International Journal of Advance Research in Science and Engineering
Volume No.07, Issue No.04, April 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

Crop-Land Suitability Analysis for Selected Crops in Vedaranyam Block, Tamil Nadu Using Remote Sensing And GIS

Gayathri T[1],Navamuniyammal M[2]

[1] M E Student, Institute of Remote Sensing,
College of Engineering, Anna University, Chennai, Tamil Nadu(India)
[2]Assistant Professor, Institute of Remote Sensing,
College of Engineering, Anna University, Chennai, Tamil Nadu(India)

ABSTRACT

A research was conducted to evaluate the suitability of soils of different land unit for various crop productions at Vedaranyam block,Tamil Nadu, India with the integrated use of Geographical Information system (GIS) and Multi-criteria evaluation (MCE). The land suitability has been done for three major crops namely Paddy, Sugarcane and Groundnut.Relevant biophysical variables of landuse, soil, climatic, and topography were considered for suitability analysis. The land use/cover map was prepared by IRS-P6 LISS-III(23.5m resolution) satellite image was classified using ERDAS Imagine Software by means of supervised classification.For Multi-Criteria Evaluation (MCE), Pairwise Comparison Matrix known as Analytical Hierarchy Process (AHP) was applied and the suitable areas for crop land were identified. The research revealed that for rice cultivation, 2.7% area was highly suitable, 48.5 % was moderately suitable, 1.06% was marginally suitable but 47.72 % was not suitable whereas for Sugarcane cultivation, 3.25 % was highly suitable, 43.15% was moderately suitable and 5.04% was marginally suitable, but 48.54% was not suitable. Similarly, for Groundnut cultivation, 1.41% was highly suitable, 41.15% was moderately suitable and 9.15% was marginally suitable, but 48.28% was not suitable for groundnut production.

Key Words- *Analytical Hierarchy Process,Geographical information System, Multi-criteria evaluation, Pairwise Comparison,Suitability.*

I.INTRODUCTION

Land suitability refers to the ability of a portion of land to tolerate the production of crops in a sustainable way. Its evaluation provides information on the constraints and opportunities for the use of the land and therefore guides decisions on optimal utilizations of resources, whose knowledge is an essential prerequisite for land use planning and development. Moreover, such a kind of analysis allows identifying the main limiting factors for the agricultural production and enables decision makers such as land users, land use planners, and agricultural support services to develop a crop management able to overcome such constraints, increasing the productivity.Land could be categorized into spatially distributed agriculture potential zones based on the soil properties, terrain characteristics and analysing present land use.

II.OBJECTIVES OF THE STUDY

There are three main objective were framed for this analysis.

- To prepare the thematic layers of required parameters.
- To calculate the weightage by AHP technique.
- To Perform the overlay analysis by wighted overlay method.

III. DATA USED FOR THIS STUDY

Table 1 Data used for the study

S.NO	DATA TYPE	DESCRIPTION
1	Soil maps	To obtain the details of texture, depth,PH,EC of soil.
2	Digital Elevation Model SRTM DEM (30m Resolution)	To obtain slope,elevation and Drainage.
3	IRS P6-LISS III image (23.5m resolution)	To obtain the landuse/landcover map by Supervised classification technique.
4	Climate details	To prepare rainfall and temperature maps.
5	Crop calendar	To obtain the details about seasonal crops.
6	Administrative boundaries	To obtain the block boundary.

IV. STUDY AREA

Vedaranyam is one of the coastal blocks of Nagapattinam district and has an area of 536.79sq km. It is situated on the coast of Bay of Bengal. It falls within the co-ordinates of 10º15'-10º35'N latitudes and 79º20'-79º55'E longitudes. It has a tropical transitional bio-climate which is characterized by monthly average temperature above 27ºC. total annual rainfall varies from 1000 to 1500 mm with a dry period of 5 to 6 months. Vedaranyam is one of the six major wildlife sanctuaries and also important coastal wetland in Tamil Nadu..The study area map is shown in figure 1.

Figure 1 Location of the study area

V.METHODOLOGY

The process of carrying out a comprehensive crop-land suitability analysis requires a consideration of a number of criteria. Figure 2 below summarizes the approach followed in identifying areas for Multi-criteria decision making analysis was integrated with GIS, AHP and remote sensing in creating the suitability map.

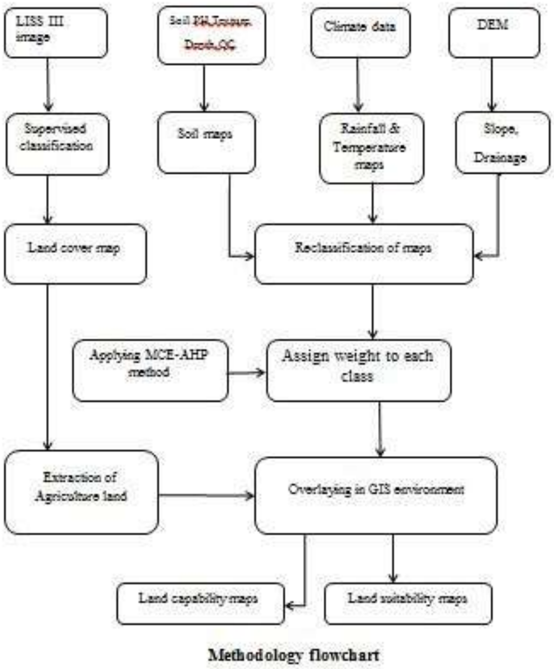


Figure 2: Methodology developed for suitability analysis

5.2 Preparation Of Thematic Maps

5.2.1 Soil Texture And Depth

The textural classes of soils of Vedaranyam block is shown in Fig 3.The classes are Clay loam,Loamysand,Sand,Sandyclay,sandy clay loam,sandyloam,Siltyclay,Silty clay loam. The study area consists of soil depth ranging from 8-35 cm. Based upon the USDA-SCS capability classification scheme the depths are classified into 3 groups.The various depth ranges are shown in fig 4.

5.2.2 Soil PH and EC

Soil pH is a measure of the relative acidity or alkalinity of the soil solution, and is expressed on a 14-point scale. The study area consists PH ranging from 5.1 to 9.most of the area covered in the range of 6.1 to 7. Cation Exchange Capacity is a measure of a medium's or soil's ability to regulate the supply of cations to the plant. The higher the CEC, improves the potential for plant growth.The abbreviated units were expressed as meq•100g-1.study area having CEC in the range of 0.1to3.5 meq•100g-1.PH and CEC values has been shown in figure 5 and 6.

5.2.3 Climate Map

Climate affects the growth, developments and yields of agricultural crops, including rice, favorably or unfavorably. Temperature and rainfall are two most important climatic factors considered in this study. Rice being a tropical and sub-tropical crop is normally grown at a fairly high temperature – high rainfall regime, ranging from 20 to 40°C and 1100mm to 2000mm of annual rainfall . The raw 5 years temperature and 5 years rainfall data of the study area were obtained The raster datasets are then generated using Inverse Distance Weighted (IDW) spatial interpolation tool in ArcGIS 10.1 platforms. The study area consists of annual rainfall ranging from 1196mm to 1432mm.From this we can conclude that the study area consists good rainfall all over the block.the temperature of vedaranyam block normally ranges between 28.35 to 28.62 °C.The rainfall and climate maps were shown in Figure 7 and 8.

5.2.4 Land Capability Classification

The Land capability classification is one of many interpretative groupings that can be used to evaluate arable and non arable lands for limitations or hazards for producing commodity crops using soil characteristics. Land Capability Classes I, II, and III are considered suitable for croplands and class IV for haylands. LCC of V, VI, VII, and VIII are not considered arable, but can be used for permanent vegetation unless it is a miscellaneous land type. Class-II, Class-III and Class-IV capability classes are identified in the study area.It indicated class II classified lands are having moderate limitations that reduce the choice of crops. It needs simple soil and water conservation practices and requires some attention to soil management, Class III classified land has severe limitations for use, hence it needs intense soil and water conservation treatment and requires careful soil management and Class-IV classified land has very severe limitations.The soil and water conservation practices are more difficult to apply and maintain.the categories are shown in Figure 9.

5.2.5 Drainage Density Map

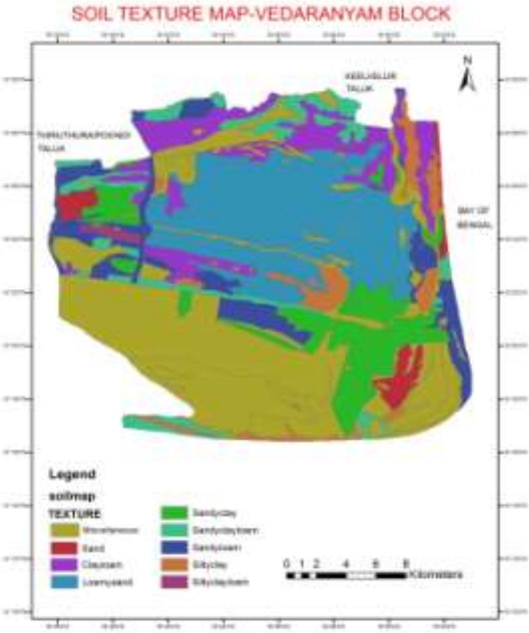
Soil drainage is one of the important soil properties affecting plant growth, water transfer and solute transport in soils. Soil drainage is also an environmental component affecting irrigation and soil reclamation, land capability for agriculture, flood control systems, engineering, health and infectious diseases Drainage Class refers to the frequency and duration of wet periods under conditions similar to those under which the soil formed. Five classes of natural soil drainage are recognized-very high density,highdensity,moderatedensity,lowdensity,very low density. From this map we can conclude that the density of the channel is depends upon the distance from the stream.If the drainage density is high there is a impermeable subsurface material so the runoff potential will be high.It results thin vegetation.If the density is low there is lower runfall and that results good vegetation cover.The drainage density map was shown in figure 10.

5.2.6 Topographic Factor

Slope is one of the basic topographic elements for crop land suitability mapping.Slope was generated from digital elevation model (DEM). In this study, the 30m spatial resolution DEM data of SRTM was acquired from USGS http://earthexplorer.usgs.gov. Then, the Slope function of Spatial Analyst Toolbox of ArcGIS 10.1 was used to generate the slope layer. The slopes were calculated in percentage of slopes. Every cell in the output raster has a slope value shown in figure 11.The study area contains slope in the range of 0-15%.hence the study area contains only moderate slope and flat terrain.

5.2.7Landuse/Landcover Map

The landuse/landcover map was prepared from LISS-III data of 23.5m Resolution. The LISS-III satellite image tiles were downloaded and the bands are stacked using Erdas imagine software.Then the tiles were mosaicked to form a continuous image.Usingarcgis the image was projected into UTM zone 44N, and clipped to the study area extend.supervised and unsupervised classification has been done using the Erdas Imagine software .In supervised classification 50 training sites are given to each classes.Accuracy assessment has been done and the accuracy of the classification has been determined. The study area divided into 8 classes namely waterbody,Swamp,Mangrooveforest,Vegetation,Settlement ,Barren land and dark vegetation.vedaranyam block lies near to the coastal line so the area consists of swamp and mangrove forest was shown in figure 12.At the same time it contains high rainfall so the crop growth rate also will be high.



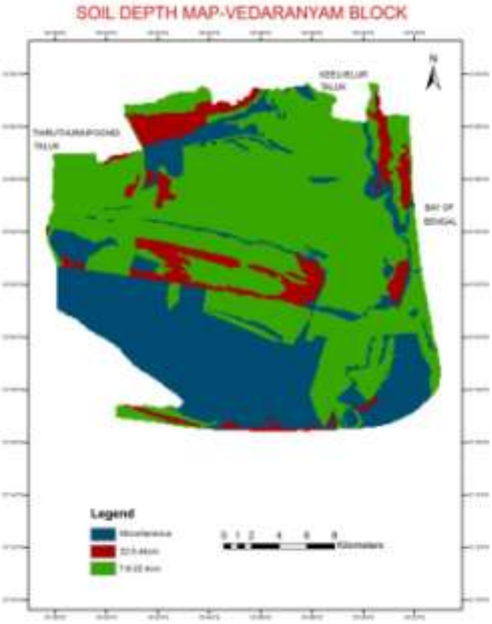
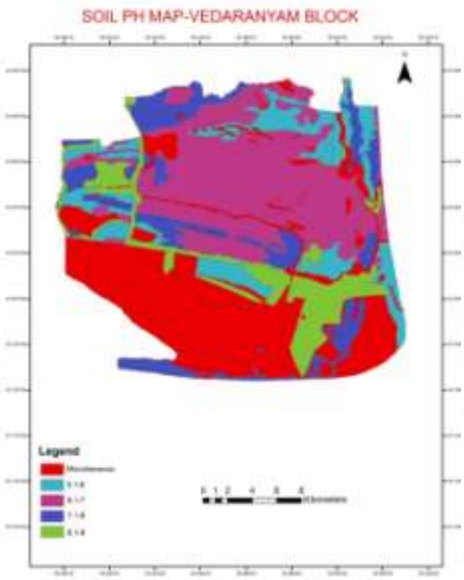


Figure 3 Soil texture

Figure 4 Soil depth



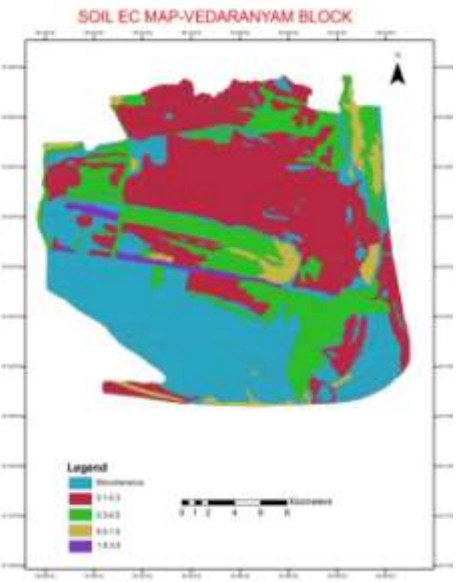
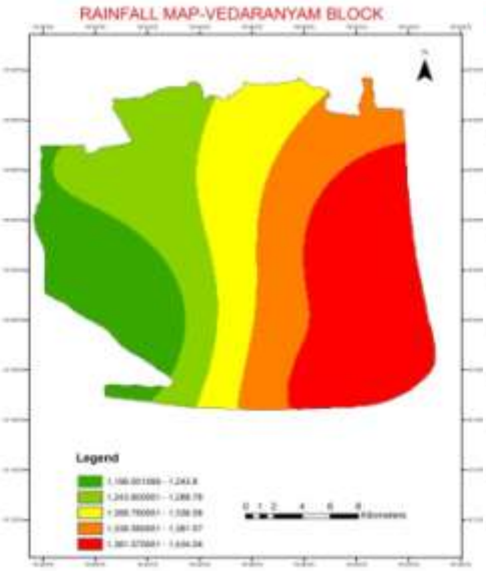


Figure 5 Soil PH

Figure 6 Soil EC

IJARSE
ISSN: 2319-8354



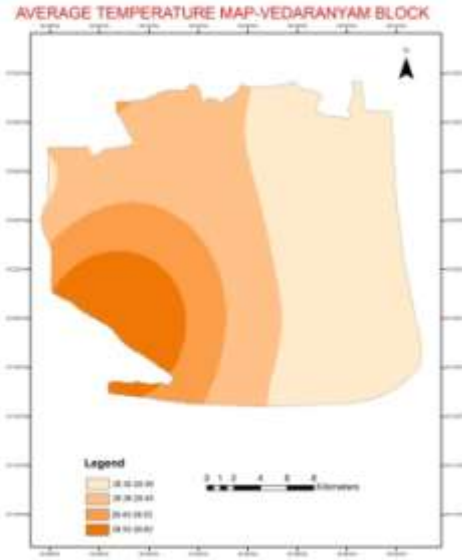
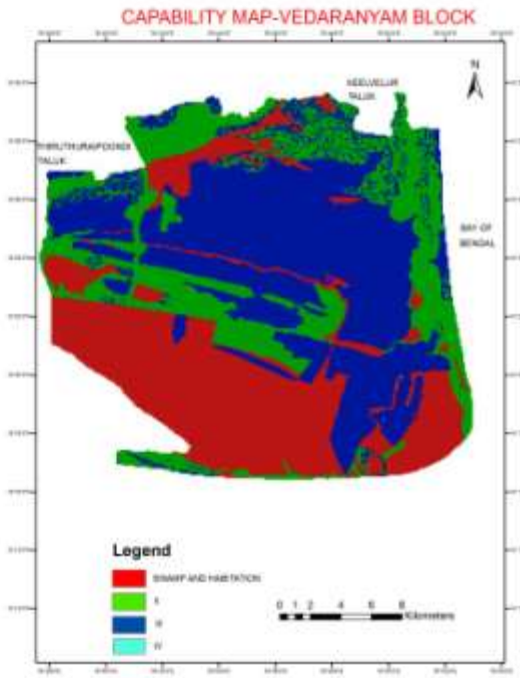


Figure 6 Rainfall Distribution in mm

Figure 7 Average temperature in ºc



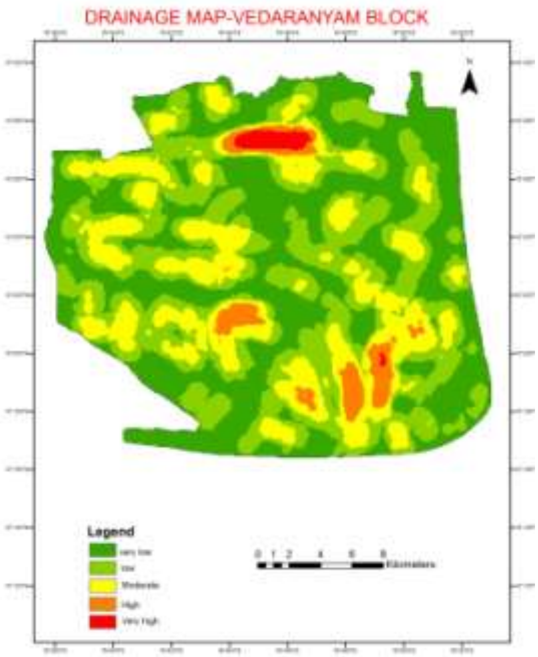


Figure 8 Land capability map

Figure 9 Drainage density map

International Journal of Advance Research in Science and Engineering
Volume No.07, Issue No.04, April 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

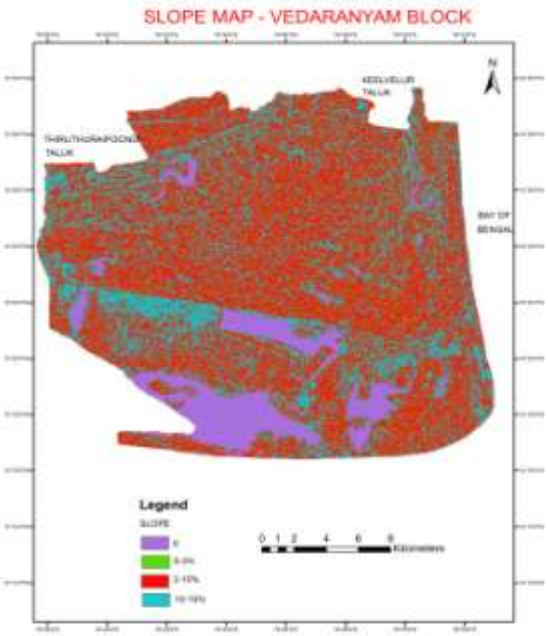


Figure 10 Slope map in Percentage

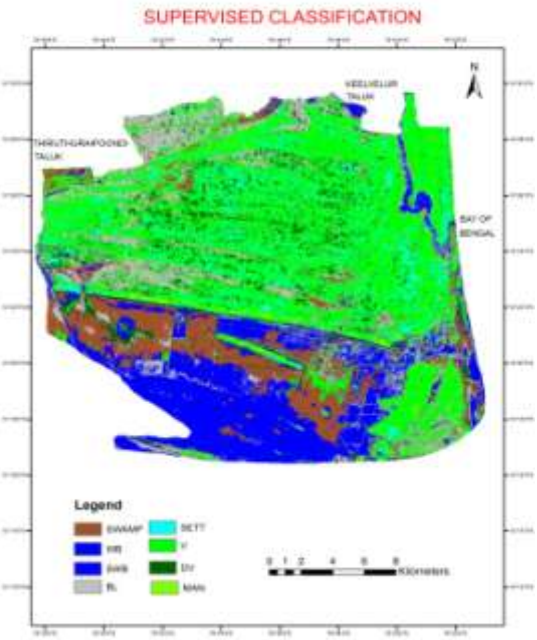


Figure 11 Landuse/Landcover map

5.3 The Analytic Hierarchy Process (AHP)

Multi criteria evaluation was acquired by applying the various procedure of AHP (Analytical Hierarchy process).Analytical Hierarchy Process, introduced by Satty (1977) was used in decision-making, with the assumption that comparison of two elements is derived from their real-time importance. AHP was carried out by following the given steps below.

5.3.2 Hierarchical organization for the criteria and sub-criteria

Table 2 Hierarchical Structure

Goal	Criteria	Subcriteria
Multi- Criteria Land Suitability	Land	Capability Classification(LCC), Drainage , Slope
	Soil	Texture,pH,EC,and Soil depth
	Climate	Rainfall,Average temperature

5.3.3 Pairwise Comparison Matrix (PWCM)

The pair-wise comparison matrix (PWCM) was carried out for rating and weighting of the of different sub-criteria and criteria. The fundamental scales given by satty's for comparing the two criteria or subcriteria was used. The qualitative value from 1-9 scales was given by (satty and vargas,2001), considering the comparative importance of two criteria or sub criteria. Queries were formed and the matrix was framed by experts opinion.

5.3.4 Final Matrix

Table 3 Final Matrix

Criteria	Slope	Drainage	Texture	PH	CEC	LCC	Depth	LU/LC	Rainfall
Slope	1	3	5	3	3	5	3	3	2
Drainage	1/3	1	½	1	3	1	1	1/3	1/3
Texture	1/5	2	1	2	1	3	1/3	1/3	1/5
PH	1/3	1	½	1	2	5	1	1/2	½
CEC	1/3	1/3	1	1/2	1	2	1/3	1/3	1/3
LCC	1/5	1	1/3	1/5	1/2	1	1/5	1/2	1/3
Depth	1/3	1	3	1	3	5	1	1	1/3
LULC	1/3	3	3	2	3	2	1	1	3
Rainfall	½	3	5	2	3	3	3	1/3	1

Maximum Eigen value λ max=10.1296

No of criteria n=9

5.3.5Calculation of consistency ratio

In AHP, the consistency ratio is defined as CR where CR = CI/RI. Saaty has shown that a consistency ratio (CR) of 10% or less is acceptable to continue the AHP analysis.

Step 1. Consistency index was calculated, Consistency index

$$(CI) = (\lambda\ max-n)/(n-1)$$

$$=0.1412$$

Where n = number of criteria λ max=Maximum eigen value

Step 2. Random consistency index (RI) was calculated RI value depends upon the number of criteria or sub-criteria acquired in the research

Table 4 RI values

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

RI=1.45

Step 3: Finally, Consistency ratio (CR) was calculated as

Below

Where, RI= Random consistency, CI= Consistency index

$$CR=CI/RI$$

$$=0.1412/1.45$$

=9.73%

CR value ≤ 10% AHP is consistent, then further process was done

CR value > 10% AHP is not consistent, revision of process was done

hence 9.73%<10%.AHP is consistant.

Table 5 Weightage values

Criteria	Slope	Drainage	Texture	PH	CEC	LCC	Depth	LULC	RF
Weightage	25.1%	8.5%	7.0%	7.9%	4.7%	3.1%	10.7%	16.6%	16.4%

5.4 Weighted overlay analysis

The various data set layers together with their weights were overlayed using the weighted overlay tool and the suitability maps for Paddy,Groundnut and sugarcane were generated. The input criteria used in the analysis process were in different dimensions and varied numbering system. It would be impracticable to have an integrated analysis involving such dissimilar criteria without a common standard of measurement. The weighted overlay analysis method demands that every criterion be reclassed into a uniform priority scale, such as 1 to 9, with 9 being the most desirable. The weighted overlay tool works only with integer input rasters. Continuous rasters must be reclassed into ranges and then integers assigned.

Table 7 Criteria for Assessing the Land Suitability for Paddy

Land qualities	**Rank**			
	1	**2**	**3**	**4**
Slope	0-2%	2-3%	3-10%	>10%
Texture	C,CL, SiCL, SiC, SiL	SCL, L	SL, SC	LS
Depth	45-30cm	30-25cm	25-7.5cm	<7.5cm
Drainage Density	Very low	Low	Moderate	High/Very High
Mean annual rainfall	>950 mm	750-950mm	550-750mm	< 550mm

S-Sand, LS- Loamy Sand, SL- SandyLoam, L-Loam, SiL- SiltLoam, SCL- SandyCLayLoam, CL-ClayLoam, SiCL-SiltyClayLoam,SC-SandyClay,

Table 8 Criteria for Assessing the Land Suitability for Groundnut

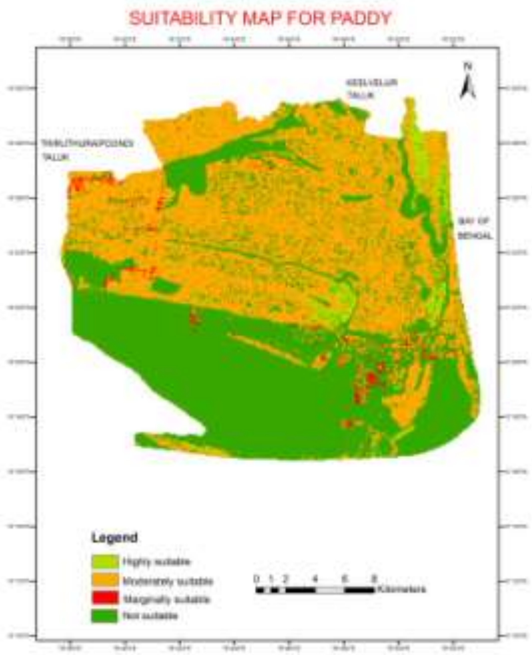
Land qualities	**Rank**			
	1	**2**	**3**	**4**
Slope	0-4 %	4-16%	16- 30%	> 30%
Texture	SL, SiL, SCL	SCL	LS	C,CL,SC,SiC,SCL

IJARSE
ISSN: 2319-8354

Depth	45-30cm	30-25cm	25-7.5cm	<7.5cm
Drainage Density	Very low	Low	Moderate	High/Very High
Mean annual rainfall	550-750 mm	350-550mm 750-950mm	950-1200mm	

Table 9 Criteria for Assessing the Land Suitability for Sugarcane

Land qualities	Rank			
	1	**2**	**3**	**4**
Slope	0-4 %	4-16%	16- 30%	> 30%
Texture	SL, SiL	SCL	LS	C,CL,SC,SiC
Depth	45-30cm	30-25cm	25-7.5cm	<7.5cm
Drainage Density	Very low	Low	Moderate	High/Very High
Mean annual rainfall	550-750 mm	350-550mm 750-950mm	950-1200mm	



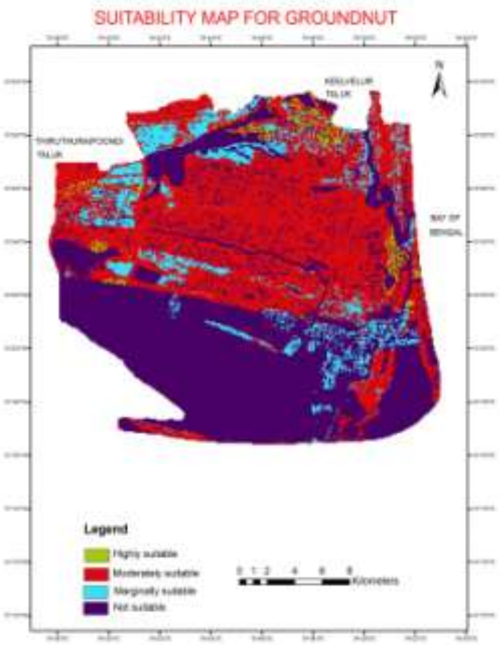


Figure 12

Suitability Map For Paddy

Figure 13 Suitability Map Forgroundnut

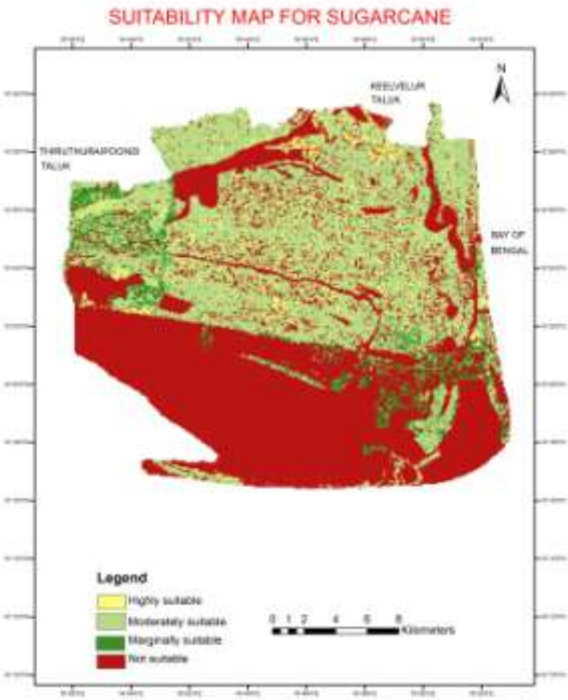


Figure 14 Suitability Map For Sugarcane

Table 10 Area under different Land Suitability classes for the major crops in Vedaranyam block

Suitability Class	Paddy		Sugarcane		Groundnut	
	Area in Km^2	Percent(%)	Area in Km^2	Percent(%)	Area in Km^2	Percent(%)
Highly suitable	256.17	47.7	260.62	48.54	259.19	48.28
Moderately suitable	14.54	2.70	17.47	3.25	7.59	1.41
Marginally suitable	260.39	48.50	231.71	43.15	220.92	41.15
Not suitable Includes forest and waterbody	5.70	1.06	27.10	5.04	4.9	9.14

V.CONCLUSION

In this research, integration of MCE and GIS techniques was used to predict suitable areas for cereal crops production at block level. The outcome obtained from this study also indicates that the integration of GIS and MCE could provide a good database and information for planners considering crop substitution to get better

IJARSE
ISSN: 2319-8354

agricultural production. The research revealed that for rice cultivation, 2.7% area was highly suitable, 48.5 % was moderately suitable, 1.06% was marginally suitable but 47.72 % was not suitable whereas for Sugarcane cultivation, 3.25 % was highly suitable, 43.15% was moderately suitable and 5.04% was marginally suitable, but 48.54% was not suitable. Similarly, for Groundnut cultivation, 1.41% was highly suitable, 41.15% was moderately suitable and 9.15% was marginally suitable, but 48.28% was not suitable for groundnut production.

REFERENCES

[1]Abd-AllaGad ,*"Land capability classification of some western desert Oases, Egypt, using remote sensing and GIS," The Egyptian Journal of Remote Sensing and Space Sciences* (2015) , PP9–18

[2]AbdelkaderMendas ,AminaDelali , *"Integration of MultiCriteria Decision Analysis in GIS to develop land suitability for agriculture: Application to durum wheat cultivation in the region of Mleta in Algeria*, Computers and Electronics in Agriculture (2012)PP 117–126

[3]Amira Baber Sheikh, ShahidParvez, Muhammad Ikram, Humaira Baber," *Land Suitability Assessment For Maize Crop In Okara District Using GisTechniques*",International Journal of Life Sciences Research,*Vol. 5, Issue 2*, pp: (37-44), Month: April - June 2017.

[4]Dr.N.AppalaRaju,"*Land Capability and Suitability in Vizianagaram district of Andhra Pradesh using Remote sensing and GIS Techniques,IOSR Journal Of Humanities And Social Science , (July 2015), Volume 20, PP 56-64*

[5]FahimehMaleki, HosseinKazemi, AsiehSiahmarguee, BehnamKamkar," *Development of a land use suitability model for saffron (Crocus sativusL.) cultivation by multi-criteria evaluation and spatial analysis",* Ecological Engineering 106 , Elesvier, 4 June 2017.PP140–153

[6]FranklineRono, Charles C. Mundia," GIS based suitability analysis for coffee farming in Kenya ,"International Journal Of Geomatics And Geosciences Volume 6, No 3, 2016 PP 1-12

[7]Getachew T. Ayehu, Solomon A. Besufekad," Land Suitability Analysis for Rice Production: A GIS Based Multi-Criteria Decision Approach ," American Journal of Geographic Information System 2015, PP 95-104

[8]HalilAkinci, AyseYavuzOzalp ,BulentTurgut ,"*Agricultural land use suitability analysis using GIS and AHP technique*", Computers and Electronics in Agriculture ,Elesvier , 6 July 2013,PP 71–82.

[9]HalusSatriawan, Erwin Masrul Harahap2, Rahmawaty, AbubakarKarim," Land Capability Evaluation for Agriculture in KruengSieumpo Watershed, Aceh, *Academic Research International Vol. 5(3) May 2014,pp1-14*

[10]Jiuquan Zhang , Yirong Su a, JinshuiWua, Hongbo Liang c," *GIS based land suitability assessment for tobacco production using AHP and fuzzy set in Shandong province of China"*, Computers and Electronics in Agriculture 114, Elesvier, 23 April 2015,PP (202–211).

[11]Jadab Chandra Halder,"*Land Suitability Assessment for Crop Cultivation by Using Remote Sensing and GIS" Ghatal block, West Bengal.* Journal of Geography and Geology,July 4, 2013, *Vol. 5*,

[12]Mohamed A.E. AbdelRahman , A. Natarajan , RajendraHegde, "*Assessment of land suitability and capability by integrating remote sensing and GIS for agriculture in Chamarajanagar district, Karnataka, India*. The Egyptian Journal of Remote Sensing and Space Sciences (2016), PP125–141

[13]Mark K. Boitt, Charles N. Mundia, Petri K. E. Pellikka, John K. Kapoi," *Land Suitability Assessment For Effective Crop Production, a Case Study of Taita Hills, Kenya,"*Journal of Agricultural Informatics, 29 Jun 2015 ,Vol. 6, No. 2,PP-23-31

[14]B. Neupane, C.P. Shriwastav, S.C. Shah and K. Sah," Land Suitability Evaluation For Cereal Crops: A Multi-criteria Approach Using Gis At ParbatipurVdc, Chitwan, Nepal,International journals of applied science and biotechnology, Vol 2(4)PP 493-505

[15]T.V. Reshmidevi , T.I. Eldho, R. Jana , "*A GIS-integrated fuzzy rule-based inference system for land suitability evaluation in agricultural watersheds",westbengal,* Agricultural Systems 101 (2012) PP(101–115)

[16]Samuel W. Kamau, David Kuria and M. K. Gachari, "*Crop-land Suitability Analysis Using GIS and Remote Sensing in*

Nyandarua County, *Kenya*, Journal of Environment and Earth Science, *Vol.5*, *No.6*, 2015

[17]SonaliBhandari, Santosh T. Jhadav, Suresh Kumar," *Land Capability Classification And Crop Suitability Assessment In A Watershed Using Rs And Gis – A Case Study Of Watershed In Dehradun, Uttarakhand*, SSARSC International Journal of Geo Science and Geo Informatics, *Volume 1 Issue 1, March 2014,*

[18]Sanda roca, Stefan bilasco, Ioan pacurar, Marcel Cornel negrusier, Danu petrea," Land Capability Classification for Crop and Fruit Product Assessment Using GIS Technology. Case Study: The Niraj River Basin (Transylvania Depression, Romania),"International journal of agriculture, 2015, *Vol43(1)*,PP235-242

[19]TiemenRhebergen,ThomasFairhurst, ShamieZingore, Myles Fisherd,ThomasOberthur, Anthony Whitbread*," Climate, soil and land-use based land suitability evaluation for oilpalm production in Ghana*", European Journal of Agronomy (2016)PP 1-14.

[20]WANG Da-cheng, LI Cun-jun, SONG Xiao-yu, WANG Ji-hua, YANG Xiao-dong, HUANG Wen-jiang, WANG Jun-ying and ZHOU Ji-hong," Assessment of Land Suitability Potentials for Selecting Winter Wheat Cultivation Areas in Beijing, China, Using RS and GIS," Agricultural Sciences in China,2012,PP1419-1430