Land Suitability Assessment Using Remote Sensing And Geographical Information System In Mannargudi Block, South India

S. Baskar, G.Kumar

Abstract : Land suitability assessment is one of the important researches in agricultural practices. The main aim of the present study is to assess the crop land suitability for cultivation in Mannargudi block, Tamil Nadu, India using remote sensing and GIS applications. The land suitability parameters such as slope, land use / land cover, soil, geology, aspect and drainage density were selected. All these parameters determine the suitability of a given area for a particular type of crop cultivation. Further, all the parameters were integrated using weighted overlay analysis is available in ArcGIS software. The final suitability map was prepared and reclassified into five classes like very high suitable (18.28%), highly suitable (52.75%), moderately suitable (21.52), less suitable (6.49%) and not suitable (1.06%) in the study area. The results revealed that about 29.02% of the study area fall under moderately suitable to not suitable for cultivation which is immediate attention need for sustainable agricultural management in the study area.

Index Terms: Land Suitability, Agricultural Crop, Cultivation, Weighted Overlay, South India.

1. INTRODUCTION

When Agriculture is the most vital economic activity of man. It is the main provider of substance for human being in India. The country like India having predominance of agricultural activity along with over population, it is necessary to give more attention to spatial organization of agriculture. Some of the regions agriculturally more developed than other while some are back word. The understanding of existing level of productivity is essential for better planning management and development of the any agricultural region. Many geographers have taken into consideration one or more features of agriculture and tried to regionalize it. Whittelessy (1936) has fixed the various agricultural sections of the world on the following conclusions such as crops, animals, fertility of soil processes, sale of agro products, mechanization the nature of agricultural settlement etc. He fixed thirteen agricultural regions of the world on the basis of the valuation of conclusions from subjective point of view. Kendall (1939) treated it as mathematical problem and he pointed out that the productivity coefficient are concerned only with the yield per acre but not in any way weight according to the volume of production Stamp (1958) applied Kendall's ranking coefficient technique on an international level in order to determine agricultural efficiency of a number of countries as well as some major crops. Enyedi (1964) worked on geographical types of agriculture. He applied new method of crop productivity. Shafi (1960) worked on measurement of agricultural efficiency in Uttar Pradesh by applying the ranking confident method of Kendall tooling eight food crops grown in each. The land has been always a basic factor for growing crops. The term land suitability can be defined in this regard as the ability of a particular type of land to support for a specific use, and the land suitability classification process involves the evaluation and grouping of a particular land area in terms of their suitability for a defined use (Prakash, 2003). Land suitability analysis (LSA) is a method to encounter inherent and potential capabilities (Bandyopadhyay et al., 2009).Crop-land suitability analysis is a prerequisite to achieving optimum utilization of the available land resources for sustainable agricultural production (Perveen et al., 2007).

The amount of cultivated land is limited, and most land has been degraded as irreversibility and become unsuitable for agricultural production in international level (Verheye, 2008). Abdel Rahman et al (2016) stated that the land suitability assessment is land evaluation which usually conducted to determine specific land use for a particular location and identify limiting factors for a particular crop production. Worqlul et al. (2017) assessed land suitability for irrigation for Ethiopia. FAO, (1976) recommended an approach for land suitability evaluation for crops in terms of suitability ratings ranging from highly suitable to not suitable based on climatic and terrain data and soil properties. GIS techniques are also used to construct various criteria maps which are applied in analytical hierarchy process to formulate the site suitability model for agricultural development (Xu et al., 2012). The main objective of the present study is to assess the crop land suitability for cultivation using remote sensing and GIS technology.

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2 STUDY AREA

2.1 Review Stage

Mannargudi is a revenue block of Tiruvarur district. It is irrigated by Cauvery River. Mannargudi block is located at 10.67"N 79.43"E. It has an average elevation of 6 m (Fig.1). The annual average rainfall of the study area is 1188 mm, the annual mean varies from 995 mm to 1646 mm. The density of the population in the study area is about 556 persons per km. This area has tropical monsoon climate. The maximum temperature is about 35.19ºC and the minimum temperature is about 26.39ºC. The river Cauvery and its tributaries are the main sources of water to this block. Development of groundwater in the area is mainly through dug wells, filter points and Tube wells.

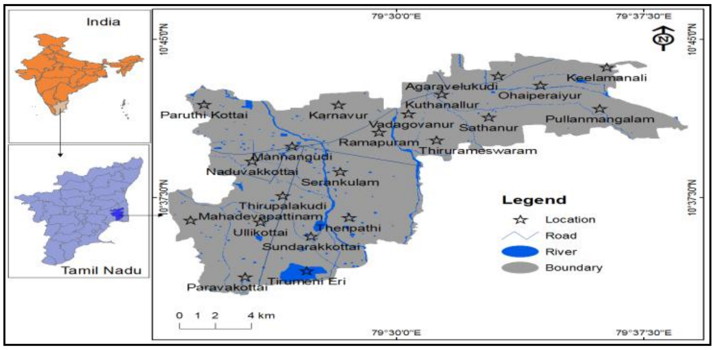


Fig.1 *Location of the study area*

3 METHODOLOGY

In the present study slope, land use / land cover, soil, geology, aspect and drainage density were selected as crop suitability factors for integration of land suitability for agricultural crops. The drainage map was digitized from topographic map in the scale of 1:50000 collected from Survey of India (SOI). The land use / land cover map were digitized from the IRS P6 LISS III satellite data. The slope and aspect maps were generated from SRTM DEM image with 90m resolution. All the themes were integrated using numerical weighted parameter analysis. Geology map were prepared from GSI map. The methodology adopted in the present study is shown in Figure 2.

3.1 Slope

Slope is the important parameter in agricultural practices. It is prepared from STRM satellite data. It is further reclassified into three categories (Fig.3). The 0-1 degree of the slope demonstrates the flat zone which is reasonable land for developing agriculture. 1-2 degree of the slope has some Steepness and is respectably reasonable for growing crop. 2-3 degree range of slope is the higher slope where upon it is not appropriate to develop growing crop because of surface run off of the rainfall water.

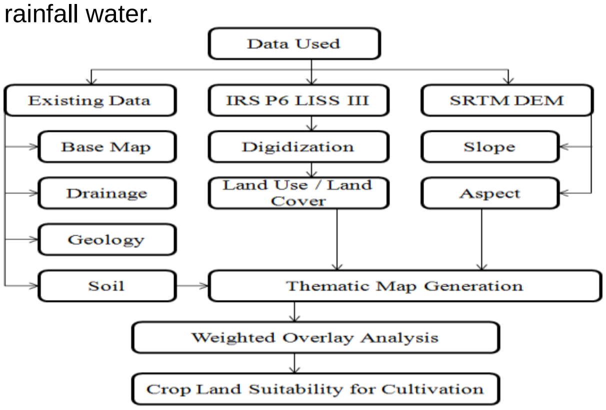
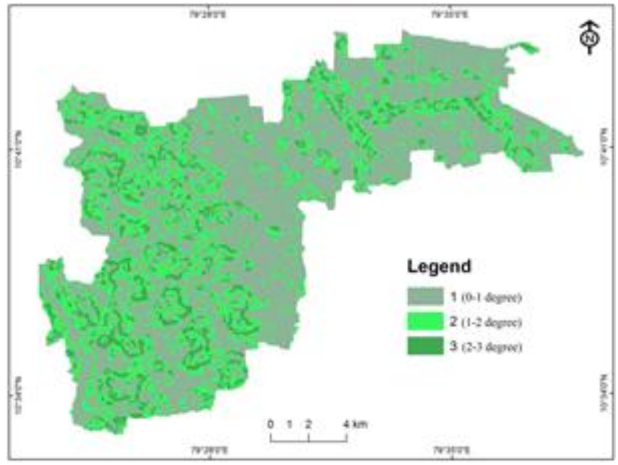


Fig. 2 *Methodology adopted in the present study*



3.2 Land Use/Land Cover

Understand the existing land use pattern in an area is the vital for cultivation. The land use / land cover map was digitized from IRS P6 LISS III data. The featured land use / land cover in the study area is agricultural land, built-up land, fallow land and water bodies (Fig.4). Agricultural land is defined as the land with standing crop as on date of the satellite image. The total contrast of the cropland varies from bright red to red and occupies around 198 sq.km of the study area.

3.3 Soil Order

Soil is the prime important factor in agricultural practices. The good soil is better for best cultivation. The soil order map prepared based on USDA classification as alfisols, inceptisol, vertisol and entisols (Fig.5). Alfisol is most appropriate for agricultural crop. The crops grown are rice, wheat, maize etc. Wheat is the major Rabi crop become both as flooded and rain encouraged conditions. The zone goes under the inceptisol soils. Maize is developed in bring down slope regions of the study area. The reasonable ranges for developing maize happen in patches inside the block.

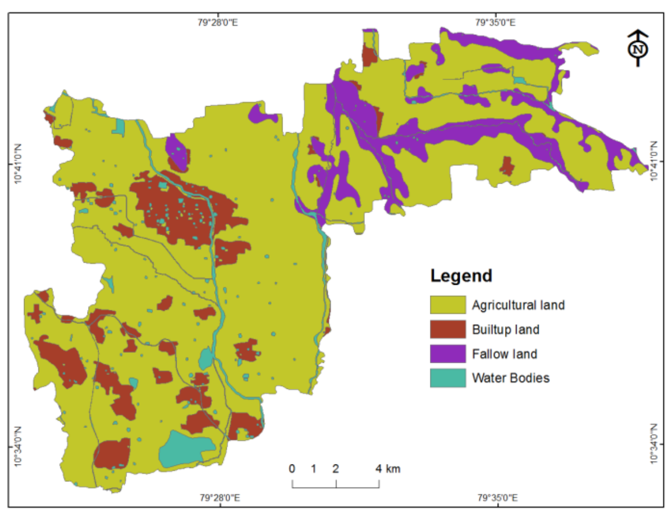


Fig. 4 *Land use / land cover of the study area*

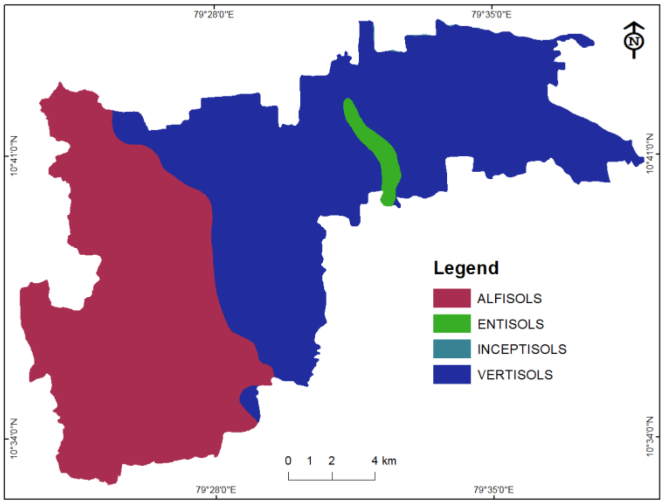


Fig.5 *Soil order in the study area*

3.4 Geology

Geology is the only source for soil formation in long term. Geology map has been prepared and featured geological classes are sand and silt, sandy clay and shale sand stone (Fig.6). The study area is covered by mostly residual soil formed by weathering of bed rocks. The soil in the study area is in general of the residual type derived from the weathering of the sand and silt. The most common rock of widespread occurrence in the study area is shally clays.

3.5 Aspect

The direction a slope faces with respect to the sun (aspect) has a profound influence on vegetation. Farmers seed crops depending on the amount of incoming solar radiation and aspect data. Cultivation of south-facing slopes is critical to successful crop growth. The overall part of the region is mostly in the southwest direction, while the western part of the study area has mainly northwest direction in terms of aspect. The northern part of the study area has essentially has northeast direction (Fig.7).

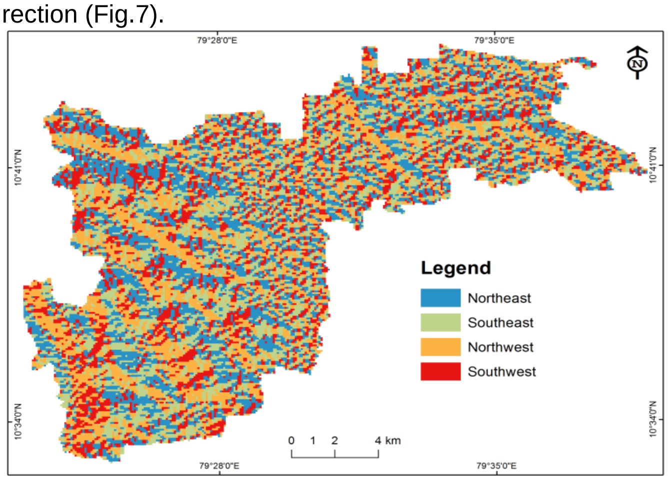


Fig. 6 *Geology of the study area*

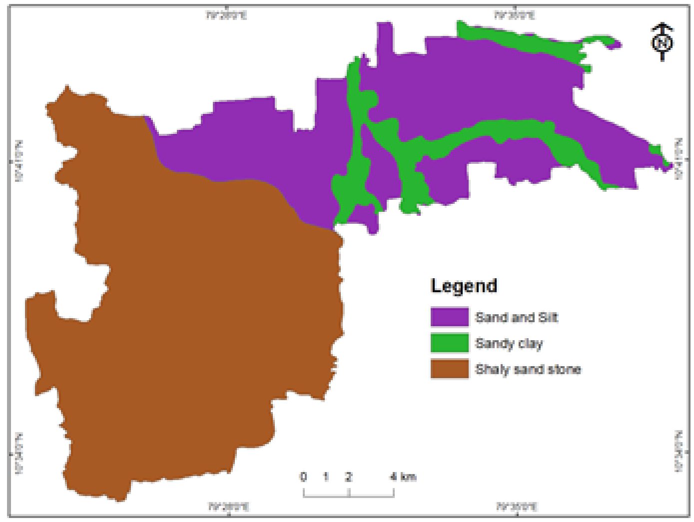


Fig. 7 *Aspect of the study area*

3.6 Drainage Density

Drainage density is one of the important factors for agricultural practices. High drainage density is often related to high sediment yield transport trough river network, high flood peaks, steep hills, low suitability for agriculture. The drainage density map were prepared from drainage and reclassified in to low, moderate and high (Fig.8). Up to 1 km from the river is extremely positive for growing crops in view of the presence of irrigational water.

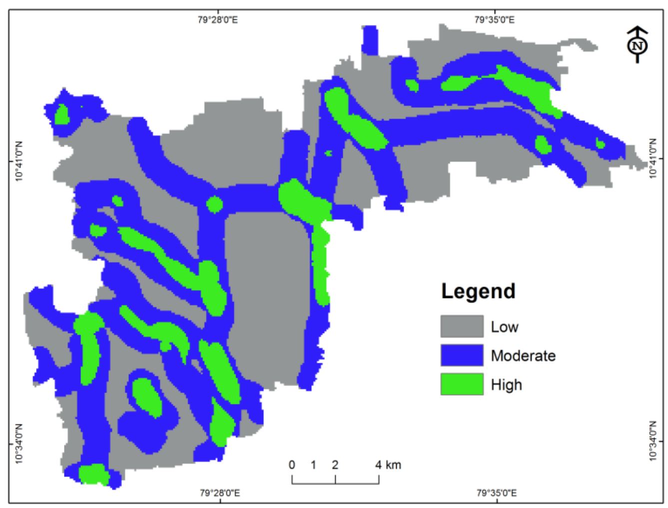


Fig.8 *Soil order in the study area*

3.7 Numerical Weighted Parameter Rating (WPR)

This study performs a GIS Spatial analysis in which models are represented as a set of spatial processes, such as classification, and reclassification and overlay techniques. Each of the input themes is assigned a weight influence based on its importance, and then the result is successively multiplied with their factors. This process is often used in site suitability studies where several factors affect the suitability of a site (ESRI, 2000). The result is summed up producing a site suitability map as shown by the formula;

$$\text{Site Suitability} = \sum [\text{factor map } (C_n) \times \text{weight } (W_n)] \qquad (1)$$

Where, Cn=standardized vector cell,
Wn=weightage based on knowledge

The three thematic layers were integrated with one after the other through GIS using the numerical weighted parameter rating (WPR) and weighted index overlay method (Table 1). The following order of sequence has been adopted to derive the final integrated map.

Slope (I1)+ LULC(I2) = O1 (2)
O1 +Soil order (I3) = O2
O2 +Geology (I4) = O3
O3 +Aspect (I5) = O4
O4 +Drainage Density (I6) = O5

Where, I1, I2… and O1, O2… are the input and output layers respectively. In the first step, slope (I1) and land use / land cover (I2) layers are integrated by the union option. The integrated output layer (O1) comprises polygons of the Soil order layer and polygons of the elevation layer and after union it resulted in new polygons having attributes of both the layers. Adding these two layers derived the weight of each polygon in the integrated layer (O1). In the next step, the O1 layer was intersected with the soil order (I3). In this step, the integrated layer O2 was generated by adding elevation, slope % and geomorphology. These steps utilized to follow by the all thematic layers up to O5. The polygons in the integrated layer (O5) contain the composite detail of all the thematic layers together numerically having maximum weight of 330 and minimum weight of 120 with standard deviation 70.

Table 1 Land suitability themes and weights

Sl. No.	Theme	Classes	Rank	Weight	Score
1	Slope	1	10	15	150
		2	5	15	75
		3	4	15	60
2	LULC	Agricultural land	7	25	175
		Water Bodies	2	25	50
		Fallow land	8	25	200
		Builtup land	1	25	25
3	Soil	Vertisols	5	30	150
		Alfisols	8	30	240
		Inceptisols	4	30	120
		Entisols	3	30	90
4	Geology	Sand and Silt	4	10	40
		Sandy clay	6	10	60
		Shaly sand stone	5	10	50
5	Aspect	Northeast	3	10	30
		Southeast	4	10	40
		Northwest	1	10	10
		southwest	1	10	10
6	Drainage Density	Low	5	10	50
		Moderate	3	10	30
		High	1	10	10

3.8 Composite Suitability Index (CSI)

Grouping of polygons of high ranks of all the thematic layers has helped in delineating the sites that are excellent for urban planning. Based upon the standard deviation, the polygons were grouped into classes suitable for construction of suitability sites. A Composite Suitability Index (CSI) has been calculated for each composite unit by multiplying weights with the rank of each parameter and summing up the values of all the parameters. Categorization of the CSI is achieved by ranging the CSI into five classes.

Class 1 Maximum > CSI >= 4 σ (3)
Class 2 4σ > CSI >= 3 σ
Class 3 3σ > CSI >= 3 σ
Class 4 3σ > CSI >= 2 σ
Class 5 1σ > CSI >= Minimum

Where σ standard deviation

4 RESULTS AND DISCUSSION

The weights assigned are 15, 25, 30, 10, and 10 respectively the final output gives the categories of are under very high suitable, highly suitable, moderately suitable, less suitable and not suitable for cultivation. The Agricultural Crop Land Suitability delineates utilizing weighted overlay analysis (Table 1). The land suitability zones of this study area can be partitioned into five classes, specifically, not suitable, less suitable, moderately suitable, highly suitable, and very high suitable zones (Fig.9). The Not suitable zone cover 2.84 sq. km (1.06%), less suitable zone covers 17.35 sq. km (6.49 %), moderate suitable zone covers 57.26 sq. km (21.42%) High suitable zone covers 141 sq km (52.75 %) and Very high suitable zone covers 48.85 sq km (18.28%) (Table 2). Paddy crop is useful for developing in the highly suitable zone. The oilseed is the better decision to develop in the moderately suitable zone of the study area. In the low suitable region of study area, it is preferable to grow pulses.

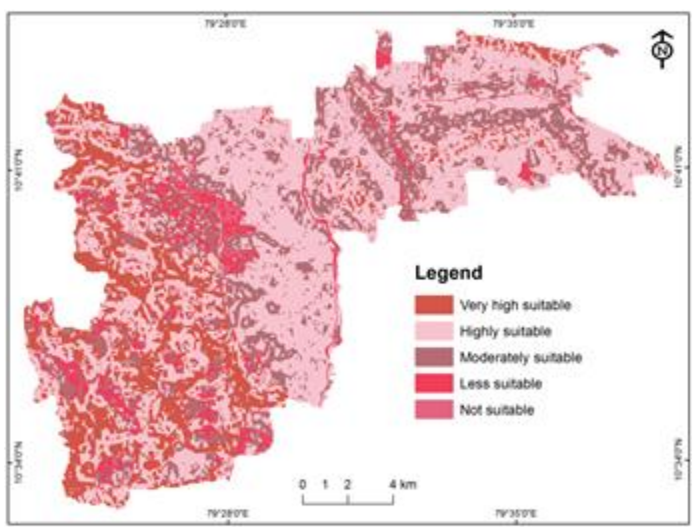


Fig.9 *Crop land suitability for cultivation of the study area*

Table 4.2 Land Suitability Area

Sl.No.	Suitability class	Area (sq.km)	Area %
1	Very high suitable	48.85	18.28
2	Highly suitable	141.00	52.75
3	Moderately suitable	57.26	21.42
4	Less suitable	17.35	6.49
5	Not suitable	2.84	1.06
	Total	267.30	100.00

5 CONCLUSION

The point of this study was primarily focused on the identification of the suitable land for cultivation in the Mannargudi block which is mostly covered by vegetation cover. Geographic information system (GIS) is used for the assessment in which six distinct parameters were chosen. The paddy cultivation indicated that the differences between this decadal changes some significant amount of decreasing trend are notified in paddy cultivation in the study area. Paddy crop is useful for developing in the highly suitable zone. The oilseed is the better decision to develop in the moderately suitable zone of the study area. In the low suitable region of study area, it is preferable to grow pulses. The final suitability map was prepared and reclassified into five classes like very high suitable (18.28%), highly suitable (52.75%), moderately suitable (21.52), less suitable (6.49%) and not suitable (1.06%) in the study area. The results revealed that about 29.02% of the study area fall under moderately suitable to not suitable for cultivation which is immediate attention need for sustainable agricultural management in the study area.

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