land Evaluation Model, and validation. The data used for evaluation included [17].

A. Soil Suitability (S)

Chi watershed covers an area about 9,477 sq. km. Soil suitability for crops plantation cover 20, 883 sq. km 67.01 %, as show as follows;

1) Crops plantation for rice 15,239.85 sq. km 72.97%

2) Crops plantation for vegetation 7.79 sq. km 00.04%

3) Crops plantation for agriculture 564.06 sq. km 26.64%

4) Crops plantation for fruit 72.24 sq. km 00.35%. In the Table 1 and was shown area and crops plantation of each Province in Chi watershed.

Table 1. Illustrate area and crops plantation of each province

Province	Area (sq. km.)	Crops plantation (rai)
Kalasin	6,946.746	2,049.166
Khonkean	10,885.991	3,289.273
Chaiyaphom	12,778.300	2,857.984
Nakhon Raschasrima	20,493.964	9,763.268
Maha Sarakham	5,291.683	2,522.035
Yasothon	4,161.664	273.935
Roiet	8,299.449	3,240.000
Loei	11,424.612	2,591.390
Srisaket	8,839.976	3,200.000
Nong Bou Lampu	3,859.086	1,514.183
Udonthani	11,730.302	3,695.807
Ubonraschathani	16,112.650	6,034.170

B. Rainfall (R) and Water (W)

The average rainfall in this area was about 1,200 mm per year (range from 1,000 to 1,600 mm/year). It was known that the amounts of rainfall were obviously influenced by the northeast and southwest monsoons which cause rain in this area during May to October every year. Chi River is mainly of canal in Chi watershed.

C. Landuse (L)

Chi watershed consists of agricultural area 1,163 sq km. The suitable areas are 20,883 sq km. (67.01%). The most suitable area was nearby Chi drainage. The overall suitable area has been 42.21 % of Chi watershed (see in Fig. 2).

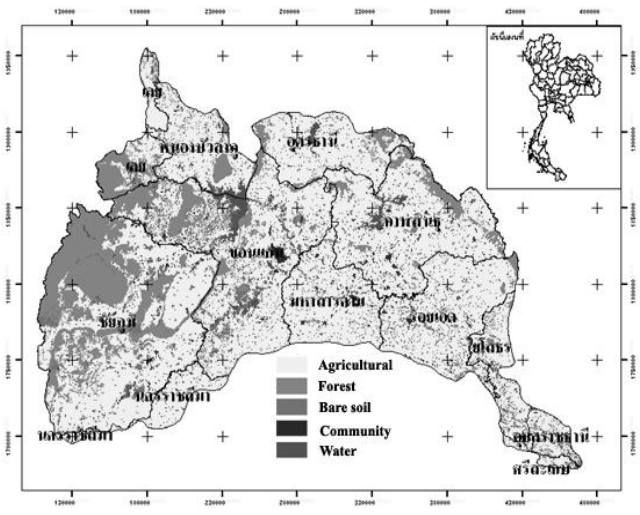
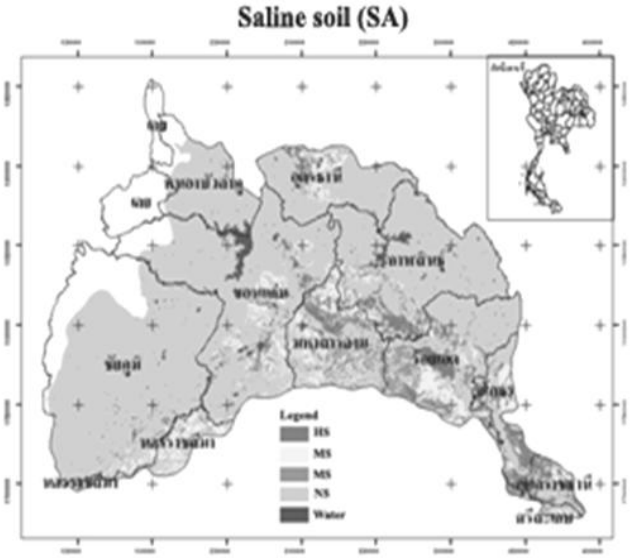


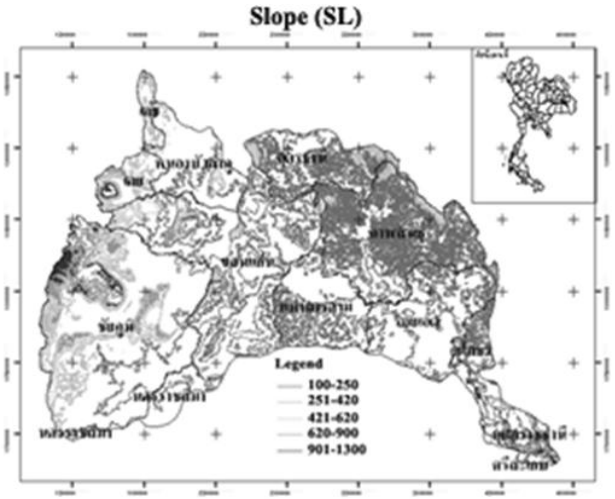
Fig.2. Illustrate Landuse in Chi watershed

D. Saline Soil (SA) and Slope (SL)

The SA and SL in the study area were shown in Fig. 3.



(a)



(b)

Fig.3. (a) Saline soils and (b) slope in Chi watershed

E. Analyzing Process

Commencing the general data from 3.1- 3.4 was separated under knowledge based suitable area as follows;

1) Non suitable is 0
2) Low suitable is 1
3) Moderate suitable is 2 and
4) High suitable is 3

These research methods consisted of data layer analysis, spatial database creation, overlaying technique analysis and validation. Physical Land Evaluation Model of data used for evaluation as follows; Soil (S), Water (W), Rainfall (R), Landuse (L), Salt area (AS), and Slope (SL) were used in this study. All six data layers were analyzed by GIS and overlay analysis and then determined factor scores by using Physical Land Evaluation Model as equation 1.

$$\text{Physical Land Evaluation} = S + W + R + L + SA + SL \quad (1)$$

The suitable areas in Chi watershed for sesame plantation are as follows; High suitable area is located in Khon kaen with the size of 6, 348.12 square kilometers, accounted for 30.11% of total area. This zone is in the middle part of Chi watershed. Moderate suitable area is located in Chaiyaphum with the size of 4,717.99 square kilometers, accounted for 32.24% of total area. This zone is in the west part of Chi watershed. Low suitable area is located in Loei with the size of 427.65 square kilometers, accounted for 36.69% of total area. This zone is in the north part of Chi watershed. Information about suitable areas at different level can be seen in Fig. 4 and Table 2.

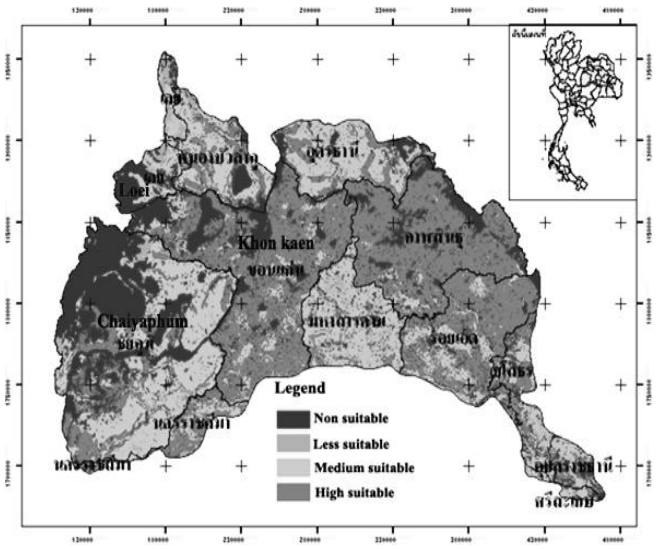


Fig.4. Mapping of suitable areas for sesame plantation

Table 2. Analysis results for suitable area for sesame plantation

Province	Suitable area sq.km.			
	High suitable	Medium suitable	Low suitable	Non suitable
Kalasin	5,252.96	226.90	0.79	1,403.66
Khonkean	6,348.12	1,046.20	1.91	2,462.45
Chaiyaphoom	2,419.18	4,717.99	324.80	5,107.45
Nakhonraschasima	773.86	352.90	0.05	71.33
Mahasarakham	557.92	2,323.50	218.70	350.48
Yasothon	670.90	676.34	48.62	345.58
Roiet	3,180.99	999.10	0.20	576.46
Leoi	30.16	550.04	427.65	795.03
Srisaket	17.58	192.23	2.60	54.77
Nongboulamphu	792.05	1,320.20	110.05	635.68
Udonthani	797.85	1,919.95	18.50	612.73
Ubonraschathani	240.98	306.74	11.46	181.74
Overall area	21,082.55	14,632.09	1,165.33	12,597.36
Overall suitable = 36,879.97				

Suitable areas for economic crops plantation based on GIS and Physical Land Evaluation Model in Chi watershed could be summarized as follows; Suitable areas in Chi watershed for sesame plantation can be categorized into high, moderate and low levels of suitability, with its size of 21,082.55 (42.61%), 14632.09 (29.58%) and 1,165.33 (2.35%) square kilometers, respectively as shown in Table 3.

Table 3: Conclusion suitable area for sesame plantation

Level	Detail	Area	
		Sq. km.	%
1	High suitable for sunflower	21,082.55	42.61
2	Moderate suitable for sesame	14,632.09	29.58
3	Low suitable for sesame	1,165.33	2.350
	Overall suitable for sesame	36,878.97	74.54
4	Forest	9,406.65	19.01
5	Community, Urban	1,930.31	3.900
6	Water	1,260.40	2.550
Overall suitable for Chi watershed		49,47.70	100.0

Moreover, suitable areas at high level for sesame plantation are in the middle and east parts of Chi watershed. Suitable areas at moderate and low levels for sesame plantation are in the north and west parts of Chi watershed. Obviously, the application of Geographic Information System and Physical Land Evaluation Model to collect and store spatial data leads to the understanding of suitable areas for sesame plantation, classification and determination of zones that is suitable to plant sesame. GIS user can understand problems and access information to support the transfer of technology. With GIS, analysis results can show which area has a problem of land misusage. So, alternative measures and plans will be proposed to solve land misusage problems. Such measures and plans will lead to pertinent solutions and sustainable land utilization. Data used to analyze and locate suitable areas for economic crops plantation will be beneficial as factors affecting crop growth and increased productivity. In addition, sesame plantation currently is important oil crops with high demand in Thailand markets. However, there are only few areas for planting these crops in Thailand. In the near future, research is needed to study and collect data about sesame demand by emphasizing factors affecting the quality of sesame oil crop.

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