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GEOGRAPHICAL INFORMATION SYSTEM BASED MODEL OF LAND SUITABILITY FOR GOOD YIELD OF RICE IN PRACHUAP KHIRI KHAN PROVINCE, THAILAND

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Abstract

Correct assessment of land is a major issue in agricultural sector to use possible capability of any land, to raise cultivation and production of rice. Geographical Information System **(**GIS**)** provides broad techniques for suitable land classifications. This study is GIS based on land suitability analysis for rice farming in Prachuap Khiri Khan Province, Thailand, where the main livelihood of people is rice farming. This analysis was conducted considering the relationship of rice production with various data layers of elevation, slope, soil pH, rainfall, fertilizer use and land use. ArcView GIS 3.2 software is used to consider each layer according to related data. To weigh every coefficient, ranking techniques are used. It was based on determining correlation of rice production and these variables. This analysis showed a positive correlation with these variables in varying degrees depending on the magnitude and quality of these factors. By combining both data layers of GIS and weighted linear combination, various suitable lands have been developed for cultivation of rice. Integrated suitable assessment map and current land were compared to find suitable land in Prachuap Khiri Khan Province of Thailand. As a result of this comparison, we get a land which is suitable for optimum utilization for rice production in Prachuap Khiri Khan Province.

Keywords: Land evaluation, land suitability, rice production, GIS, suitability analysis, ArcView.

1. Introduction

Rice is the staple food of about half of the world population. In most of the Asian countries, it ranks as the main agricultural production. Rice is considered to be highly productive export crop in Thailand, that's why rice is cultivated over more than 60% of cultivated land. Government's new concept has created a tendency of firm expansion in Thailand's farming division (Thailand's Rice Strategy, 2004-2005).

Investors in large numbers are interested to identify the best suitable place for rice production and, in Thailand research is being done in land classification for last two decades. There are two categories of land which are used for classifications:

- Land which is capable for crop,
- Land suitable for production of rice.

Currently, latest technologies like GIS and satellite remote sensing are used for this purpose. By digitally encoding already available maps, spatial database is to be formed (Mongkolsawat et al., 1997; Zhou et al., 2005). The main theme of this study is to create spatial model for determining suitable land for cultivation and production of rice by GIS.

2. Background

As a part of the effort for developing a GIS based land suitability for rice production process in Thailand; Prachuap Khiri Khan province, located in the central part of the Thailand (province code=29), has been selected as the study area for further analysis. This study aims to find suitable land for rice production with respect to related variables through a model.

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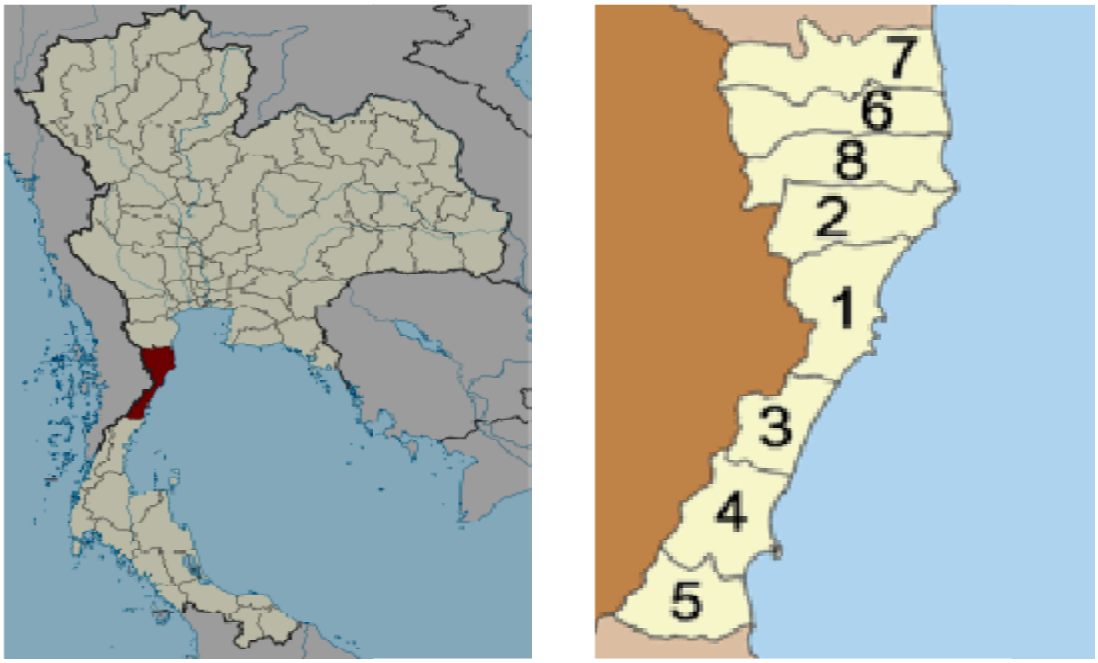
Prachuap Khiri Khan is located in the central part of Thailand and 281 km far away from the Capital. The province has 8 districts and a sub-district. In the north, it touches Phetchaburi, and in South, it connects with Chumporn, in the East is the bay of Thailand and in the West is Mayanmar (Figure 1).



(a) **(b)**

Figure 1: (a) Map of Thailand highlighting Prachuap Khiri Khan province, (b) Districts of the province.

In Prachuap Khiri Khan province, agriculture is the main source of livelihood for the people. They cultivate rice on slope lands, in addition to cultivating lowland paddy in small valleys. Due to increase in population density and/or economic necessity, unused arable lands have already become scarce in many parts of the mountainous area of Prachuap Khiri Khan. However, there is a necessity to determine the land suitability based on a scientific analysis in order to ensure the long-term sustainability of the rice production of the area.

GIS based land suitability model for rice production prepared for the Prachuap Khiri Khan province is basically focused on the relationship of rice yield with various parameters as follows.

- To find relationship between rice yield and elevation,
- To find relationship between rice yield and aspect,
- To find the relationship between rice yield and slope,
- To find relationship between rice yield and use of fertilizer.

The final output is a composite map of favorable lands for good yield of rice in Prachuap Khiri Khan province.

3. Used data layers

Spatial variability of rice production often needs to be evaluated due to different topographic situations, condition of soil and weather situation within a specific region. Topography of the land plays a major role in selecting a land for paddy cultivation. Traditionally, the preference has been given for flat lands as they provide a favorable environment for this high-water-consuming plant. However, increasing demand for the rice has led to use of new methods for cultivation even on higher elevations of the land. In this situation, it is important to concern about the topography parameters such as slope and elevation of the land when selecting a land suitable for rice production. In addition, low inherent nutrient content of the soil that affect for the rice production needs to be

overcome by application of fertilizer. Fertilizer response on rice yield is an important aspect to be considered when identifying the suitable areas for rice production.

Literature Review

Evaluating any land is the process of assessment between type of land and its possible needs and requirements. Land-use planning is the organized valuation of land, options for the use of land and economic situations, so that to choose and accept the best available land option (FAO, 1996).

Mongkolsawat et al. (1997) used Global information system for evaluating land suitability for rice production. They analyzed that by spatial modeling suitability of any land can be determined with better precision, furthermore rice yield can be improved by increasing component of modeling input.

Charuppat (2002) adopted global information system and developed spatial model to assess the best suitable land. He has observed that the proposed system gave effective results for the task.

Samanta et al. (2011) selected Morobe province situated in Papua New Guinea for their study. They used spatial multicultural decision approach. They chose 12 factors as input dataset. They observed that after cross checking the output with Geobook data set, the results were favorable.

Jun et al. (2010) selected the Yellow River Delta to identify the best land resources in the project of Three Network Greening. They combined different factors like type of soil, level of underwater, etc., and based on these factors, they classified the area into eight categories. Based on the results, all the areas which are non-green but suitable for grass and forest are recognized and allotted in proper route. These are then combined with Three Network Greening standards for classification of these lands.

Kuria et al. (2011) evaluated Tana delta as the best suitable place for rice production. They selected the east Tana river for their study. They developed land suitability rating model using ArcGIS building techniques, and from that they classified land in four categories.

Bobade et al. (2010) have identified land suitability centered on soil survey using GIS. They selected Seoni district. They combined both soil site factors and climate conditions for every crop. FCC and NPK can be used for concerning yield response with combined nutrient management for different cropping systems.

Boateng (2005) used Geographical Information System for spatial entry for the best suitable place for rice production focusing on Ghana. He observed that the proportion of very suitable rice production area is twice from middle ripened variety to early ripened variety, and from early ripened variety to very early ripened variety. He found that for very suitable rice production area, the land area enhanced to fifty percent, for middle ripened variety the yield range from eighteen to twenty three percent. The best suitable land for rice production in Ghana is one which has a rice production from twenty six to forty eight percent.

Bhagat et al. (2009) selected different factors for checking land suitability for cereal production, like weather condition, type of soil and land-use, using Geographical Information System in Himachal Pradesh. It was observed by them that over eighty five percent of cultivated land was situated in low hilly subtropical area and middle hilly sub-humid area.

Forkuo and Nketia (2011) developed shared geodatabase for land suitability of citrus, cassava and palm oil. They developed choropleth map for visual understanding of suitable land. They used both ArcGIS and SQL server as a database. Different attributes like slop, pH value, temperature, etc. were selected. They have seen that by map, which they have generated, can be got efficient, effective and useful results.

Mokarram et al. (2007) have selected eight parameters of soil like texture, humidity, CEC, ESP, Gypsum, pH value, $CaCO_3$ and landscape. They used coefficient of Kappa for comparing parametric method and Fuzzy theory and for suggesting better output. They have seen that Fuzzy method has better result.

4. Methodology

After obtaining relevant data layers, the data has been processed using ARC View. Available data were found for central part of Thailand. The technique and methodology is made to assess suitable land for cultivation of rice having certain condition in the central Thailand, since the study

area located in the central part of Thailand. Selected four layers are processed on the base of their exact connection with the evaluation of suitable land for good yield of rice. After identifying the correlation of rice production with elevation, aspect, slope and fertilizer use, suitable land areas for rice production in Prachuap Khiri Khan province according to tambon are identified.

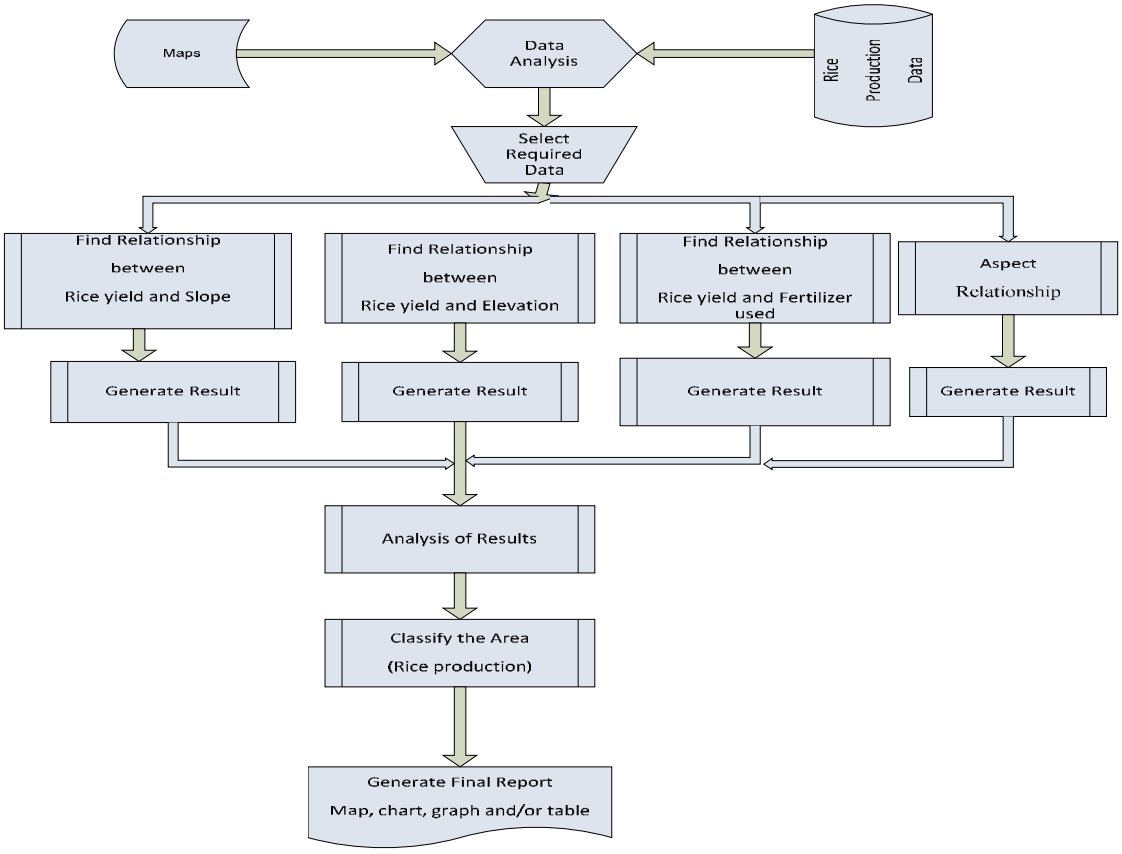


Figure 2. Schematic flow chart of methodology

The division of tambons of required province and other relevant information found in following shape files and dbf files available in folder CENTER.

Table 1. Database related to rice production

Database(.shp)	Description
amphoe	**map of amphoes**
polbndry	**political boundaries of amphoes**
tambon	**tambon map with associated attribute data**
slope	**slope of the area**
elev	**elevation of the area**
soil	**pH of the soil**
land use	**land use of the area**
ricefarm.dbf	**Tambon wise rice production, fertilizer use data**

Methodology used for land suitability analysis for rice production is described below:

4.1 Collection of data

GIS data layers of Prachuap Khiri Khan province are collected source (GIS data directory of RS-GIS lab of AIT). The data layers contain:

- Political boundary (Amphoe and Tambon)
- Elevation
- Slope
- Aspect

4.2 Calculation of relationship between rice yield and other data layers

Relationship between rice yield and slope

The process starts by extracting of the data of Prachuap Khiri Khan from whole Central Data Layers. Separation of Amphoes of the considered

province is simply done by Property Definition of theme in ArcView. To find the tambons in the province, the political boundary coverage (.shp) is intersected with the ampho coverage of Prachuap Khiri Khan (from previous operation). The name of the intersected coverage is provided *Amphoe*. For sub district level, we take the political boundary it will show entire Thailand, for our area of interest we just intersect it, using geoprocessing method with respect to amphoe theme. To get the data of rice yield and use of fertilizer, the table of rice.dbf is joined with attributes of polbndry.shp using common field tam_code.

We summarize the zone between rice yield and elevation, slop, aspect and use of fertilizer and get the graph from which we can easily get the data that which part has what ratio of rice. The grapy that represents the relationship is represented in Figure 3, Figure 4, Figure 5 and Figure 6.

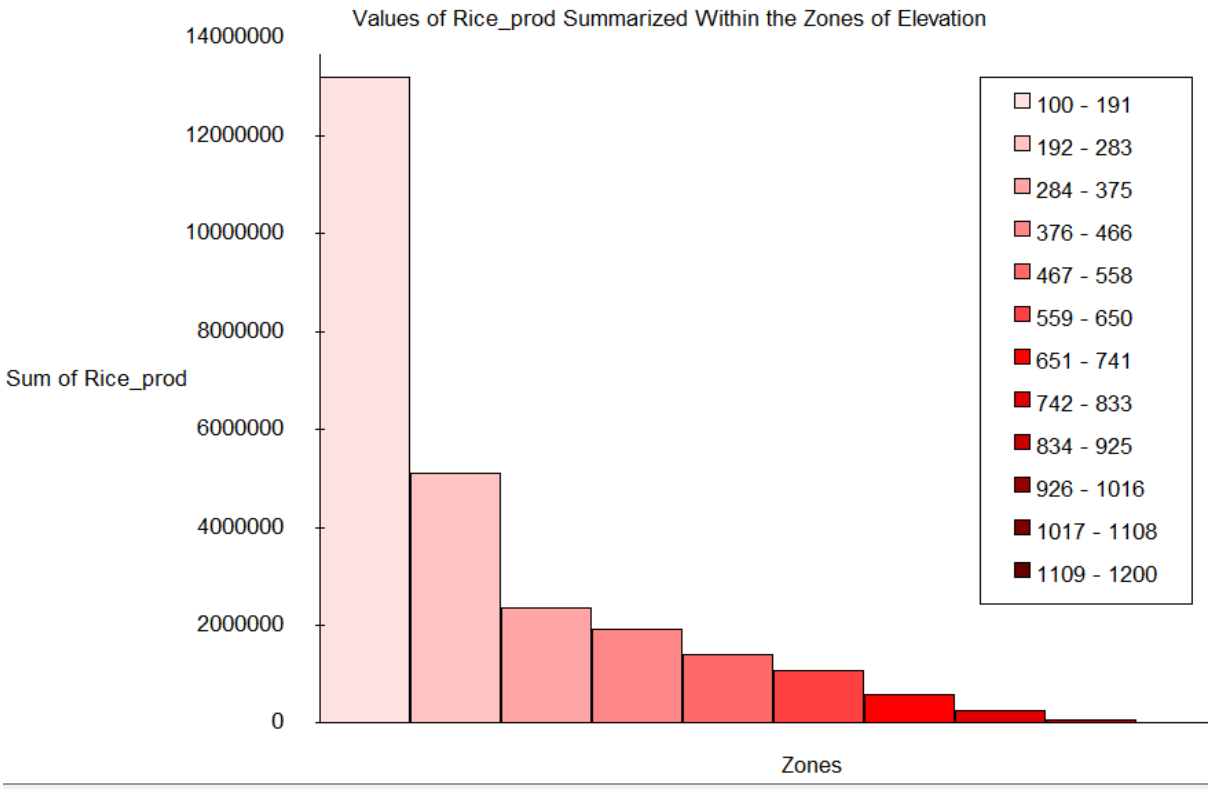


Figure 3. Relationship between rice yield and elevation

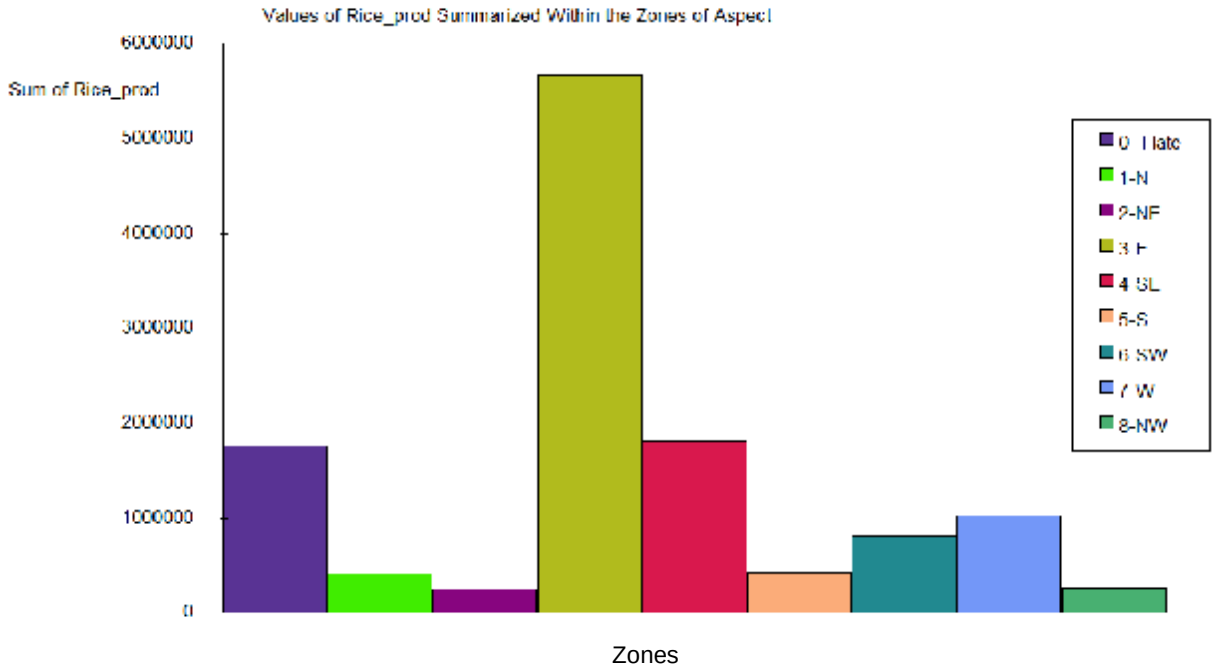


Figure 4. Relationship between rice yield and aspect

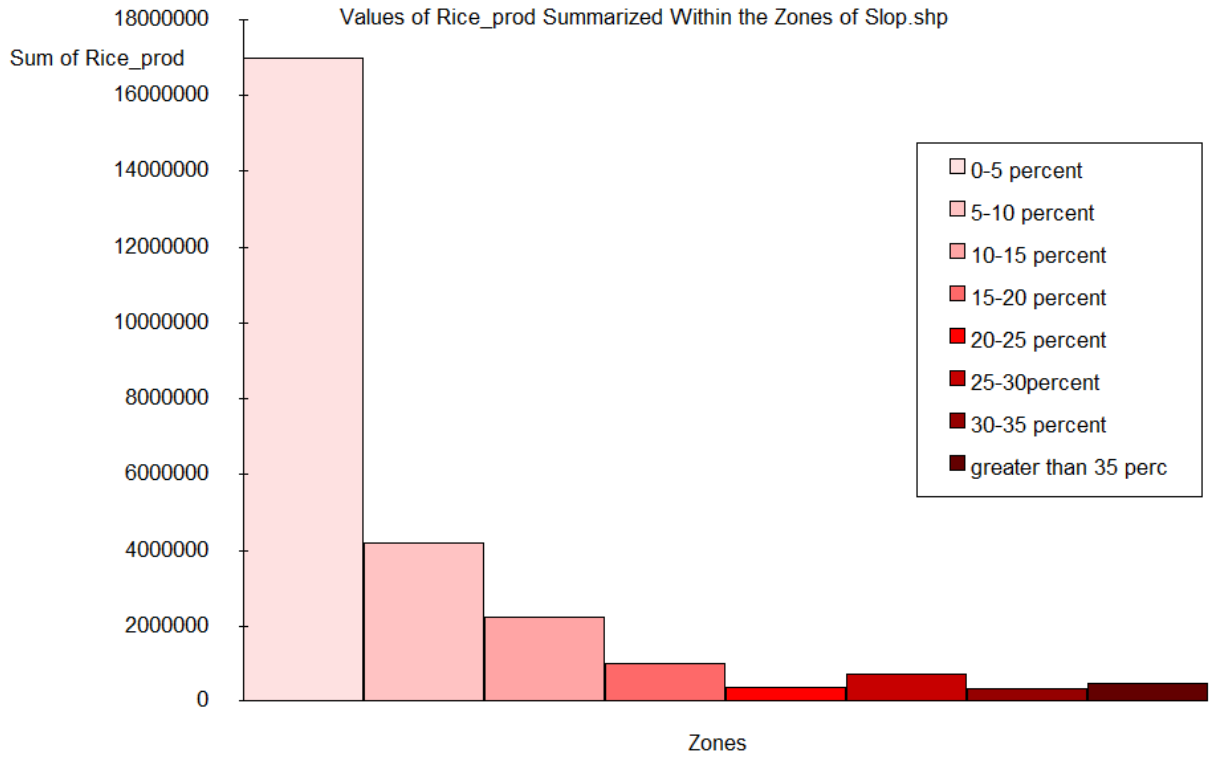


Figure 5. Relationship between rice yield and Slop

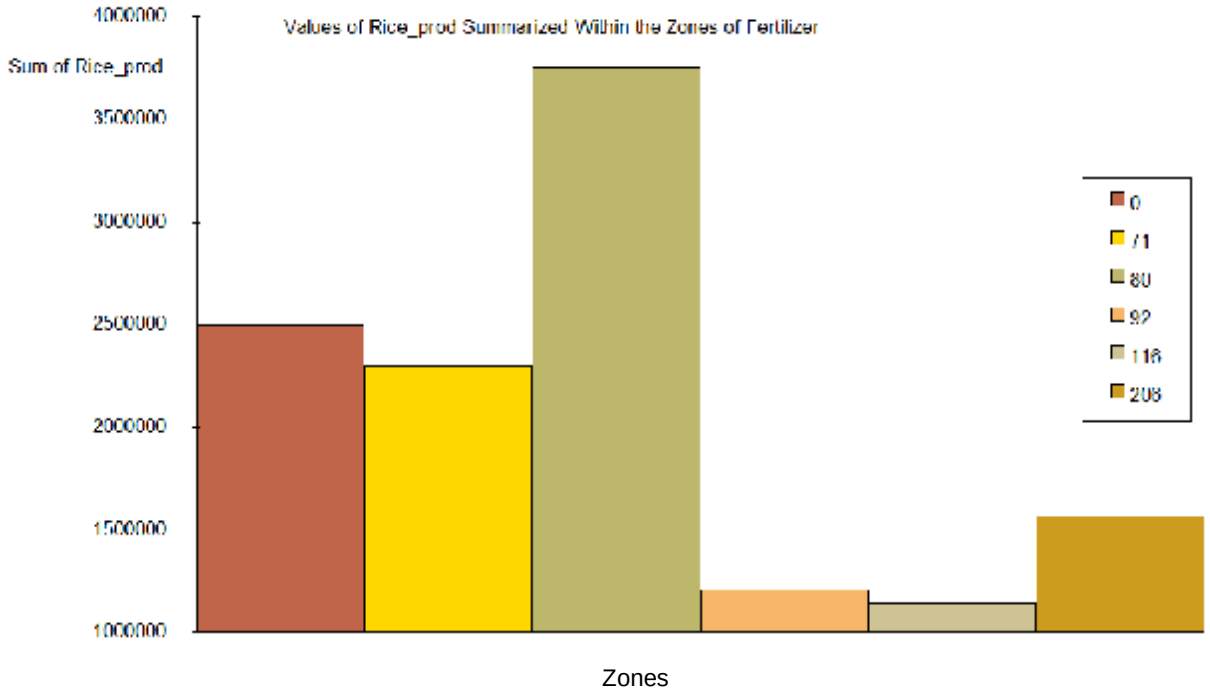


Figure 6. Relationship between rice yield and use of fertilizer

4.3 Findings

To use the map calculator, it is needed to convert the shape file to grid file, for this purpose first convert shape file of slop, elevation, aspect and fertilizer into grid file. From relationship charts of rice and other factors, we can categorize each into following classes.

From rice and elevation, we see that when the elevation is less than 375 then we can get very good rice production, so we classify the grid file of elevation into two portions, i.e. those areas which have elevation less than 375, we put as 1; and the wrest of place is as 0, means suitable and not suitable for rice production.

From rice and aspect chart, we can see that in region 3, i.e. East, very high rice production can be produced, while the area 0 and 4, i.e. flat and in South East, are also good for rice production; so, we classify these three areas as 1, meaning good location for rice production and wrest of the aspects as 0, meaning not suitable for rice production.

From rice and slop chart, we see that if slop is between 0-15%, then it means that there is good rice production so we classify these as 1, meaning good location for rice production and the wrest of the portion as 0, meaning not suitable for rice production.

From rice and Fertilizer, we see that wherever the fertilizer value is 0, 71 and 80, we can get good rice yield, so we classify them as 1, which means good location for rice production and the wrest of the portion as 0, meaning not suitable for rice production.

For model of favorable land for good yield of rice, we can put the following formula in map calculator and we can get the following graph.

[Rice_prod]) and ([Aspect] = 3) or ([Aspect] = 0) or ([Aspect] = 4) and ([Elevation] < 400) and ([Fertilizer] = 80) or ([Fertilizer] = 71) and ([Slop] = 1) or ([Slop] = 2)

Formula for land of good yield of rice

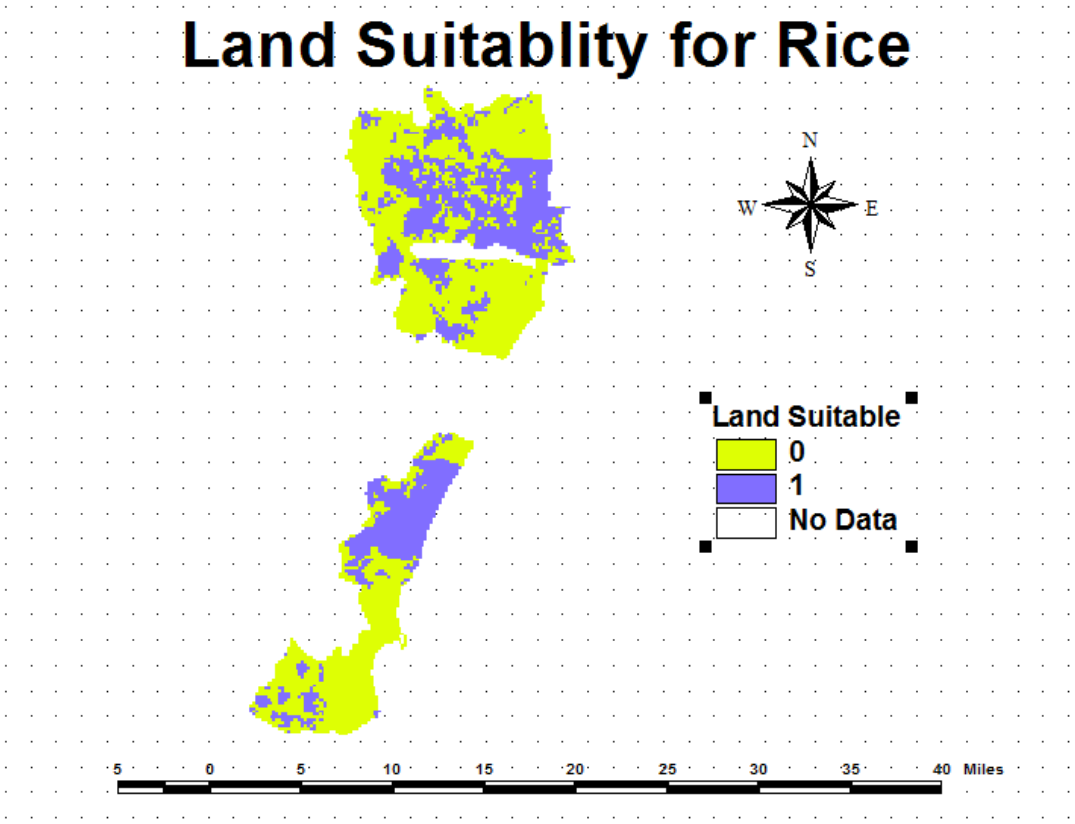


Figure 7. Suitable land for cultivation and production of rice

5. Result

Land suitability for rice production depends on several categories factors. This includes geological factor, climate factor, microclimate, topographic characteristics and socio economic characteristics of the area or piece of land. Thus, such suitability analysis, it is necessary to consider number of variables in a scientific manner to get a meaningful output.

In this case, we have taken 4 variables for the study. Among those, some qualitative data against the variable is found from secondary sources and is transferred into quantitative form and a weight is calculated on the basis of the correlation between the yield of rice and the variables. Finally, the weights are added and classified into 4 classes of suitability for rice production. It is to be mentioned that only those lands which are currently engaged in agricultural production are considered for such suitability analysis.

6. Conclusions

This land suitability analysis gives an idea where should farmers produce rice, so that they can be benefited from that land. It also indicates the required quantity of fertilizer for a particular area. In addition to this, proper set of guidelines is mandatory for the management of nutrients and by contributing by all stakeholders could enhance yield.

In future, we will perform suitability of land for schools and hospitals in rural areas of Pakistan.

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