

Original Research Article

Multiple Criteria Analysis for Site Suitability of Rice Yields in Prachuap Khiri Khan, Thailand

ABSTRACT

Southeast Asian countries takes rice as one of their necessary food intake to survive for a day. With a booming population of the third world countries, the need for higher production of rice was sought as one of the priorities of the countries like Thailand to identify areas which are deemed suitable for rice production. Thailand is one of the prominent exporter of rice in the whole world and it is important that Prachuap Khiri Khan can go with trends of identifying areas for good rice production that would therefore contribute for the economic improvement of its very own districts up to its own country Thailand. This study aims to identify the suitable areas for good rice production in the province of Prachuap Khirikhan. Factors such as slope, aspect, elevation, land use, road proximity, stream network and rainfall were considered to identify the suitable site for good rice yields. The spatial analysis of ArcGIS software was used in the generation of the different maps. Results shows that the southern portion of the province has a very high suitability of rice production, while the Northwestern portion of the province shows the very low suitability of rice production.

Keywords: rice suitability, multiple criteria analysis, rice production.

1. INTRODUCTION

Thailand is a beautiful and a touristic country situated in 15.870032°N and 100.992541°E in Southeast Asia with 68,253,595 (17 March 2017) populations and covering an area of 513,120 square kilometers. The country has mysterious places, beautiful cities, nice beaches, delicious foods, marvelous culture which all of these great characteristics come together and attract millions of tourist's attention to Thailand. According Tourism Authority of Thailand, all international tourists arrivals reaches to 29.8 million in 2015. This has a significant impact on Thailand economy and growth.

Rice production is affected by natural environmental factors such as Climate , topography, soil, agricultural management, agricultural mechanization, and other environmental factors [1].

Rice production can be improved through sustainable agriculture. The sustainable agriculture or farming concept involves producing qualitative products that are environmentally friendly, socially acceptable and cost-effective [2], ensuring efficient agricultural production with maximum use of available natural resources. In order to comply with these principles of sustainable agriculture, one has to grow crops in suitable places and the requirement is to analyze the suitability of the target land [3].

Suitability is the assessment of crop requirements and soil characteristics [4]. Matching the characteristics of the land with the needs of the crop makes it suitable for the desired crop. Therefore, suitability is a measure of how well the characteristics of a land unit match the needs of a particular form of land use. Land suitability should be analyzed in such a way that local needs and conditions are well reflected in the final decision [5].

Prachuap Khiri Khan is a province located in Thailand south of island sharing its boundary with Phetchaburi to the north, Chumphon to the south, the Gulf of Thailand to the east and Myanmar to the west. It is located between 11.82° N and 99.7841° E. There are very good and luring tourist places in the province. Pa Ra-U waterfall, Khao Sam Roi Yot, Suan Son Pradipat national parks, Laem Sala Beach etc. are few of the examples which carry enough potential of the tourism industry. So this research is conducted in Prachuap Khiri Khan Province in Thailand to find out a suitable area for rice production and to do multiple criteria analysis for site suitability of rice yields in Prachuap Khiri Khan Province.

2. LITERATURE REVIEW

Land suitability as defined by FAO is the fitness of a given type of land for a defined use. The land may be considered in its present condition or after improvements. The process of land suitability classification is the appraisal and grouping of land in terms of their suitability for defined uses [6].

Asia is the world's important rice plantation area with approximately 90% of total production harvested in the region. Many countries grow rice mainly to serve domestic consumption, especially China, India and Indonesia. Therefore, the amount of rice traded in the global market is only 8-9% of the total output. As of 2015, the major rice exporters are Thailand with 24% world's rice exports, followed by India (22%), and Vietnam (17%) [7].

A land suitability analysis for rice production conducted by Ayehu et. Al (2015) in the country of Ethiopia states the different levels of agricultural production can be achieved by cultivating rice crop in a highly and moderately suitable areas while for marginally suitable areas for rice crop can be augmented through a practice of diversification of other crops other than rice.

This study used the GIS-based Multi-Criteria Decision Support Approach. Furthermore, soil, climatic conditions and topography were the criteria identified as necessary for the study. And result of this study states that more than 70% of the study area in Ethiopia were found to be highly and moderately suitable for rice production [8].

A study conducted by Samanta et. Al (2011) uses a chemical soil properties and land accessibility as an additional criteria in the analysis of land suitability for rice production. Its results indicates that in

his area of study, Papua New Guinea, four percent (4%) land can be identified as highly suitable while twenty one(21%) percent as only medium high [9].

A study of land suitability for rice production conducted at Kenya also uses the physical and climatic factors of production using a Multi-criteria evaluation & GIS approach. The study was using Pairwise Comparison Matrix in order to derive a suitable area for rice crop [10]. The identification of important attributes for good rice cultivation are the presence of soil experts, soil salinity, texture, organic matter, pH, water quality, rainfall and temperature [11].

A study in Sakon Nakhon Province Thailand about the suitability of rice production states that it uses the data for rainfall, elevation, slope, soil depth, soil texture, soil pH and soil drainage. And it shows that only 1.05% of total area in Sakon Nakhon Province highly suited for rice production [12] [13].

2.1 Ideal road network and political boundary in higher rice yield

Road network refers to the network of motorways, trunk roads and principal roads that serve the country's strategic transport needs [14]. The access to market will be improved by increasing the capacities of rural infrastructure such as storage/warehouses, feeder roads and trading network. . Information on prices and finance will be made available to smallholder farmers. By encouraging formation of farmer based organizations such as cooperatives, linkage between producers and traders will be facilitated [15].

2.2 Ideal water resources in higher rice yield

Water resources is one of the factors to be considered in the selection of site suitability for good rice production in the area. Rice lands need to be a bounded fields or paddy fields to generate good yield [16].

Rice lands needs around 1300-1500 mm amount of water for irrigated rice in Asia. International Rice Research Institute (IRRI) suggested that if in case of water scarcity, the farmers need to apply water saving technology and consider changing planting method from puddled transplanting to non-puddled transplanting.

2.3 Ideal slope and elevation in higher rice yield

Because rice is grown under flooded conditions, it is best produced on land that is nearly level. A slope of less than 1 percent is necessary for adequate water management. Precision grading of fields to a slope of 0.2 foot or less will be important for rice production to allow for uniform depth of flooding [17].

2.4 Ideal soil type in higher rice yield

Rice is a tropical plant that requires sufficient water to grow well. Therefore, the soil used in growing rice should have a good water holding capacity. Silt clay, silt clay loam and clay are some of the soil textures that are best for rice farming. The potential hydrogen (pH) of the soil should be 6 or 7, but rice can also do well in a potential hydrogen pH ranging from 4 to 8. Flat lands are better for rice farming to allow balanced water distribution [18].

2.5 Ideal temperature in higher rice yield

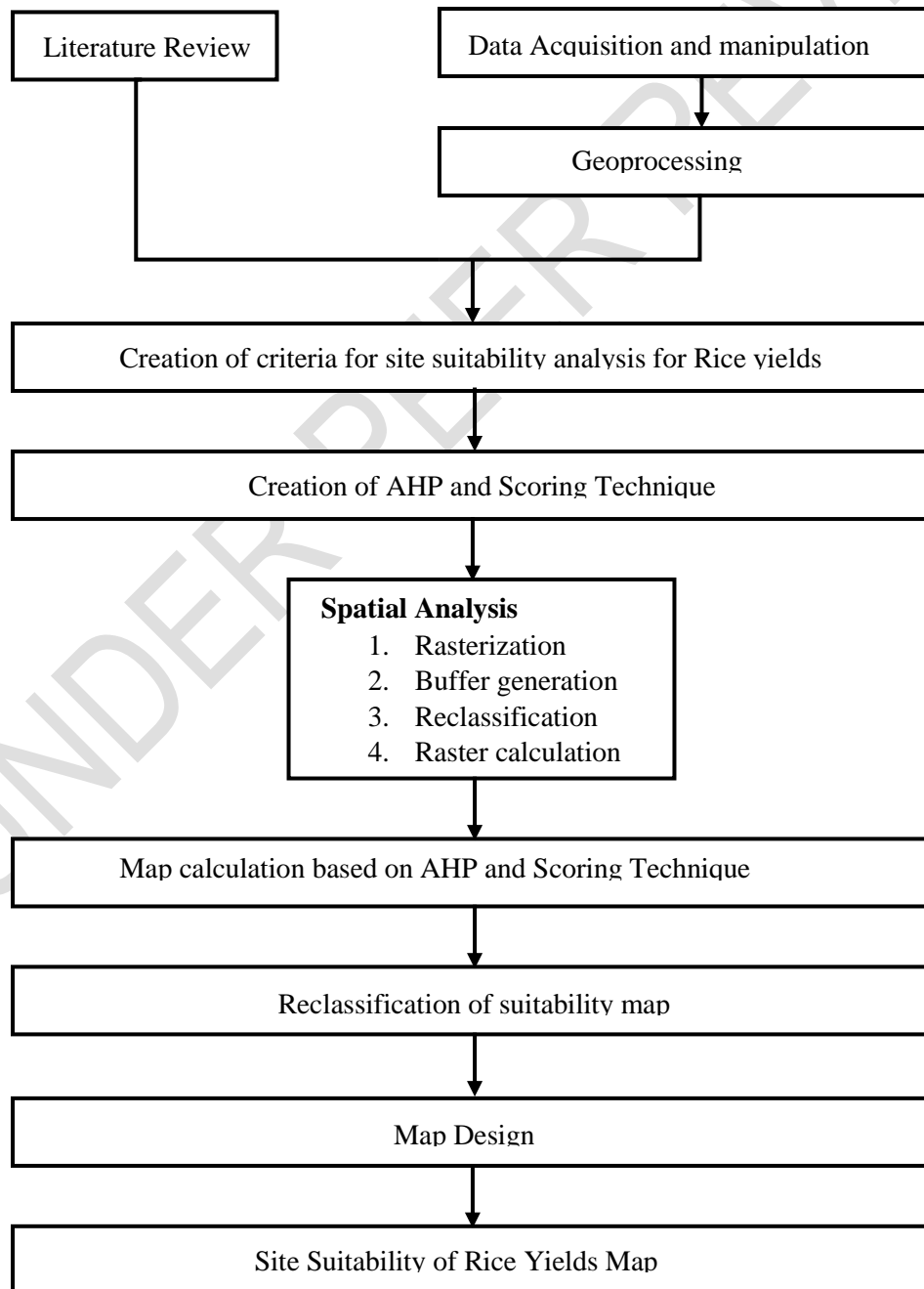
Temperature is another climatic factor which has a favorable and in some cases unfavorable influence on the development, growth and yield of rice. Rice being a tropical and sub-tropical plant, requires a fairly high temperature, ranging from 20° to 40°C. The optimum temperature of 30°C during day time and 20°C during night time seems to be more favorable for the development and growth of rice crop. Rice cultivation is conditioned by temperature parameters at the different phases of growth [19].

2.6 Land Use

Land use refer to a major subdivision of rural land use and are usually considered in and evaluation studies of a qualitative in nature. Land Utilization type is a kind of land use described or defined in a degree of detail greater than that of A major kind of land use. Examples are national park, commercial wheat production on large freehold farms, farming and rain fed annual cropping [20].

3. METHODOLOGY

Geographic information systems (GIS) is a tool to support spatial decision making. GIS provides functionalities to analyze areas suitable for rice cultivation. By starting to support the cultivation of native rice varieties. Therefore, it is very important to build confidence in farmers' decision to grow rice. It resulted in the farmers know the suitability of their area to grow rice and turn to grow more rice in order to increase the rice farming area and increase the yield of rice.



3.1 Factor Determination and Questionnaire Survey

Rice farming requires several factors to get the most profit and cost savings. Hence, before investing on rice farming, it is very necessary to know what the factors that help farmers are. To know the farmer behavior, we develop a questionnaire and conducted survey within community of farmers as representative all farmers. We asked a group of questions: 1) Which factors have resulted in good rice yields? And 2) What are the factors they do not like?

On the basis of the preferences the respondents have provided. Ranking technique was applied to select the positive factors and the risk factors as well as their corresponding weights for the selection of rice farm area.

3.2 Ranking Technique

The data in the questionnaire was divided into two groups: Firstly, places which affect the good yield when they consider doing for a rice farm. Secondly, respondents should answer by selecting ranges from 1 to 5 and from this result is multiplied to the total number of people. For example, the total number of people who are selected in weight 2 for slope is multiplied by 3 then the total number of weight 2 is 6. Next, summation all the total weights in scale and the highest number is the priority to be considered and rank in each group.

Final step is using the ranking method to arrange the order based on priority. There are three methods of Ranking: Rank sum, Rank Reciprocal and Rank Exponential. We used Rank Reciprocal method in this research. The formula of the Rank Reciprocal method is with n criteria, rank r receives the weight $1/r$, its reciprocal value (ranging in value from 0 to 1). Then, we used the result to calculate the weight for finding the suitable area for setting the rice farm.

4. RESULTS AND DISCUSSIONS

4.1 Study Area at a District Level

Prachuap Khiri Khan is a province located in south of island sharing its boundary with Phetchaburi to the north, Chumphon to the south, the Gulf of Thailand to the east and Myanmar to the west. It is located between 11.82° N and 99.7841° E. It has eight provinces as shown in the below figure 1.

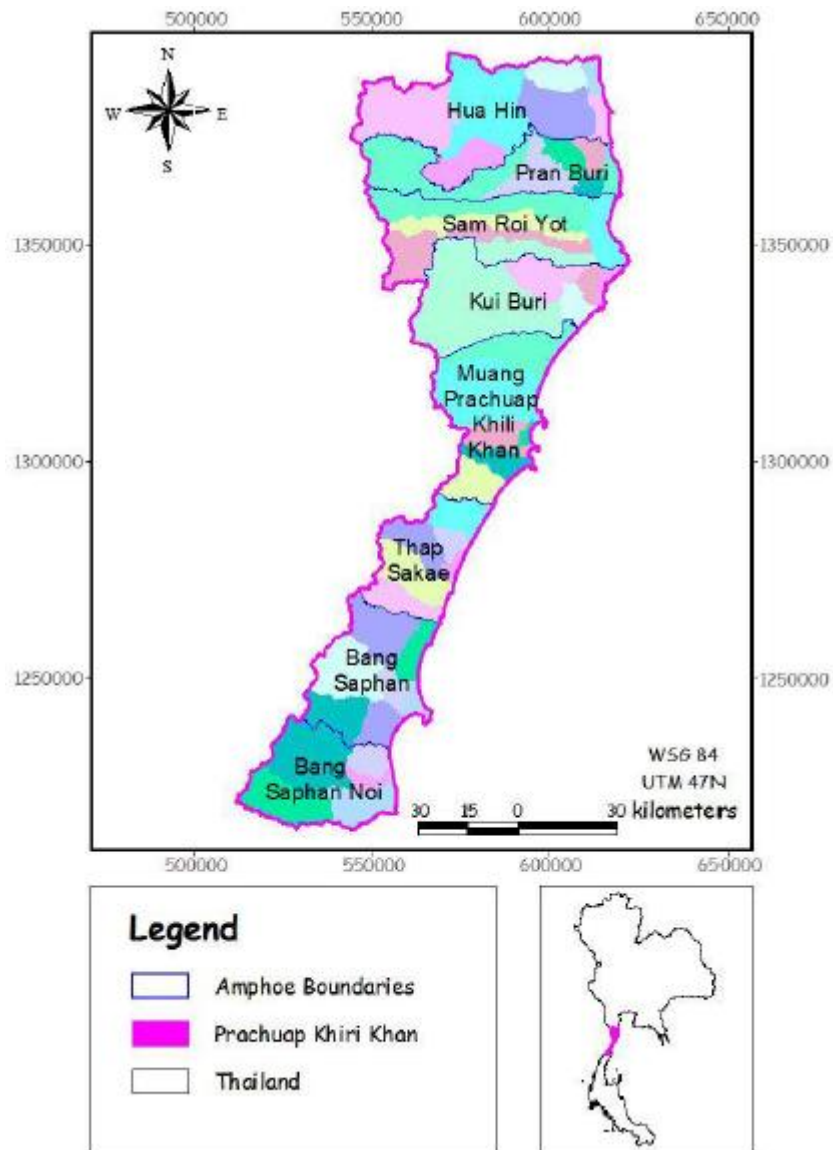


Fig.1. Prachuap Khiri Khan District Level

Table1. Criteria for finding Rice Suitability According to different factors

Criteria	Rank	Ratio scale	Original weight	Normalized weight	Value	Rank	Weight	Normalized Weight
Elevation	4	50	1.667	0.137	200	1	5 0.68	0.046
					201-300	2	4 0.55	0.037
					301-500	3	3 0.41	0.027
					501-700	4	2 0.27	0.018
					701-1300	5	1 0.14	0.009
Slope	7	30	1.000	0.082	0-5	1	5 0.41	0.027
					5.0-10.0	2	4 0.33	0.022
					10.0-15.0	3	3 0.25	0.016
					15.0-30.0	4	2 0.16	0.011
					>30	5	1 0.08	0.005
Aspect	6	35	1.167	0.096	1 to 71.2	1	5 0.48	0.032
					71.2-143.4	2	4 0.38	0.026
					143.4-216.6	3	3 0.29	0.019
					216.6-287.8	4	2 0.19	0.013
					287.8-360	5	1 0.10	0.006
Rainfall	1	80	2.667	0.219	1201-1300	1	5 1.10	0.073
					1101-1200	2	4 0.88	0.058
					1001-1100	3	3 0.66	0.044
					850-1000	4	2 0.44	0.029
					850	5	1 0.22	0.015
Road proximity	5	40	1.333	0.110	<500	1	5 0.55	0.037
					500 - 1000	2	4 0.44	0.029
					1000-1500	3	3 0.33	0.022
					1500-2000	4	2 0.22	0.015
					>2000	5	1 0.11	0.007
Land use	3	60	2.000	0.164	Agriculture	1	5 0.82	0.055
					Forest	2	4 0.66	0.044
					Miscellaneous	3	3 0.49	0.033
					Urban	4	2 0.33	0.022
					Water Bodies	5	1 0.16	0.011

Stream network	2	70	2.333	0.192	100	1	5	0.96	0.064
					200	2	4	0.77	0.051
					300	3	3	0.58	0.038
					400	4	2	0.38	0.026
					500	5	1	0.19	0.013

4.2 Land Use

The following figure 2 shows that more than half of the area in Prachuap Khiri Khan is very high suitable for rice production according to the land use features. There are significantly high areas which can be categorized under high suitability area. But moderate, low suitable and very low suitable areas are significantly very low.

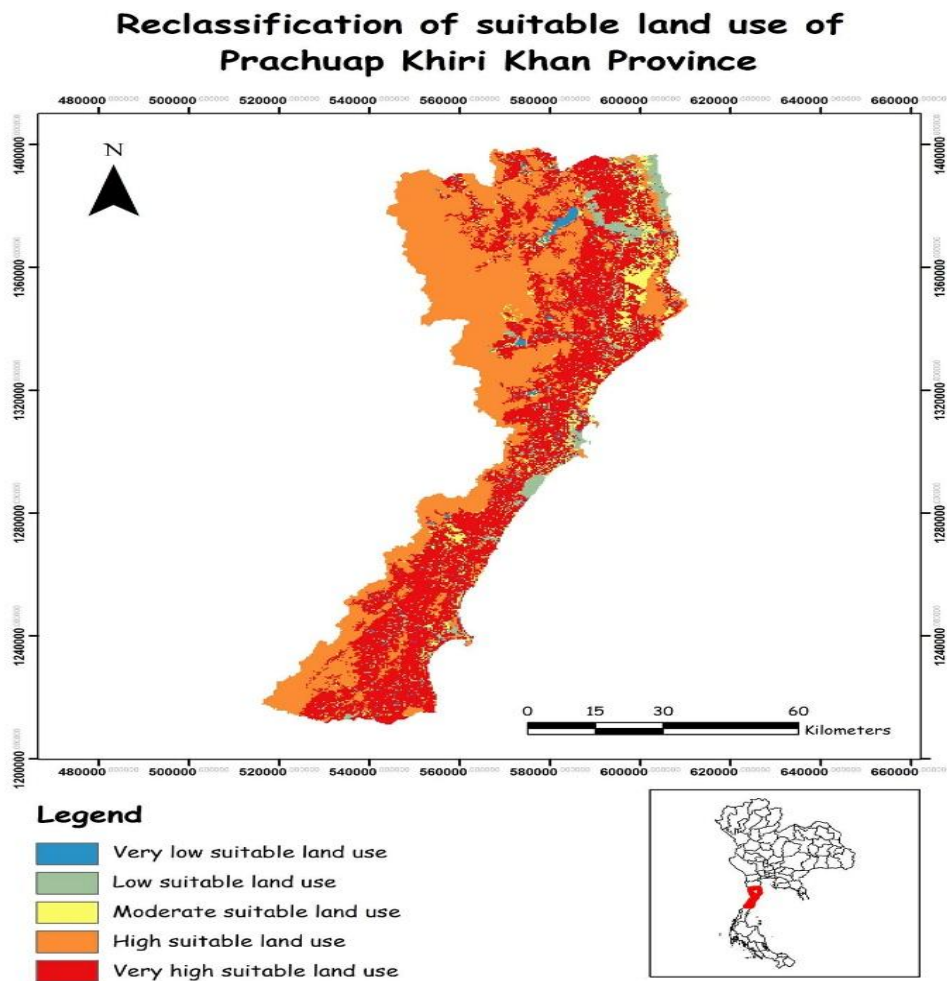


Fig. 2. Suitable Land Use

4.3 Slope

Slope is the rate of maximum change in z-value from each cell. The use of a z-factor is essential for correct slope calculations when the surface z units are expressed in units different from the ground x,y units. The range of values in the output depends on the type of measurement units. For degrees, the range of slope values is 0 to 90. For percent rise, the range is 0 to essentially infinity. A flat surface is 0 percent, a 45 degree surface is 100 percent, and as the surface becomes more vertical, the percent rise becomes increasingly larger.

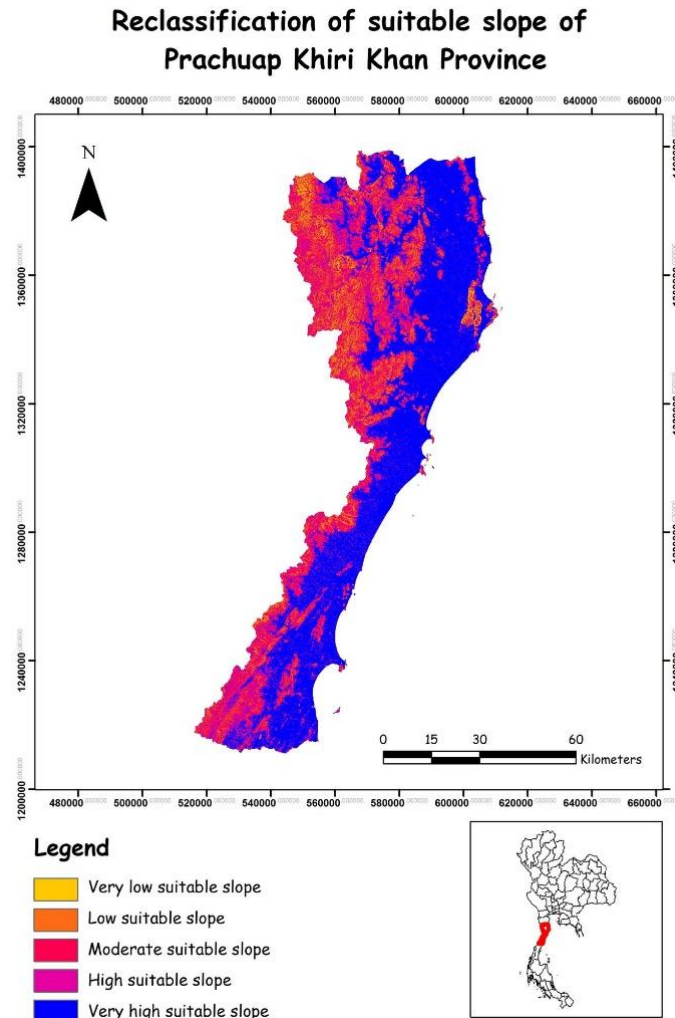


Fig. 3. Suitable Land Slope

4.4 Rainfall

Figure 4 shows accordingly that the rainfall data of the southern part of the province is having very high suitable areas for rice production. Relatively smaller areas are high and moderately high for the rice production. The northern part of the area is low suitable for rice culture.

Reclassification of suitable rainfall of Prachuap Khiri Khan Province

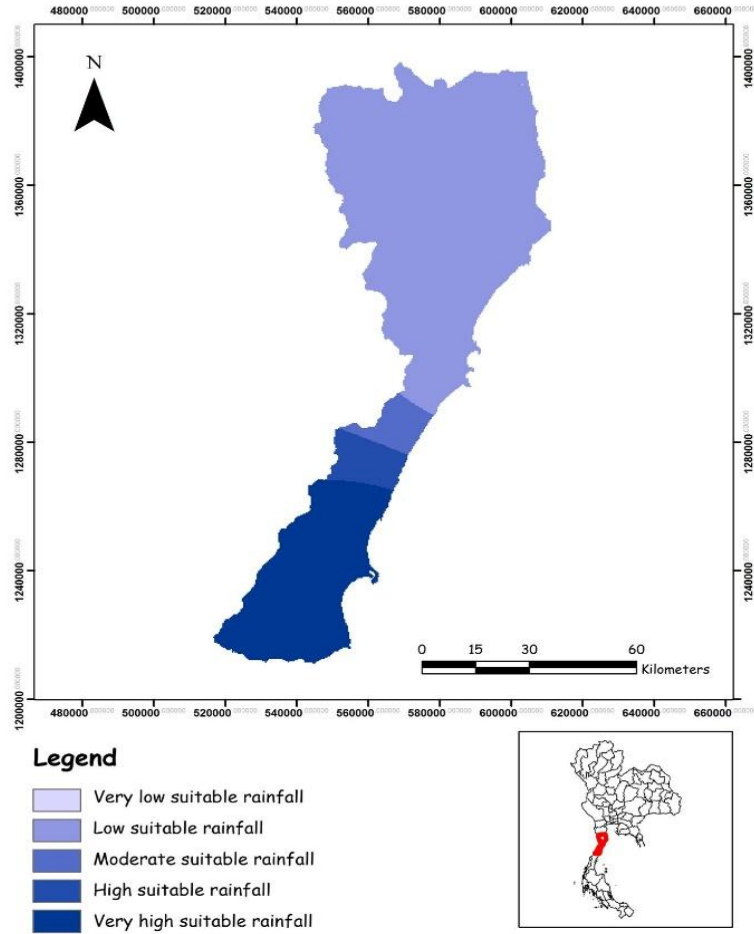


Fig. 4. Suitable Rainfall

4.5 Aspect

This map illustrates that the majority area of the province is very highly suitable or high suitable for rice production according to the aspect.

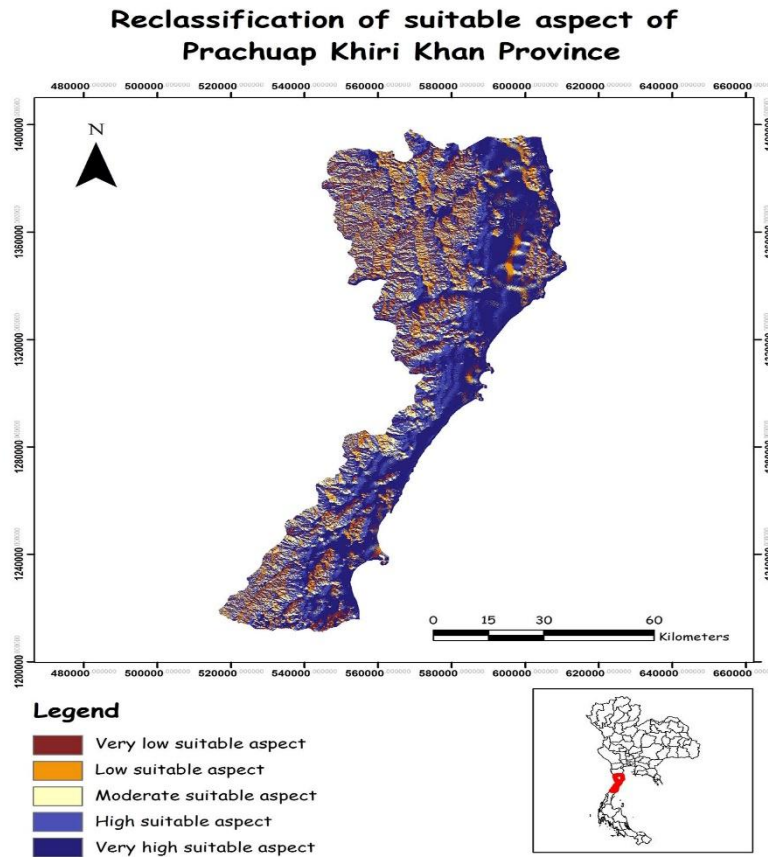


Fig. 5. Suitable Aspect

4.6 Elevation

Elevation is distance above sea level. Elevations are usually measured in meters or feet. They can be shown on maps by contour lines, which connect points with the same elevation; by bands of color; or by numbers giving the exact elevations of particular points on the Earth's surface. Elevation influences climate, as well as where and how people live. Most of the world's people live on coastal plains at elevations of 150 meters (500 feet) or less.

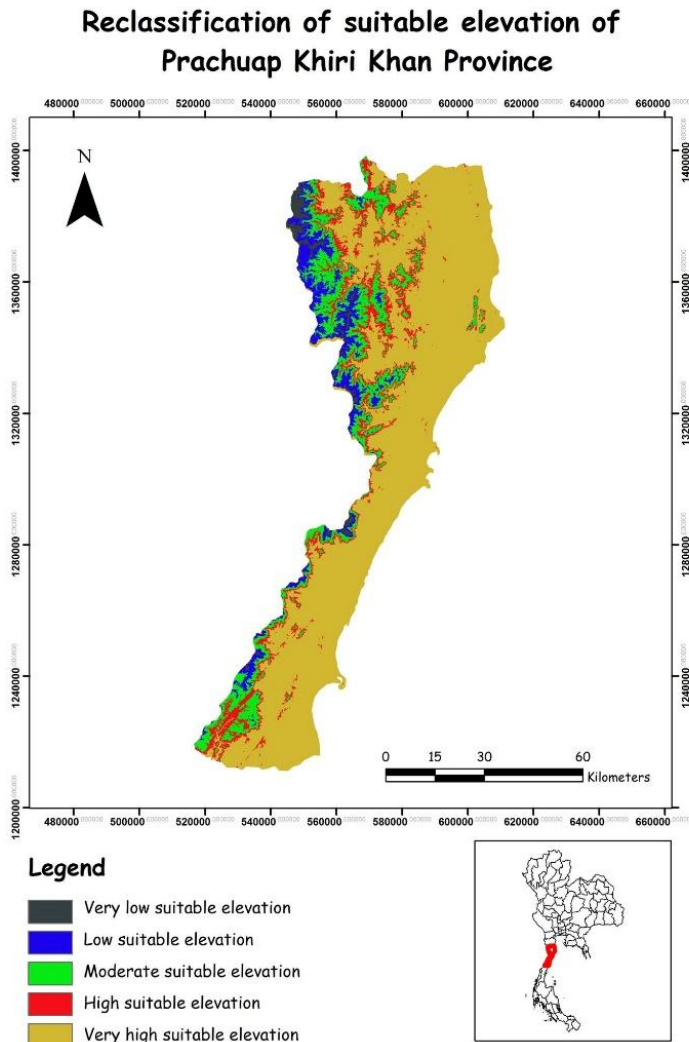


Fig. 6. Suitable Elevation

4.7 Road Proximity

Figure 7 shows the road proximity of suitable rice production. Roads are considered as the backbone for an economy. The color in the following figure 7 shows that high suitable area near the road with color yellow or red.

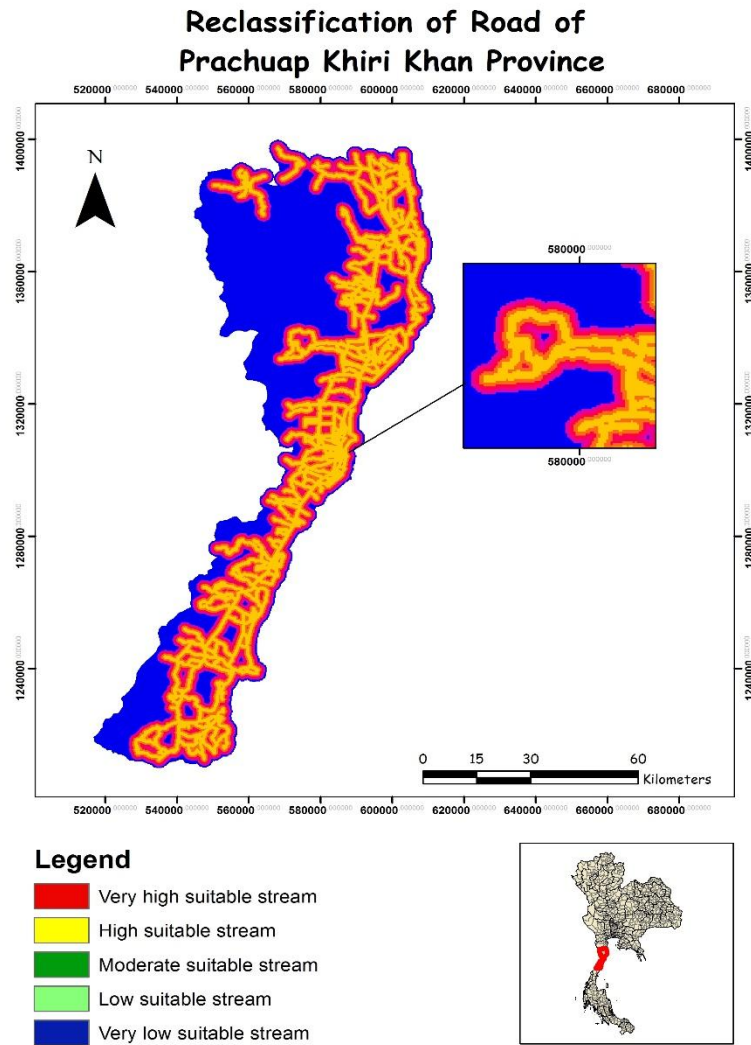


Fig. 7. Suitable Road Proximity

4.8 Stream

Reclassification of stream of Prachuap Khiri Khan Province

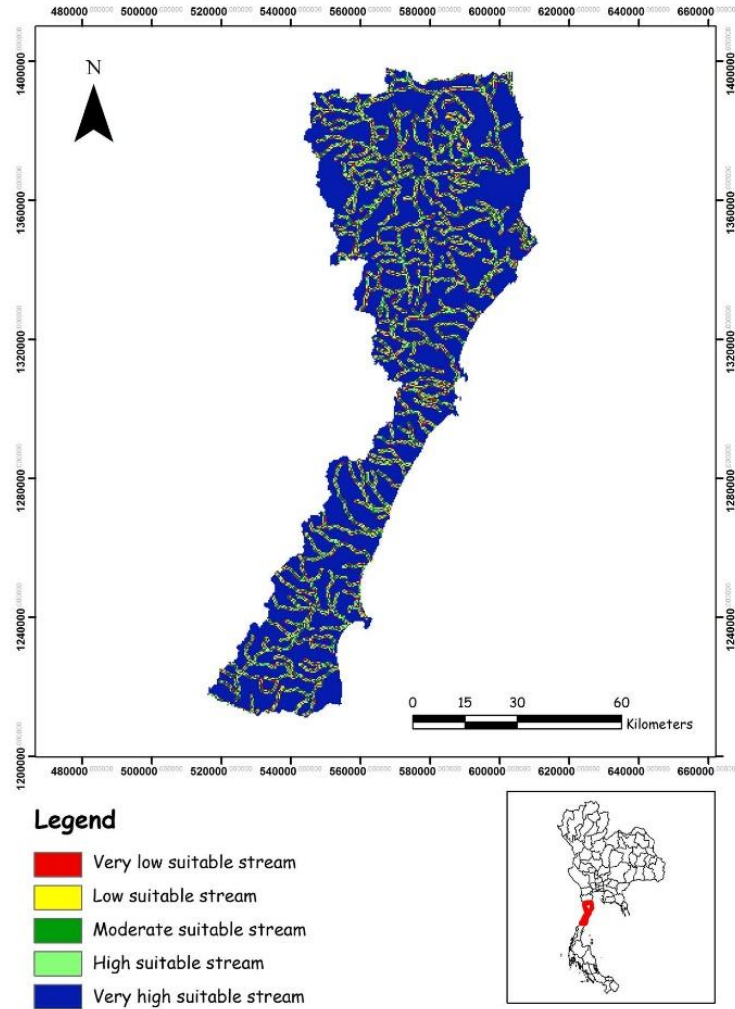


Fig. 8. Suitable Streams

4.9 Rice Suitability in the Prachuap Khirikhan Province

The following figure 9 shows that the southern part of Prachuap Khiri Khan is more suitable for rice production and the Northern part has low suitability.

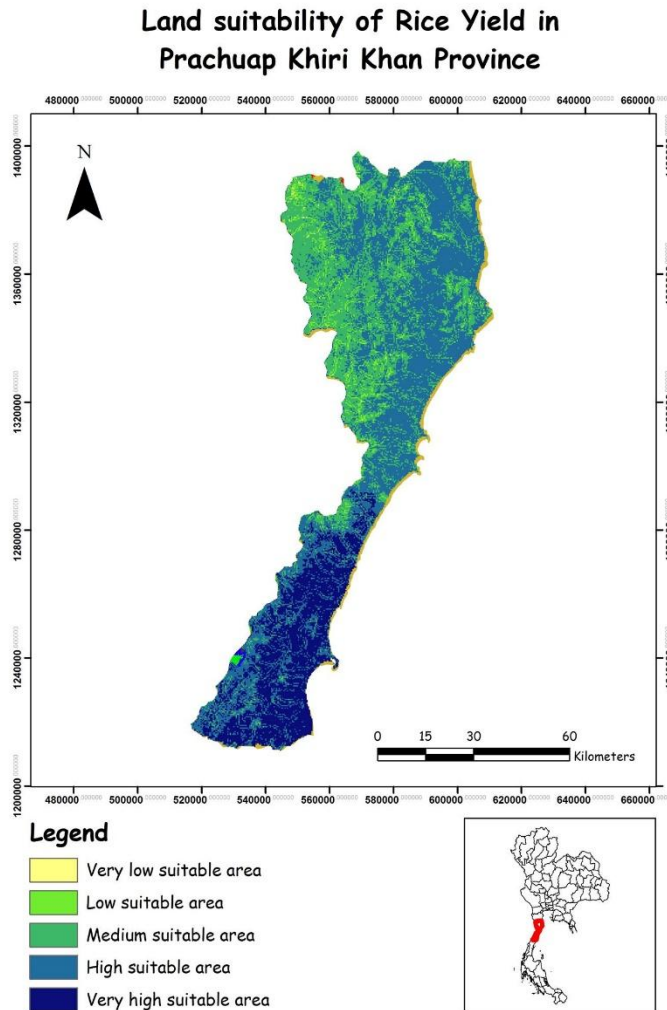


Fig: 9 Suitable Site for Rice Production in the Area

5. CONCLUSION AND RECOMMENDATIONS

The conduct of land suitability for rice production is no easy task. One of the important task to do is gather the primary data for the analysis part. The use of ArcGIS in this research has contributed a lot specially in the mapping and representation of the different data gathered.

The main objective of this research was to find the most suitable area for rice production and to do multiple criteria analysis for site suitability of rice yields in Prachuap Khiri Khan Province. Six factors Such as (Slop, land use, rainfall, stream, elevation, and road were considered to identify suitable area for good rice production in Prachuap Khiri Khan Province, Thailand. This research was able to identify the southern part of Prachuap Khiri Khan Province, Thailand as highly suitable for rice production.

It is then highly recommended that if there are projects for rice productions in the province of Prachuap Khiri Khan, the group suggested that the stakeholders will consider the southern part of Prachuap Khiri Khan to get a good rice yields.

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