ORIGINAL ARTICLE

Integrated GIS and AHP techniques for land suitability assessment of cotton crop in Perambalur District, South India

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Abstract The paper under consideration addresses a combined holistic approach to analyze the process of agricultural land suitability using the structured combination consisting of multicriteria decision analysis technique together with geographical information systems (GIS) methods. Identifying suitable cropland is one of the challenging problems is to improve agricultural land management for efficient use of land resources. Integrating analytical hierarchy process alongside GIS provides additional pliable and precise decisions into the decision-making bodies, that are focused on the evaluation of the effective factors. The connected bio-physical variables related to soil and topographical parameters have been taken into consideration for suitability analysis. The specific objective in this study is to prepare a suitability map concerning cotton (*Gossypium hirsutum* L.) cultivability with a basis on physico-climatic related factors that are considered suitable for production along with identification of the potential areas for expansion and optimization of the production in the Perambalur district of Tamilnadu. The analysis revealed that in the study area, 19.768% (345.2463 km^2) of total cropland is highly suitable, 30% (524 km^2), 16.7% (292 km^2) of the total area were moderately, marginally suitable areas respectively and 9.39% (164 km^2) was under not suitable areas.

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1 Introduction

The primary occupation in India is agriculture, the country's economy is very much dependent on the level of food production of the intensely expanding population. The analysis of Crop-land suitability is necessary and sufficient for a sustainable mode of agriculture crop production. Agricultural resources are considered to be one of the more significant renewable as well as dynamic of all available natural resources. A rise in population and developments in the civilization provided man to settle in a single area and grow crops in the same land this year and subsequent years. The terminology 'suitability' in this context refers to a function based on crop requirements and land factors and is akin to a measure that characterises the features of the land unit to liken the requirements of specific land use (FAO 1976). The process of Suitability analysis will provide the solution to

the query, 'Where to grow what?' Reliability, accuracy, and proper information in time on agricultural resources prove to be highly significant. Land suitability analysis (LSA) happens to be the systematic procedure in finding the aptness of a land area under consideration for the specific type of land use (forest, agricultural land, recreation, etc.). This process can be called as a consolidated function of requirements of a crop, condition of the soil, and characteristics of the land. The aspect of suitability is evaluated with basis on the criteria where the land qualities counterparts the requirements of the crop. Cotton crop is very much a significant commercial crop of India adhering to approximately 64% of the entire domestic fibre consumption. This country is the 3rd most significant producer of cotton in line after the countries China and the United States (US) and is the largest areal spread of cotton, amounting for 24% of world acreage. Yet, India has the lowest mean value of crop yield (286 kg/ha when compared alongside with the global mean value of 567 kg/ha) among the significant cotton growing countries on the globe.

Evaluation of Land suitability per FAO standards was applied in numerous areas of the globe, developing countries in particular (FAO 2013). To find land suitability for a specific agricultural crop shall warrant the involvement of numerous criteria (Abushnaf et al. 2013) such as biophysical elements involving relief (elevation), terrain slope, field drainage, soil properties, nutrient content, atmospheric conditions, vegetative aspects, etc. and this also includes social, ecological and cultural aspects in taking important decisions. In this type of predicament, numerous parameters are considered and each one of the parameters shall be allotted with a weightage per its relative significance with consideration of the optimal growth conditions of crops with the help of MCDA (Perveen et al. 2007). Integrating GIS with MCDA is helpful for land-use planning and management to improve in taking the important decisions by the concerned bodies (Malczewski 1999).

Numerous studies with the usage of GIS along with Multi-criterion Decision Analysis (MCDA) technique methods in order to model the suitability of land problems have been undertaken. There are numerous approaches for determining weight requirements in the MCDA methodology such as weighted averaging (OWA) with the usage of analytic hierarchy process (AHP), Fuzzy AHP (FAHP), weighted linear combination (WLC), and analytic network process (ANP), TOPSIS, etc.

Sarkar et al. (2014) represented results of integrated use of MCDA with GIS technique in land suitability analysis of the rabi crop wheat in the Beko watershed (Purulia, India). Zhang et al. (2015) explored the innate potency of using GIS, fuzzy set, AHP, and integrated approach of these to ascertain suitability of land accurately for producing the tobacco in the province called Shandong in China. Maddahi et al. (2017)

developed a fuzzy approach to AHP methodology in assessing potential land suitability for rice cultivation at Mazandaran Province of Iran. Musakwa (2018) studied the agricultural land suitability for south Africa considering fifteen parameters of Socio-environmental, physical and climatic parameters. AHP methodology has been used to find the weights of each of the various factors. Purnamasari et al. (2019a) used GIS, remote sensing and fuzzy export system in land suitability analysis for producing cassava on a regional scale in the land of Indonesia. Özkan et al. (2019) assessed land suitability in rice cultivation with the usage of multi-criteria decision analysis with basis on fuzzy-AHP and TOPSIS variants in alluvial delta plain called Bafra in Turkey. With regard to that particular study, nine soil criteria were considered for the model development such as texture, pH, Electrical Conductivity, $CaCO_3$, Total Nitrogen, Available Phosphorus, Available Potassium, drainage and Available zinc.

Purnamasari et al. (2019b) studied GIS, remote-sensing and Analytical Hierarchy Process are capable to be utilised in the suitability of land determination pertaining to different criteria with relation to ecologically based conditions to maximize in production cassava on a regional scale in the land of Indonesia. Seyed Mohammedi et al. (2019) assessed land units of maize that were under irrigation using sprinklers with the help of the criteria like soil texture, coarse fragment, soil depth, gypsum, $CaCO_3$, available moisture content, pH, OC, available phosphorus, available potassium, CEC, Electrical Conductivity, ESP, slope, flooding, drainage and climatic variables with the combination of ANP and GIS.

Tashayo et al. (2020) studied the suitability of land for the crop wheat in the saline, calcareous, and soils with Sodicity in Marvdasht Plain situated in the land of southern Iran, using AHP–Fuzzy and GIS. Tercan and Dereli (2020) corroborated the result of citrus cultivation in Turkey using AHP and GIS. In this study, thirteen criterion factors have been considered for LSI development. Wanyama et al. (2019) assessed land suitability for maize cultivation in the country of Kenya by considering three soil parameters and two climatic parameters using geospatial technologies and AHP. Habibie et al. (2021) assessed the land suitability analysis with the help of the multiple criteria consideration and GIS for assuring the sustainability of maize production in Tuban Regency in the land of Indonesia. This manuscript is structured data collection, input layers preparation, determination of parameters weights using AHP and derivation of suitability class and analysis of the results. In the current study, AHP is structurally combined with GIS was applied to evaluate the suitability of the agricultural land for cotton crop cultivation in the Preambular district of Tamilnadu India, using the physical and chemical parameters of soil through the MCDA technique.

2 Study area and data used

2.1 Demography

This study was conducted in the district of Perambalur which is situated in the central region of the state of Tamil Nadu in India.The geographical location of the study area is situated between 10° 53′ and 11° 31′ of Northern latitude and 78° 38′ to 79° 31′ of Eastern longitude. When considering the altogether general physiographical information of this Perambalur district, it consists of hilly ranges, plain lands, deep valleys, undulatory upland regions and disconnected chains of Eastern Ghats viz., Pachamalai hills (Fig. 1).

The study region consists of a typical semi-arid climatic zone with summers that are hot and medium cool winter. The hottest season spans from the month of March to May. In the duration of this period, the highest temperature surpasses 40°C frequently. The district gets rainfall influenced by both north-east and South-west monsoons.

There has been a constant reduction in rainfall as one moves from the northeast to the southwest direction of the district. The normal rainfall in the period (1901–2007) is in the range between 843 and 1123 mm. The district under study typically possesses high humid climate. The wind velocity in the period between June and August is greater than 24.9 km/h, after which there is persistent gradual reduction in the wind velocity, with a base value equal to 7.7 km/h. Rain-fed agriculture, as well as irrigation of crop fields are prevalent in the study region. In major parts of the area under study, cotton cultivation has been carried out along with the Kharif crop like paddy, the perennial sugarcane, hot weather crops like onion, vegetables as well as pulses. Regarding soil distribution, Black cotton, Clayey loam and red sandy soil are the prominent soil variants in the region of study. Fine-textured soil (Soil with significant clayey content) accounts for 16,596 ha (35.38%). Fine loamy soil together combined with moderate clayey content amounts up to 27,188 ha (7.28%). loamy textured soil has areal spread of 1,08,348 ha (29.25%). Sandy soil in texture covers 63,855 ha (17.20%).

2.2 Land use, soil and topography

The land-use/land-cover map of the study area is generated with the help of the Landsat8 (OLI) using a maximum likelihood classification algorithm with five classes (Fig. 2a). The information about soil was collected from the Remote sensing division of Tamil Nadu Agricultural University located in Coimbatore in the land of India. In total, 6 soil characteristics, i.e., texture, soil drainage, water content, pH, consistency, and organic matter content in soil were appended to the polygon attribute data table using the software ArcGIS 10.2 and maps related to various themes were generated for each of the soil characteristics.
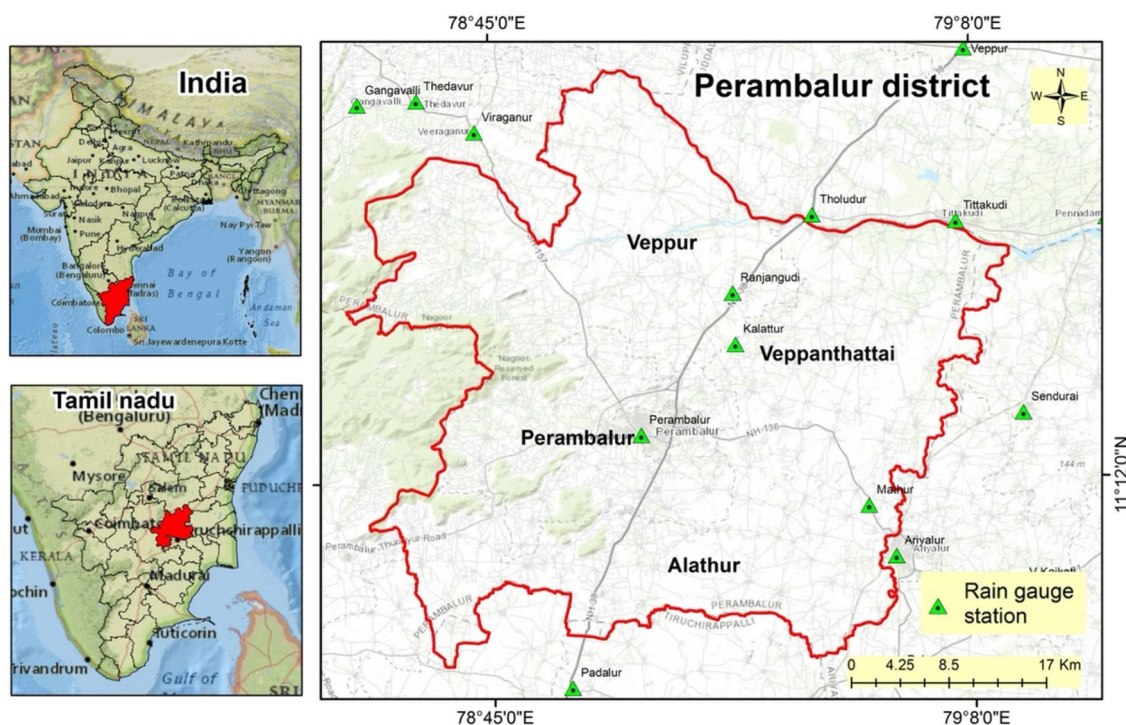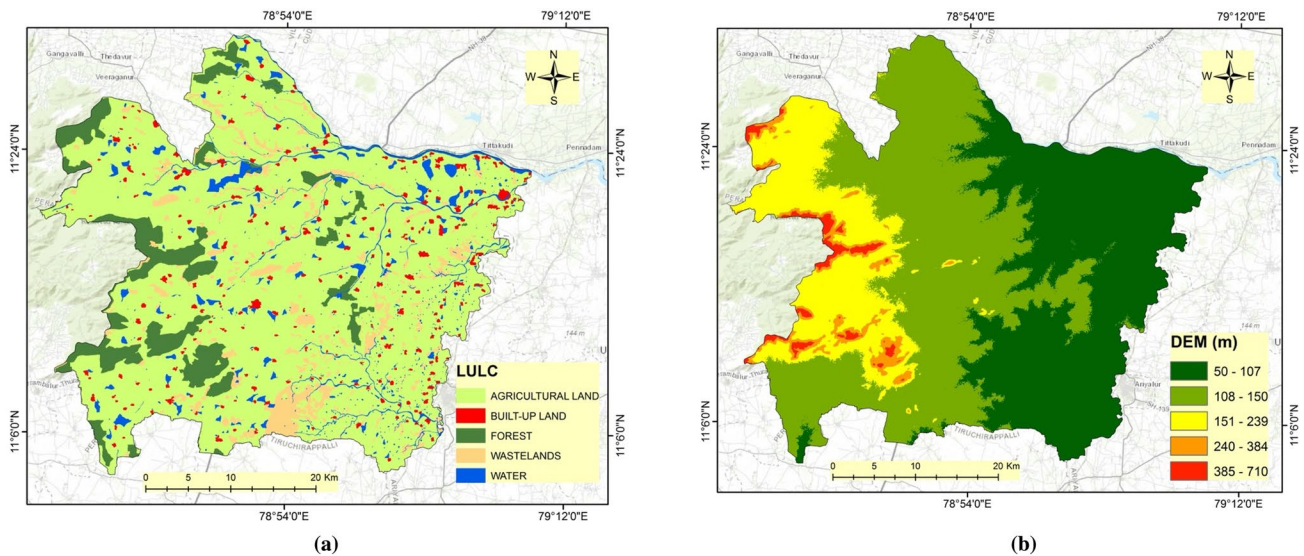

Fig. 1 Location of the study area

Fig. 2 Thematic layers: **a** Landuse and **b** DEM map of the study area

The Universal Transverse Mercator coordinate system has been utilised to identify locations of the geographical elements onto the generated maps. Slope in degrees and type of land information has been procured with the help of Digital Elevation Model (DEM) with the usage of GIS software application, ArcGIS 10.2. The DEM was sourced from SRTM (Shuttle Radar Topographic Mission) with 30 m spatial resolution as shown in Fig. 2b. The holistic flowchart diagram of the part of the methodology that has been followed in the current research study has been depicted in Fig. 3. Table 1 shows Input data and sources used for mapping land suitability.
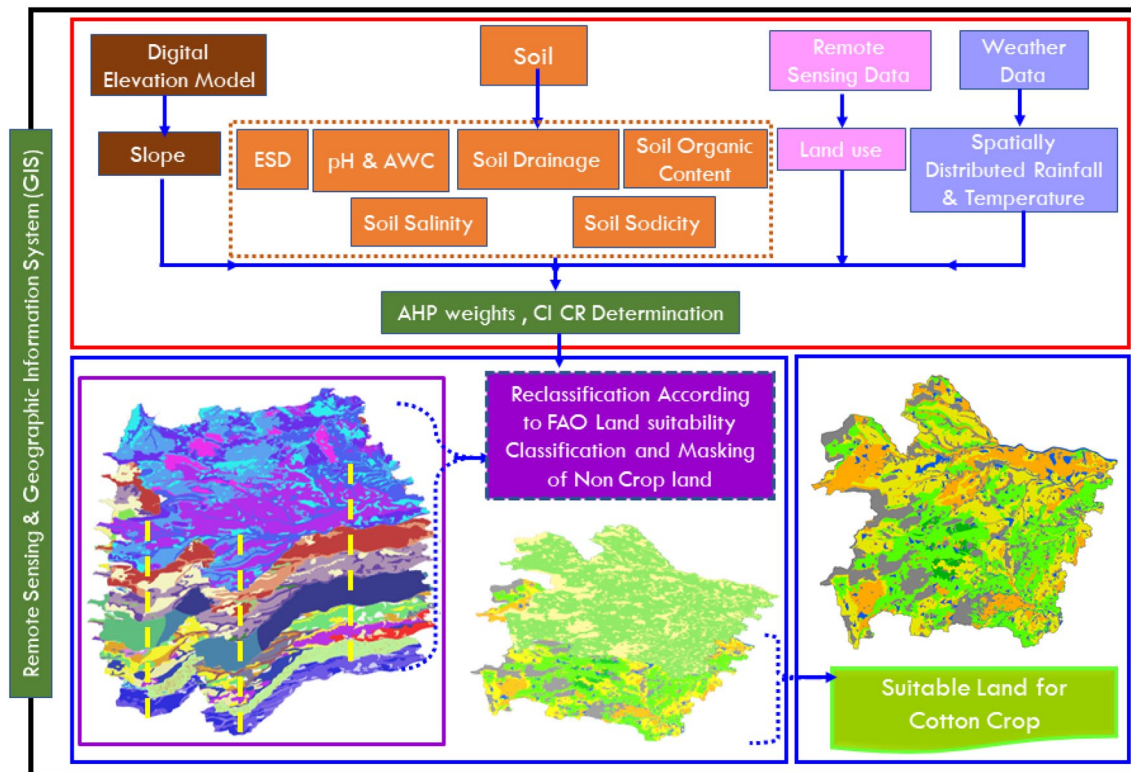
3 Methodology

3.1 Input parameter generation

Eleven criteria have been chosen which includes two climatic factors (temperature, rainfall) and nine soil parameters (soil texture, soil drainage, depth of soil layer, available water content of the soil, electrical conductivity of soil, soil reaction (pH), soil organic content, expandable sodium content), and one topographic parameter (slope of the terrain) as input for the model. The spatial distribution of rainfall and temperature has been prepared from the observed monthly value and interpolated with the Inverse Distance Weighted method (IDW) with a spatial resolution of 30 m cell size. The slope of the terrain was derived from the SRTM DEM of 30 m resolution. The remaining eight soil parameters are derived from a soil map obtained from the TNAU

Coimbatore and converted into a 30 m cell size. Landsat 8 (OLI/TIRS) satellite image was downloaded from earth explorer and classified using supervised image classification with 30 m spatial resolution. This land use/land cover data were further classified for the mask layer by masking reserve forest, urban settlement rock outcrops, and water bodies.

3.2 Analytical hierarchy process (AHP) model

The methodological application of the analytical hierarchy process (AHP) has been formulated and credit goes to (Saaty 1980). This method gives group decision-making, where decision-makers shall utilise their respective experience scientifically and the wisdom to separate a problem into a hierarchical structure to give a solution through the AHP process. AHP also provides for disintegration and pairwise comparison, reduces inconsistent nature, and enables the calculation of priority vectors. In general, the AHP model includes six steps: (1) define the structure-less problem together with objectives/aims; (2) Finding of the wholesome criteria and alternate variables; (3) applying comparisons done pair-wise in order to prepare the matrix of comparison; (4) utilisation of the eigenvalue method to find the relative weights of the factors affecting the decision making; (5) computation of consistency index of each of the different matrices; and (6) finally obtain a holistic rating for the alternates (by integrating the weighted factors affecting decision making). So as to find the weight of each factor of conditioning, questionnaires of comparisons rating with basis on Saaty's 1–9 scale depicted in Table 2 were prepared and filled out by several experts (agriculture/soil scientist, farmers, etc.) residing within the study area (Table 1).

Fig. 3 Overall methodology followed in generating suitability map of Cotton crop

Table 1 Input data and sources used for mapping land suitability

Characteristic	Data source	Processing method
Rainfall	Tamil Nadu Public Work Department (TN_PWD)	Interpolation Inverse Distance Weightage (IDW) Method ArcGIS10.2
Temperature	Tamil Nadu Public Work Department (TN_PWD)	Interpolation IDW ArcGIS10.2
Digital Soil Map	Tamil Nadu Agriculture University, Coimbatore	Derived ESP, OCR, Using Surface in Spatial Analyst Tool ArcGIS10.2
Topographical Aspect	(SRTM)- Digital Elevation Model (DEM) Satellite Data	Surface component in Spatial Analyst Tool ArcGIS10.2 was used to derive Slope (in degrees)
Land use map	Landsat 8 (OLI/TIRS)	Supervised image classification

Inconsequent to the above, the entire land suitability factors are in comparison concerning each other in a pairwise comparison matrix. With the usage of Expert Choice software Choice, E. (1995). it determined the normalized weights for factors to condition (priorities among alternatives) and to testify for the consistency ratio (CR). The equation below is utilized to determine the CR:

$$CR = \frac{CI}{RI} \qquad (1)$$

where RI is called to be the randomised index depicted in Table 3, the value of which depends upon the matrix order,

and CI is called to be the consistency index that has been acquired as:

$$CI = \frac{\lambda \max - n}{n - 1} \qquad (2)$$

where λ is the highest eigenvalue of the matrix which could be found readily from the aforementioned matrix, n denotes the numeric value of the number of thematic map layers. As per Perveen et al. (2007), Malezewski (1999), Saaty (1980) the consistency ratio (CR) must and should be less than 0.10.

Table 2 Basic scale for pairwise comparison matrix per Saaty (1980)

Intensities of importance	Definition	Explanation
1	Identical significance	Two criteria enrich identically to the objective criteria
3	Less significance of one over another	Judgements as well as experience don't strongly favor one criterion with respect to another
5	Strong or essential significance	Judgements and also the experience largely favour
7	Established importance	One of the criteria is largely favoured and its dominant effect has beenproved and is in practice
9	Absolute or high importance	evidence favouring one criterion with respect to another is of the highest probable order of Confirmation
2,4,6,8	Intermediary values among the two adjacent importance or judgements	When adjustment is needed
Reciprocals	In case criterion i possesses one of the above values assigned to it and when compared with criteria j, thereafter j has the reciprocal value after comparison with i	

Table 3 Random inconsistency index values (RI) for n = 11

N	1	2	3	4	5	6	7	8	9	10	11
RI	0	0	0.57	0.91	1.13	1.25	1.31	1.40	1.45	1.48	1.51

3.3 Criteria selection and criterion maps derivation

In the current study, the factor maps have been ranked per Saaty's underlying scale (Saaty 1980) withnumerical1 to 9 as presented inTable 2. The questionnaires related to comparison ratings on the Saaty's scale was made and completed by experts (Agriculturist as well as soil scientist) from Tamilnadu, to find the weight attributed to each thematic layer. Subsequently, the entire thematic layers are made to compare to others in the pairwise comparison matrix. The methodology employed in this study has been illustrated in this Fig. 3.

In the reclassification process, the entire criteria maps have been standardized into four categories (unsuitable (N), marginally suitable (S_3), moderately suitable (S_2) and highly suitable (S_1)) with values that range starting with 1 ending with 4, in which, 1 denotes S1, which indicates the area that is worthier for the cultivation of Cotton crop and 4 indicates N that denotes the land unit is unworthy for growth of cotton crop and some different crops shall be grown. Each criterion is individually analysed for its suitability in helping the cultivation of cotton crop with basis of the FAO requirement of crop suggested by Walke et al. (2012) for cotton with the usage of the parameters shown in Table 4.

All the layers are classified based on Table 4, and four composite layers are constructed using factor weight calculated from the Pairwise Comparison Matrix. The final land suitability (LS) layer for the cotton is prepared by the linear weighted overlay analysis using the following Eq. (3).

$$
\begin{aligned}
LS = {} & Rain\_R * Rain\_W + Tmax\_R * Tmax\_W + \\
& + SDR\_R * SDR\_W + SD\_R * SD\_w \\
& + AWC\_R * AWC\_W + EC\_R * EC\_W \\
& + ESP\_R * ESP\_W + ST\_R * ST\_W \\
& + pH\_R * pH\_W + OC\_R * OC\_W + SL\_R * SL\_W
\end{aligned}
\tag{3}
$$

where Rain is annual average rainfall, Tmax is maximum temperature, $S_{DR}$is max. infiltration capacity, SD is soil depth, AWC is available water content, EC is the electrical conductivity of soil, ESP is the percent of exchangeable sodium percentage, ST is the soil texture, pH is soil reaction (pH), OC is organic carbon, and SL is the slope of the terrain. The subscript letter 'W' is the weight of each of the criteria (computed by AHP), whereas 'R' refers to the rating of each group of the specific criteria. Table 4 shows Land Suitability Criteria for Cotton Crop.

4 Results and discussion

4.1 Suitability map for the crop cotton

The map of the cotton crop suitability, deciphered in AHP derived weighted overlay with the usage of spatial analyst tools in ArcGIS10.2 is depicted in Fig. 4. Analysis mask cover was prepared from Landsat 8 (OLI) data by computing the NDVI. With the basis of the appropriate NDVI values, the delineation of agricultural crop cultivation land has

Table 4 Land suitability criteria for cotton crop (Modified version of Walke et al. 2012)

Factors	In-situ soil characteristics	Rating			
		High suitable (S₁)	Moderate suitable (S₂)	Marginal suitable (S₃)	Unsuitable (N)
Climate	Mean temperature (°C)	26–32	33–35/24–26	36–38/22–20	> 38/< 20
	Rainfall (mm)	850–1000	750–850	600–750	< 600
Oxygen availability in rootzone	Soil drainage	Well drained	Imperfectly to moderately	Poorly drained or somewhat excessive	Stagnant/very poorly drained
Rooting condition	Soil Depth(cm)	100–150	60–100	30–60	< 30
Moisture availability	AWC (mm/m)	200–250	125–200	50–125	< 50
Soil toxicity	EC (dS/m)	Non-saline	1–2	2–4	< 4
	ESP (%)	< 5	5–10	10–15	> 15
Soil characteristic	Texture	l, scl, cl, sil	sl, sc, sic,c	c (ss, ls,s)	–
Nutrient availability	pH	6.5–7.5	7.6–8.0	8.1–9.0	> 9.0, < 6.5
	OC (%)	> 1.0	0.75–1.0	0.5–0.75	< 0.5
Erosion hazard	Slope (%)	0–1	1–2	2–3	3–5

been done from the other classes of land use. Every grid cell of this has the numerical value of 1 or 0, which indicates if this is an aerial spread of crop whether irrigated or not (Fig. 5). Ultimately, the map of suitability for the crop of cotton (Fig. 6) has been represented by the weighted overlay method with the usage of spatial analyst tools in ArcGIS 10.2.
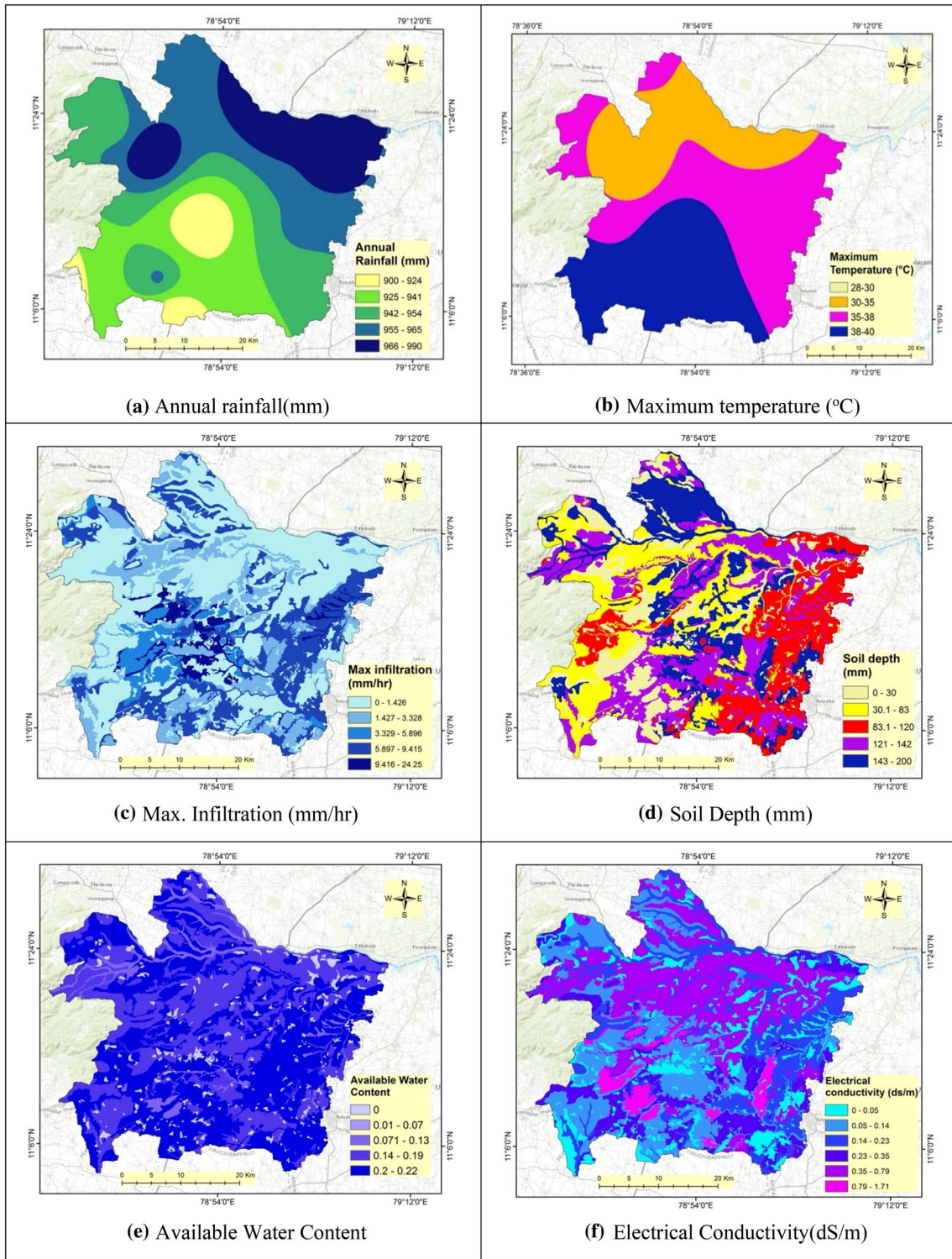
Six classes were identified for the soil depth of this region. Around 11% of the area was found to be deep soils and mostly concentrated in the eastern and north-eastern parts, while approximately 42% has been covered with predominantly deep soils. The soil depth ranges between 0 and 200 m. The map of soil texture of the catchment area has been categorized into clayey loam, sandy loam, sandy clayey loam, and loamy sand. Almost 45% of the area is covered with clayey loam and 33% is covered with sandy clayey loam soil. The soil drainage in the catchment area was categorized as well-drained, moderately well-drained, somewhat excessively drained, excessively drained, imperfectly drained, and poorly drained. Nearly 42% of the study area can be called well-drained. Nearly 24% of the study area comes under the category of imperfectly drained and its location is on the eastward side of the area under study. The soil pH of the study region was categorized as very much acidic, moderately acidic, less acidic, and neutral categories. Approximately, 28% of the area under study was found to be very acidic, and more than 43% of the area was entirely distributed as moderately acidic. About 15% of the area comes under the category of slightly acidic soils, whereas 17% was ideally better as far as pH is considered. In this study area, the available moisture content of the soil has been analyzed and 57% of the area consists of black-cotton soil which contains available moisture content equal to 200 mm/m, 10% of the areal spread of the study area falls under the category of sandy soil zone and with Available moisture content of

25 mm/m, rest of the area comprises of loamy clay soil and AWC falls in the range of 150 mm/m and 75 mm/m, which is appropriate for cotton crop growth. Nearly, 22% of the area under study has a value of Exchangeable Sodium Percentage (ESP) greater than 30% and is not suitable. Also, 56% of the study area has ESP lower than 10% which is relatively more ideal. But the cotton crop is highly tolerant in sodic and saline soils, for optimum crop growth and high yield ESP shall be less than 30%. Similarly, the values of salinity range from 2 to 22 dS/m. Nearly, 24% of the area under study is found to be under high salinity and 69% of the study area is found to be less saline land and it can be said to be highly suitable for the cultivation of cotton.

The map of the slope was derived from the SRTM 30 m DEM. This evaluation study of cotton crop growth suitability has an extreme influence on how the cultivation work can be performed efficiently, practices of erosion control, and adaptability of the cotton crop to the soil and climatic conditions. A significant proportion of the current area under study comes under the category of mild slope (1%) and is currently suitable and a smaller portion is categorized as steep and very steep (8–80%) classes, and it can be said as unsuitable. Rainfall continues to be the single water source for rain-fed agriculture, its even /uneven distribution, and high/low dependability has an important impact on the optimization of crop production. This area under study is likened to be favourable as it is provided with rainfall from southwest and northeast monsoon.

The maps of various criteria have been categorized (reclassified) into 4 different classes (unsuitable (N), marginally suitable (S₃), moderately suitable (S₂), and highly suitable (S₁)) have been provided with values that range between 1 and 4, in which, 1 denoted S1, which indicates the area which is more suitable for cultivation of the cash crop Cotton and 4 indicates N that indicates

(a) Annual rainfall(mm)

(b) Maximum temperature (ºC)

(c) Max. Infiltration (mm/hr)

(d) Soil Depth (mm)

(e) Available Water Content

(f) Electrical Conductivity(dS/m)

Fig. 4 Suitability criteria of the input parameters **a** Annual rainfall(mm), **b** Maximum temperature **c** max. Infiltration capacity, **d** soil depth (mm) **e** available water content, **f** electrical conductivity (ds/m), **g** exchangeable sodium (%), **h** soil texture, **i** pH, **j** soil organic carbon, **k** slope considered in the current study
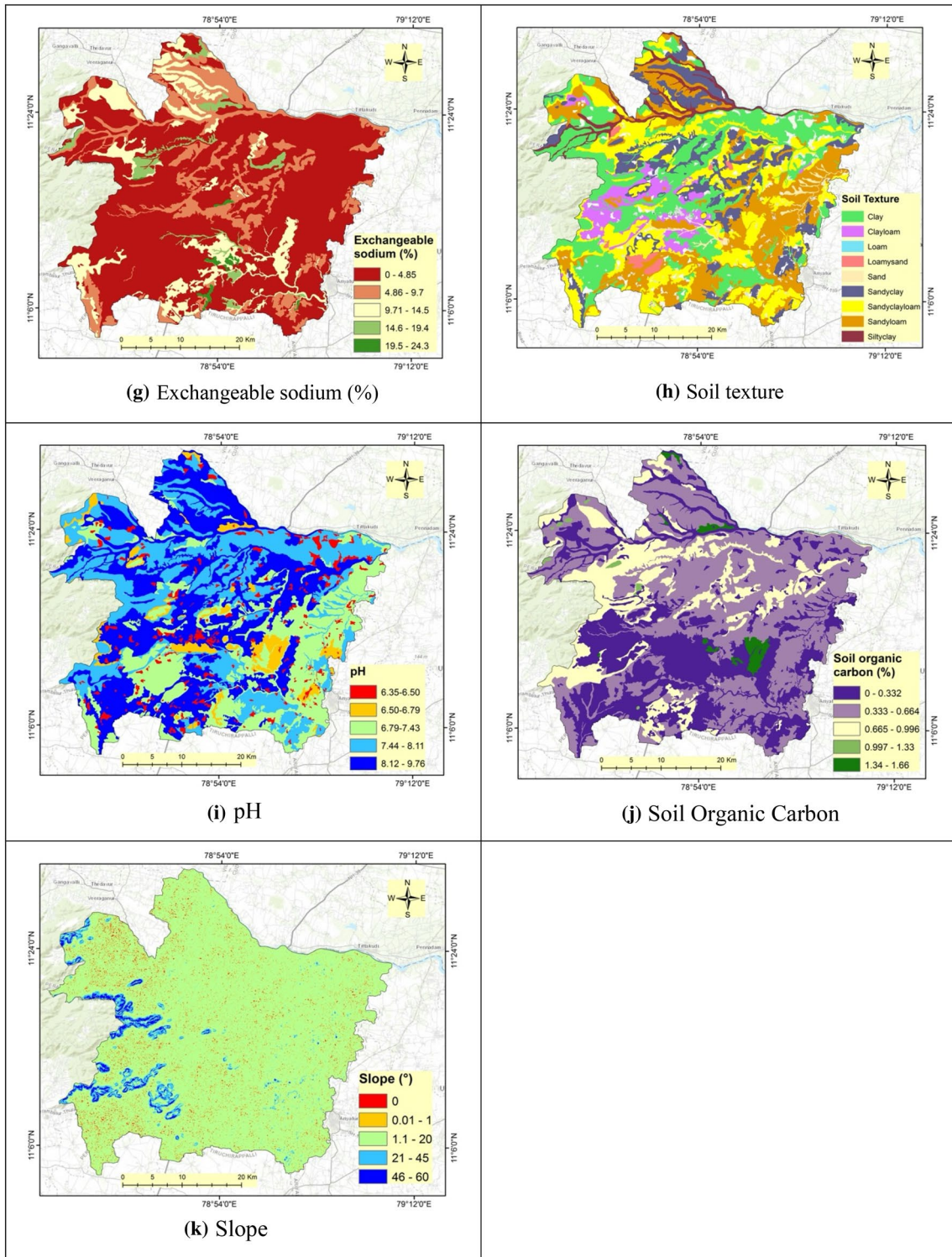
(g) Exchangeable sodium (%)

(h) Soil texture

(i) pH

(j) Soil Organic Carbon

(k) Slope

Fig. 4 (continued)

that the land unit which is not suitable for cotton crop growth and other different crops need to be planted. Every criterion is individually analyzed in its suitability to support the cotton crop cultivation with the basis on the FAO crop requirements applicable for Cotton. Table 5 shows the Pairwise comparison matrix for the AHP process.

Fig. 5 Mapthat represents a mask cover for crop land that is cultivable (green) and non-cropland that is uncultivable(orange)
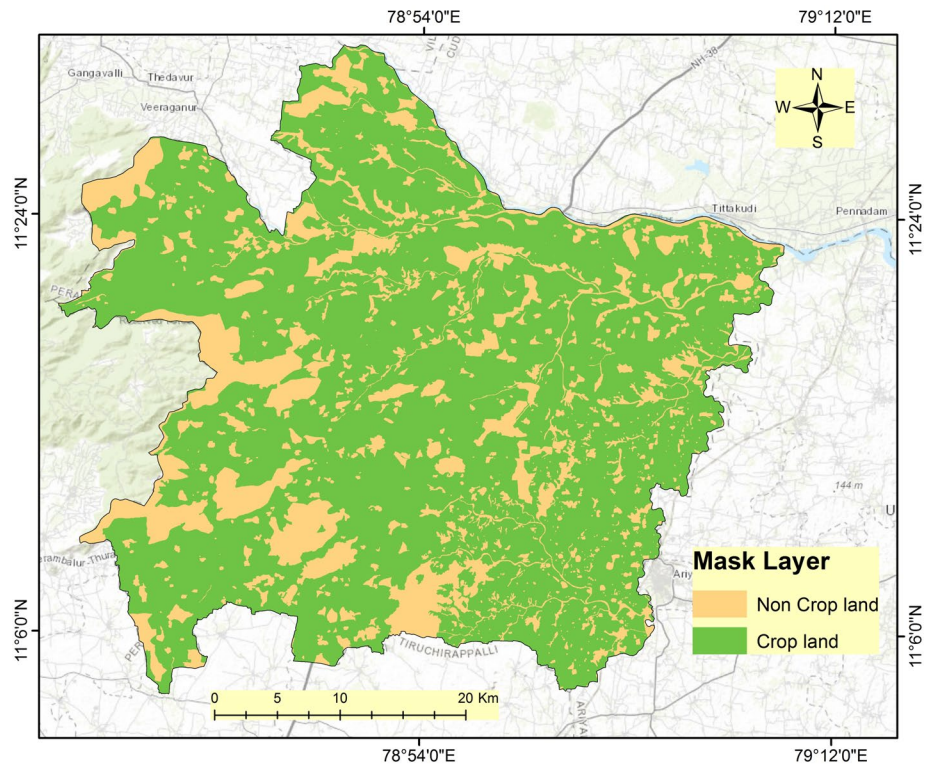
Fig. 6 Land suitability map of cotton with the usage of AHP
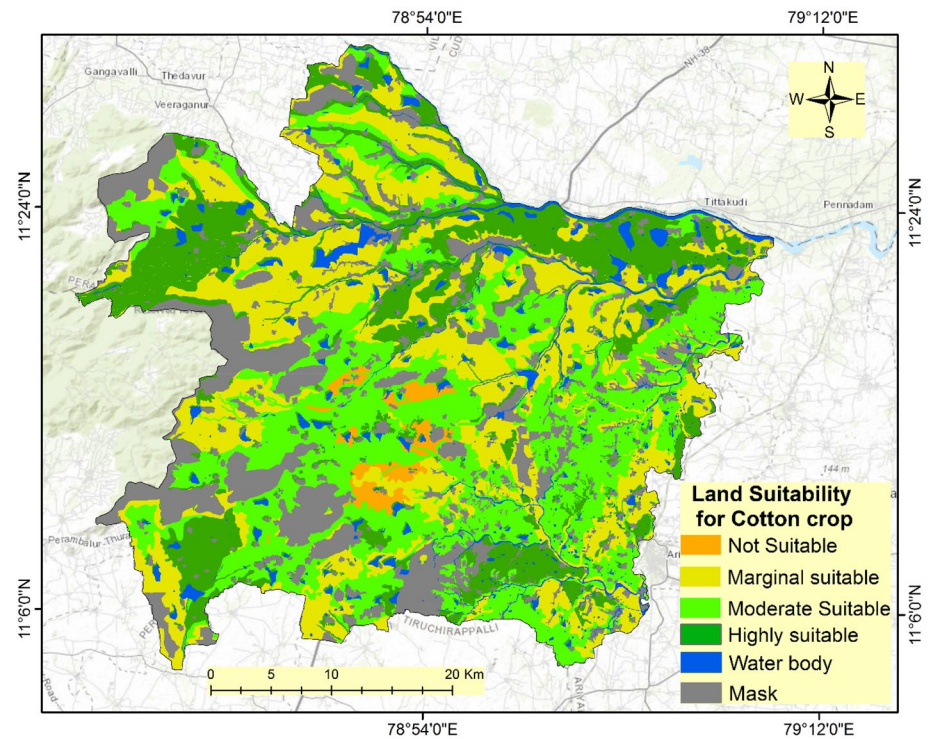
As depicted in Table 6, The analysis revealed that in the study area, 19.768% (345.2463 km^2) of total cropland is highly suitable, 30% (524 km^2), 16.7% (292 km^2) of the total area were moderately, marginally suitable areas respectively

and 9.39% (164 km^2) was under not suitable areas. About 24% (420 km^2) of land area covers under not suitable agriculture purpose with respect to the current land-use classification. With basis on the results, about 67% of the area

Table 5 Matrix of pairwise comparison in the AHP method

	Temp C1	Rain C2	Sdin C3	Sdep C4	AWC C5	EC C6	ESP C7	Stex C8	pH C9	OC C10	Slope C11	Avg.W	CR
Temp													
C1	0.256	0.356	0.289	0.381	0.212	0.236	0.140	0.195	0.154	0.170	0.167	0.232	12.391
Rain													
C2	0.085	0.119	0.145	0.095	0.212	0.142	0.140	0.098	0.115	0.128	0.133	0.128	12.205
Sdin													
C3	0.128	0.119	0.145	0.190	0.141	0.142	0.140	0.146	0.115	0.128	0.133	0.139	12.107
Sdep													
C4	0.064	0.119	0.072	0.095	0.212	0.142	0.093	0.195	0.154	0.085	0.100	0.121	12.646
AWC													
C5	0.085	0.040	0.072	0.032	0.071	0.189	0.186	0.098	0.115	0.085	0.100	0.098	12.000
EC													
C6	0.051	0.040	0.048	0.032	0.018	0.047	0.140	0.098	0.115	0.085	0.067	0.067	11.157
ESP													
C7	0.085	0.040	0.048	0.048	0.018	0.016	0.047	0.049	0.077	0.085	0.067	0.053	11.900
Stex													
C8	0.064	0.059	0.048	0.024	0.035	0.024	0.047	0.049	0.077	0.085	0.067	0.053	12.083
pH													
C9	0.064	0.040	0.048	0.024	0.024	0.016	0.023	0.024	0.038	0.085	0.067	0.041	11.604
OC													
C10	0.064	0.040	0.048	0.048	0.035	0.024	0.023	0.024	0.019	0.043	0.067	0.040	11.563
Slop													
C11	0.051	0.030	0.036	0.032	0.024	0.024	0.023	0.024	0.019	0.021	0.033	0.029	11.394

CI 0.091; *RI* 1.59; *Lambda* 0.060

under study is said to be suitable for cotton crop growth. The unsuitable land is because it is characterized by partially sandy clay texture, low soil depth, highly saline, less water retention, and over drainage. Figure 5 shows a map that represents a mask cover for the crop-land area that is cultivable (green) and non-cropland (orange) that is uncultivable.

5 Conclusions and recommendations

This study, it was evaluated the suitability of land for Cotton cultivation in Perambalur district, South India with the usage of GIS and multi-criteria evaluation approach with

FAO framework for the identification of suitable areas of cotton crop cultivation. A total of 11 parameters like annual average rainfall, maximum temperature, Slope, Soil infiltration capacity, effective soil depth, AWC, pH, EC, ESP, soil texture, Organic carbon Content, were considered for the determination of the cropland suitability index. Weights of each factor are determined using the AHP approach. Suitability levels for each of the factors were classified into four classes, highly suitable (S_1), moderately suitable (S_2), marginally suitable (S_3), unsuitable (N) based on the structure of FAO land suitability classification. Based on the result 345.24 km^2 (19%) areas are highly suitable followed by moderately suitable 524 km^2 (30%), 292 km^2 (16.7%) of the total area are marginally suitable areas and 9.39% (164 km^2) was under not suitable areas for cotton cultivation. The main limiting factors of the cultivation of cotton in this district are slope, shallow soil depth, alkaline soil reaction, and erosion hazard. Application of specific fertilizers, organic manure, pH, and provision of improved road network with better irrigation facilities may increase the land suitability. The findings in the study shall help in the improvement of land use efficiency with altogether a management of better cotton cultivation in this district. The wholesome approach of GIS and MCDA will help to assess the potency of land for other different crops.

Table 6 Different suitability index classes for final land suitability for cotton in Perambalur District

LSI	Area (km^2)	Area (%)
Highly Suitable	345.246	19.769
Moderately suitable	524.193	30.015
Marginally suitable	292.449	16.745
Unsuitable	164.151	9.399
Mask (Urban, Rocky, Forest)	420.4467	24.072
Total	1746.486	100

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