Land Capability and Suitability in Vizianagaram district of Andhra Pradesh using Remote sensing and GIS Techniques

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Abstract: *India's future is threatened by shortage of food, water and energy and these should be given priority. Agricultural productivity has to be enhanced to meet the increasing demand of ever growing population of the country. The study area covering an about 6533 sq km has been studied for the land systems, landforms, soils, land use and hydro-geomorphology using IRS-P6, LISS III data on scale 1: 50,000. The major soils of the study area are red loamy soils, red sandy soils, deltaic alluvial soils, laterite soils and coastal soils. The major part of the land is utilized for cultivation of paddy (Kharif). The hills of the region contain degraded forest. The land capability has been evaluated based on the physical characteristics of the study area seven classes of land are identified. Land capability classification is a scientific appraisal of the physical characteristics of land, its inherent soil qualities and the farm management practices. The land capability maps are more useful for the delineation of potential arable lands. The information on land suitability gives an idea about the soils, which are suitable(S) and not suitable (N) for a given crop. Within the class suitable, soils are further grouped into highly suitable, moderately suitable and marginally suitable.*
Key words*: Land capability, Land suitability, Land use, Soils, Hydro-Geomorphology and GIS.*

I.   Introduction

Land is an important natural resource. Land is an area of the earth's surface, the characteristics of which embrace all reasonably stable, or predictably cyclic, attributes of the biosphere vertically above and below this area including those of the atmosphere, the soil and the underlying geology, the hydrology, the plant and animal populations, and the results of past and present human activity, to the extent that these attributes exert a significant influence on present and future uses of the land by man (FAO, Soils Bulletin No.32, 1976). The most important aspects of land are its role in providing anchorage space to all resources, and the fact that most human activities take place on land. Land is limited in supply and there is completion for its use. In the light of increasing population, the demand is also increasing, thus optimum use of land has become a necessity. Land is also unevenly distributed in terms of its qualities. It has its limitations for different uses. Land can be improved for particular use by certain measures, it can also be improved by a certain kind of land use or at least sustained production can be assured. Land can deteriorate by its mismanagement, wrong land use or by certain cultivation practices. Land qualities related to management and inputs include possibility of mechanization; accessibility and size of land holdings. The concept of land quality is relevant only for suitability studies for a particular land use. It can be used for estimating potentials only in relation to defined land utilization types.

The present study is an attempt to analyses the land capability and land suitability classes of Vizianagaram district. Numbers of research papers were published relating to land capability and land suitability analysis. Alaguraja, P. Durairaju, S et al. (2010) have analyzed Land use/ Land Cover categories i.e. crop land, dense forest, fallow land, barren rocky land, land with or without scrub, plantations and water bodies of Madurai district in Tamilanadu using satellite data. Ravi Singh (2000) studied land use levels of agricultural development in Arunachal Pradesh. Land is one of the critical natural resource on which most developmental activities (Jitendra Kumar, 2011). The applied landscape-ecological method takes account of topography, climate, soils, geology, biological diversity, wildlife, forest, land use, and hydrology (Jan-Peter Mund (2006). Land suitability rating model was developed using model building techniques in ArcGIS. From the results of this research, a rice suitability map was prepared identifying the various areas as four classes: most suitable, suitable, less suitable and unsuitable (David KURIA et al 2011). The major land systems are hilly terrain, undulating terrain, rolling plains and fluvial plains (Krisnaiah Y.V 2011).

The degradation of land resource due to overexploitation and misuse and consequent economic, social and environmental impacts has intensified the pressure on the land resoureces of the country (EFAP, 1994). The soil-based GIS data was complied and interpreted for land use suitability and fertility assessment (S.V.Bobade, B.P.Bhasekar et al 2010). Jasbir Singh (1977) studied the landuse efficiency using ranking co-efficient, selecting five variables, namely net sown area, non-cultivable land, irrigated land, land cropped more than once and cultivable waste land. Mohammad Shafi (1984) has applied ranking score method for determining the agricultural efficiency of Uttar Pradesh by taking the crop yields of eight food grain crops. Reddy and

Ramanaiah (1985) have applied standard coefficient method which is modified form of Kendall's ranking coefficient method in analyzing agricultural land use efficiency in Andhra Pradesh.

II. Study Area

The district is a part of the Northern Coastal plains of Andhra Pradesh and lies between 17°-15^1 and 19^0-15^1 of the Northern Latitudes and 83^0-0^0 to 83^0- 45^1 of the Eastern Longitudes (Fig.1). It is bounded on the north by the Orrisa state, on the West and South by Visakhapatnam district, on the East by the Srikakulam district, South-East by Bay of Bengal. Vizianagaram District is predominantly an agricultural district as 68.4% of the workers are engaged in agriculture and about 82% of the population of the District is living in rural area and depend on agriculture for their livelihood. Rainfed farming is the characteristic of agriculture in the District as about 60% of its area is cultivated purely under rainfed conditions. Even the rest of the area which is termed as irrigated area is mostly dependent on the rainfall received in the district. In view of the un assured irrigation conditions in the district majority of crops grown are dry crops. Paddy crop is cultivated mainly during Kharif season with 80% of its area under tank irrigation which is in turn depending on the local rainfall. The major crops grown in the district are Paddy, Ragi, Bajra, Sugarcane, Pulses, Mesta, Cotton and Groundnut.

Objectives

To analysis the land capability and land suitability of Vizianagaram district using remote sensing and GIS techniques.

III. Methodology

The present study was based on primary and secondary data sources. Land Capability and Suitability analysis of the district was carried out by image processing of IRS P6-LISS III data of March 2006 using ERDAS and Arc Map imagine software. The topographical maps nos 65M/8, 65M/12, 65N/2, 65N/3, 65N/4, 65N/5, 65N/6, 65N/7, 65N/8, 65N/9, 65/N10, 65N/11, 65N/12, 65N/13, 65O/1, 65O/5 & 65O/9 were scanned, geo-referenced and all the maps were joined using the composer in ERDAS imagine environment. After applying necessary enhancement techniques digital data have been converted to vector formats for further GIS analysis. Based on the information obtained from the satellite imagery and corresponding ground truth verification in the field, various categories of the land capability and suitability categories have been identified.
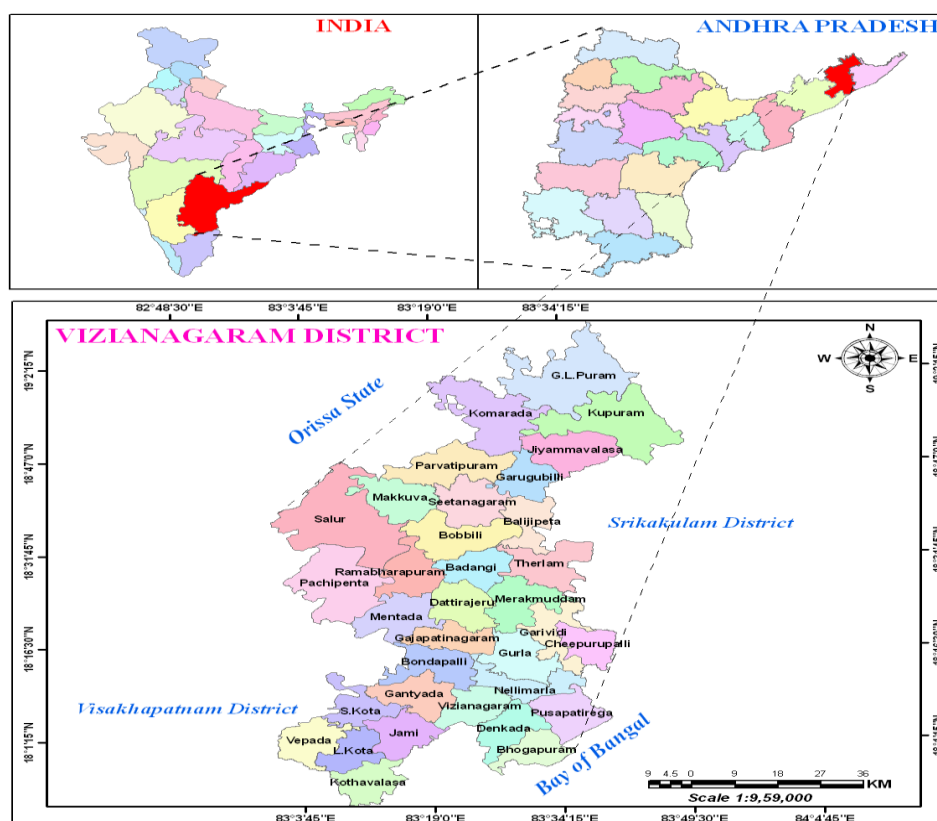

Fig1. Location map of the study area

IV. Results And Discussions

Relief

The district can be divided into two distinct natural physical divisions i.e., plain and hilly regions. The hilly region is mostly covered with densely wooded forests and comes under agency tract of the district. Since it is hilly tract, its elevation is also uneven. The plain portion of the district is a well cultivated tract. The agency tract mostly consists of the hilly regions covered by the Eastern Ghats, which run parallel to the coast from the northeast to the southwest. The average height of these hills is about 914 meters and the highest peak is the Shankaram in Srungavarapukota mandal which is over 1,615 meters. The main hill ranges are Dumakonda, Antikonda, Palakonda, Kodagandi and Gamatikonda. All these individual ranges form part of the Eastern Ghats. These ranges with their detached hills show a distinct northwest-southeast trend. In the Parvathipuram division the hills are steep and rugged terrain devoid of plateaus.

Flood plains are restricted to river basin. Active beach forms a narrow strip along the coast. Thick mantle of flood plain deposits comprising clay and silt are restricted to the Gostani, Champavathi, Kandivalasa, Vegavathi, Suvarnamukhi and Nagavali river valleys. Coastal deposits comprising beach sand and dune sand occur as a narrow belt of 500 m to 2 km wide (Fig.2) along the coast between Konada and Duvapeta regions.
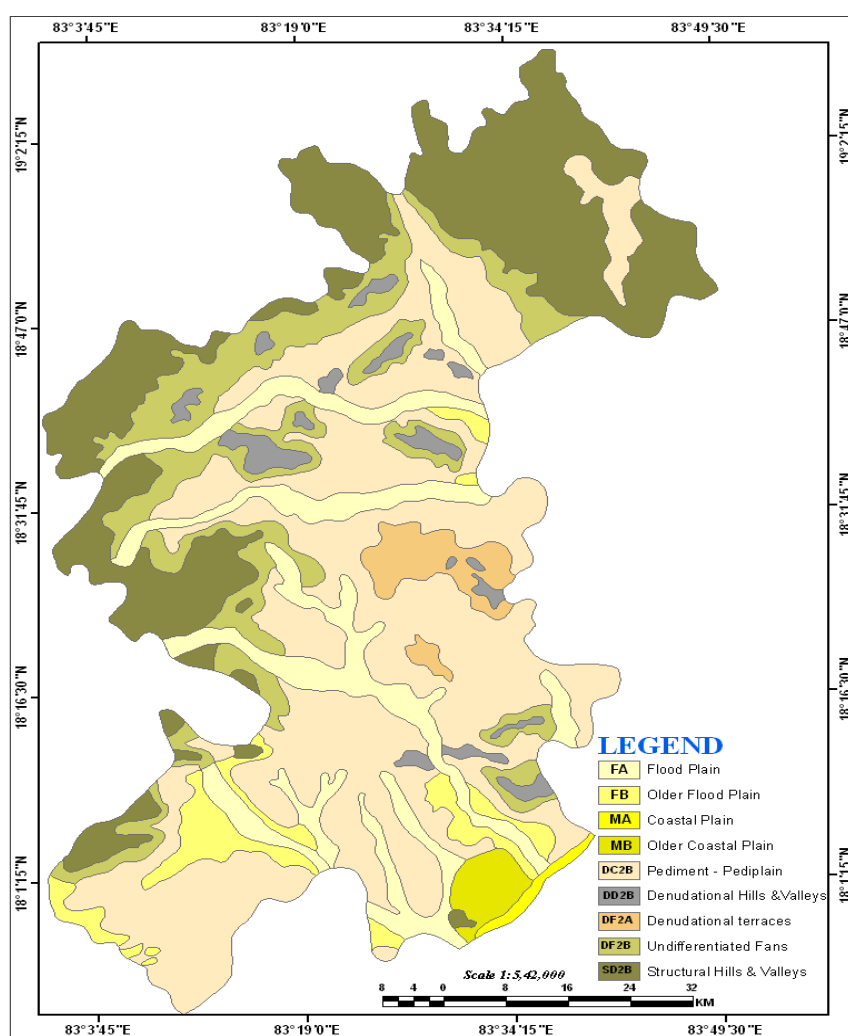

Fig 2. Geomorphology of the Study area

Soils: In any agricultural operations soil is of the utmost importance as it is the cradle for all crops and plants. The top soil having an average depth of about 15 to 20 cm on the face of the land is the natural body of soil on which plants grow and the farming activities flourish. The standard of living of the people depending on agriculture which is often determined by the fertility and productivity of soils. Soil fertility may be maintained by scientific crop rotations, and the application of manure of fertilizers. Loam soils are often regarded as ideal, although heavier clay soils may be suitable for certain crops. Sandy soils are generally infertile, although they may respond to heavy application of fertilizer.

Agriculture is dependent on soils to a great extent. Texture of the soil, structure of the soil, colour of the soil and temperature of the soil are important physical factors. For the optimal growth and development of crops, the presence of moisture in the soil is also essential. In the fertility of the soil, the availability of both moisture and oxygen are extremely important. Besides the physical properties, the chemical characteristics are also of great importance as the fertility of the soil to a large extent depends on its chemical structure. Chemical composition of soil shows the minerals that are present in the soil and these are essential elements for the growth and development of plants. These elements include nitrogen, phosphorous and potash and these are called nutrients of plants.

In order to increase the productivity of the shrinking land resources, a comprehensive data base on soil and land resources is essential. It is with this purpose, the National Bureau of Soil Survey and Land Use Planning (NBSS &LUP 2006) under Indian Council of Agricultural Research had initiated a project in the year 1991 on Soil Resource Mapping of Andhra Pradesh to generate comprehensive data base on soil and land resources of the state.

For the present study, the soil resource data of Vizianagaram district were collected from the Dept of Agriculture. The predominant soils of the district are red sandy loams with clay base and coastal sands. The district is characterized by 5 types of soils (1) they are red sandy soils occupy the major part of the district, (2) sandy clay loamy soils, along the western part of the district and also north eastern and south eastern parts of the study area. (3) Laterite soils, covers a small area in the south eastern part (Cheepurupalli) (4) Deltaic alluvial soils, seen near Parvathipuram, in the northeastern extremity and east of Cheepurupalli and (5) Coastal sandy soils, occur as a narrow strip along the coast near Konada (Fig.3& Table.1).
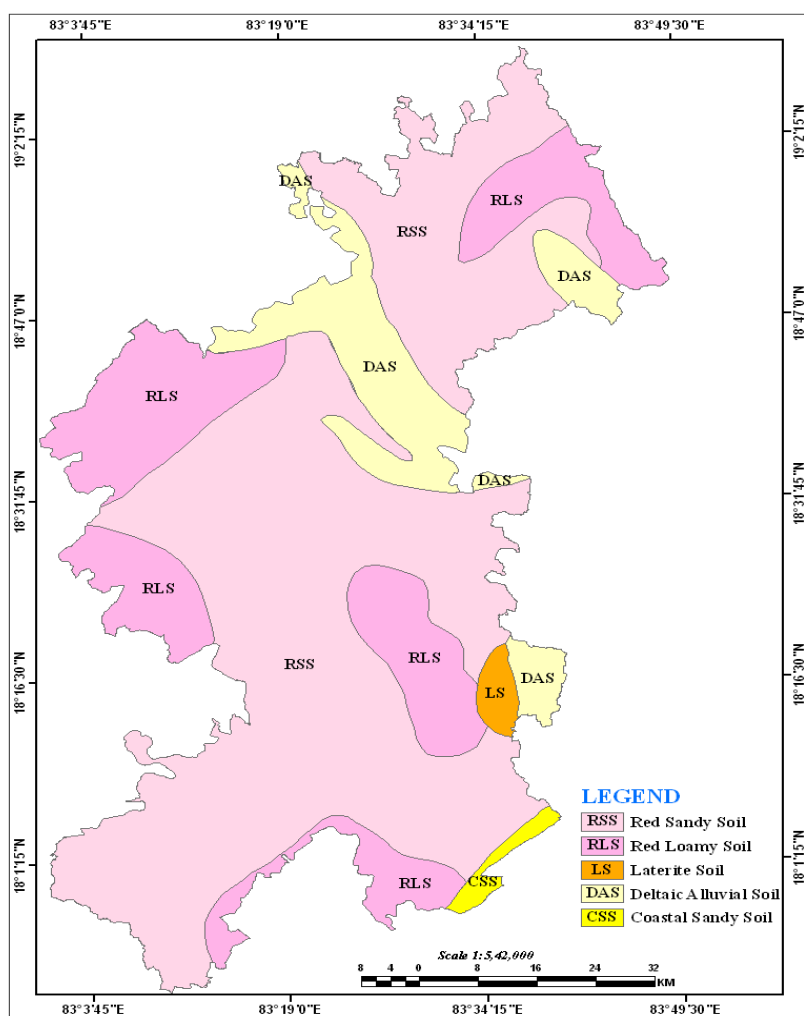

Fig 3. Soil types in the Study Area

Table 1. Soil types existing in the District

Sl.No.	Soil Type	Percentage
1	Sand	05
2	Loamy sand	22
3	Sandy Loam	37
4	Sandy Clay Loam	25
5	Clay Loam	08
6	Clay	03

Soil Slope

Slope refers to inclination of the land surface. It is defined by the gradient, shape and length which form integral part of soil as a natural body. The length and gradient of slope influence soil formation, depth, process of erosion and affect land use and development. In the study area there are gently sloping lands in Bobbili, Therlam, Cheepurupalli, Garividi, Gurla, and Kothavalasa mandals followed by steeply sloping lands in Gajapathinagaram and Vepada mandals. In Saluru, steeply sloping and moderately sloping lands are extensive in area whereas in Pachipenta and Ramabhadrapuram mandals, gently sloping lands are available moderately sloping lands occur in Parvathipuram, Komarada, Makkuva and Badangi mandals. Steeply sloping lands occur in large areas in Kurupam and Gummalakshmipuram mandals.

Soil Texture

Soils are also classified on the basis of texture. Soil texture refers to the size of soil particles and their arrangement. Soil texture indicates the relative proportion of primary particles of sand clay present in the top 25cm soil depth. The surface soil textural class provides a guide to understand soil water retention and availability, nutrient retention, infiltration, physical and chemical behaviour, microbial activity and crop suitability. As agriculture yield is highly influenced by the existing textural conditions, a description of soil texture needs mention. The textural classes of soils of Vizianagaram district is presented in Table 3. Sandy loam soils with 37 percent predominant soils in the district. Sandy clay loam soils account for 25 percent followed by loamy sand soils with 22 percent represent second order of soil texture. Clay loam soils occupy 8 percent of the total soils followed by sand with 5 percent and clay soils with 3 percent which occur in small areas.

Soil Degradation

Soil degradation refers to the decline in productivity of soils due to natural or human induced process such as floods, earth quakes, volcanic eruptions, excessive irrigation, deforestation, overgrazing, excessive use of chemical fertilizers and pesticides. All these processes reduce the productive capacity of the soils, affecting food security. Moderate soil erosion occurs in Bobbili Seethanagaram mandals. Moderate water erosion and water logging / flooding are the major degradation process prevalent in Vizianagaram, Pusapatirega, Denkada, Gantyada and Bhogapuram mandals. Slight to moderate erosion as major degradation process is prevalent in Kothavalasa division. Moderate to extreme water erosion is major degradation problem prevalent in Kurupam and Gummalakshmipuram mandals.

Land use/cover

Agricultural land includes cultivated crop land in both Rabi as well as Kharif seasons and agricultural plantations. The total area under this category is 4,423.6 km^2, which comes out to be 68 percent of the total geographical area of the district (Fig. 4 & Table.2). The total area occupied by the forests is 972.82 km^2 and accounts for 14.87 percent of the total geographical area of the district. There are some reserved forests in the district. Waste land category includes mainly dense scrub land covered an area 451.69 km^2 while at few places; patches of open scrub land prevail in the north eastern part of the district. The covered urban area of 20.69 km^2 of land represents 0.3 percent of total geographical area of the district. The rural built up land covered 71.89 km^2 of area accounts for 1 percent of total geographical area (Fig 4). Hence, the total area under built up land covered 1.3 percent of the total geographical area of the district. The area occupied by these tanks comes out to be 405 km^2, which is 6.1 percent of the total geographical area shown in table 2. The area under tank irrigation is about 49 percent of the net irrigated area.
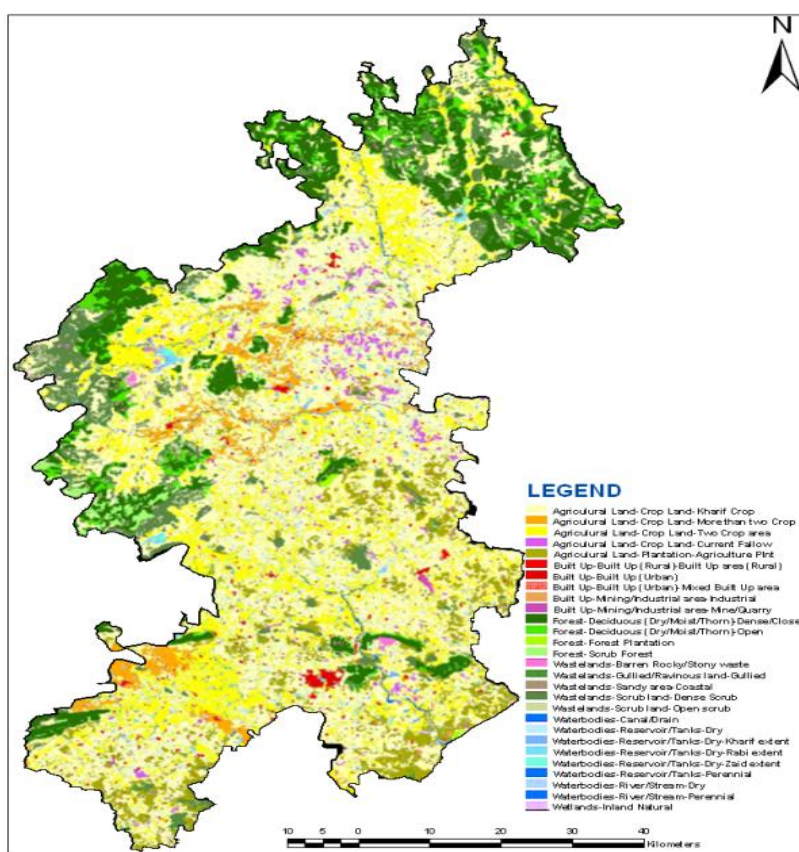
Fig.4. Land Use/ Land Cover map of the study area

Table.2 Land Use/ Land Cover Statistics

Land Use/ Land Cover category			Area	
S.No	Level I	Level II	Area in Sq.kms	% of the total geo. area
1	Agricultural Land	Crop land	3944.2	60.3
		Plantation	479.4	7.7
Sub total			**4423.6**	**68.0**
2	Built up Land	Urban	20.69	0.3
		Rural	71.89	1.0
Sub total			**92.58**	**1.3**
3	Forest	Forest-deciduous dry/moist/thorn/dense	710.36	10.8
		Forest deciduous - open	178.40	2.7
		Forest- Plantation	5.61	0.08
		Forest- Scrub Forest	78.45	1.1
Sub total			**972.82**	**14.87**
4	Waste Land	Barren Rocks/stony waste	36.14	0.5
		Gullied/Ravenous land	42.96	0.6
		Sandy area –coastal	1.86	0.02
		Scrub land -dense scrub	451.69	6.9
		Scrub land -open scrub	100.18	1.5
Sub total			**632.8**	**9.67**
5	Water bodies	Canal/drain	2.09	0.03
		Reservoir/tanks-dry	175.76	2.68
		Reservoir/tanks-dry Kharif extent	94.10	1.43
		Reservoir/tanks-dry Rabi extent	39.76	0.60
		Reservoir/tanks-dry zaid extent	16.04	0.2
		Reservoir/tanks-Perennial	5.25	0.08
		River/stream-dry	40.82	0.6
		River/stream- Perennial	31.52	0.48
Sub total			**405.34**	**6.1**
6	Other	Mining/industrial	11.14	0.1
		Wet lands- inlands	0.67	0.01
Sub total			**11.81**	**0.11**

Land Capability

Land capability classification is the grouping of soil map units to show the capability of the soils to produce field crops or to be put to other uses on sustained basis. The assessment of physical quality and agricultural potential of land is also known as "land capability". The quality of land and its soil depend on the parent material, temperature, rainfall, water retaining capacity, soil texture, soil structure and humus content. Land classification, on the basis of land capability has been considered as important document for the planning and development of agriculture. Land capability classification is a scientific appraisal of the physical characteristics of land, its inherent soil qualities and the farm management practices. The land capability maps are more useful for the delineation of potential arable lands. The land capability classification indicates the relative suitability of land for sustained production of common agricultural crops and other uses adapted to the existing physical and environmental condition. Any physical development of the land or physio-chemical changes of the soil may likely to change land capability classes. In that respect land capability classification is an economic evaluation of land at the time of field survey and not potentiality classification for crops. The physical suitability of an area or the suitability of land has a great influence on its multiple uses. It express the degree to which the sustained implementations of a land use on a certain land unit is feasible without risk to the human or natural environment.

In India, the primary aim of soil survey is to achieve land capability classification. The all India Soil and Land Use Survey Organization, 1970 has identified eight different land use capability classes as given below.

Land Suitable for Cultivation

Class I: Very good cultivable land with no specific difficulty in farming.
Class II: Good cultivable land which needs protection from erosion or floods, drainage improvement and conservation of irrigation water.
Class III: Moderately good cultivable land where special attention has to be paid to erosional control, conservation irrigation water, intensive drainage and protection from floods.
Class IV: Fairly good land suited for occasional or limited cultivation, needs intensive erosional control, intensive drainage and very intensive treatment to overcome soil limitations.

Land not Suitable for Cultivation

Class V: Very well suited for grazing but not arable farming, needs protection from gullying.
Class VI: Well suited for grazing or forestry but not for arable farming.
Class VII: Fairly well suited for grazing or forestry but not for arable farming.
Class VIII: Suited only for wildlife, recreational facilities and protection of water supplies.

Based on the limitations of climate, drainage conditions, erosion, and soil factors, land capability was worked out for the study area. Soils suitable for agriculture are grouped under classes I to IV and soils which are not suitable for agriculture are grouped into classes V to VII for pasture / forestry / wild life/ recreation. Land capability classes and areas designated under different land capability classes in the study region shown in table 2.

Class-II, Class-III, Class-IV and Class-VII land capability classes are identified in the study area. Class-II lands are found in three mandals out of 34 mandals. They have to good cultivation in that mandals. Class-III lands are found in four mandals of 34 mandals, they have to moderately good cultivation in that mandals. Class-VII lands are found in five mandals of thirty four mandals, they have utilized in that area are grazing lands and forestry cover (Table 3).

Most part of the study region comes under the category of moderately good cultivation and few areas are highly productive/ good cultivation (Fig 6). Northern parts and small portion of southern part of the district comes under low productive category. Areas include G.L.Puram, Komarada and Kurupam in the north and Saluru and Parvathipuram in northwest come under non productive category on account of forest cover (Fig.5 & Table 3).

Land Suitability

The information on land suitability gives an idea about the soils, which are suitable(S) and not suitable (N) for a given crop. Within the class suitable, soils are further grouped into highly suitable, moderately suitable and marginally suitable. There are about 13 factors considered as limitations affecting the preferences of the crop. Based on these limitations, land suitability was worked out for the study area. The following land suitability classes are observed in Vizianagaram district (Table.4).
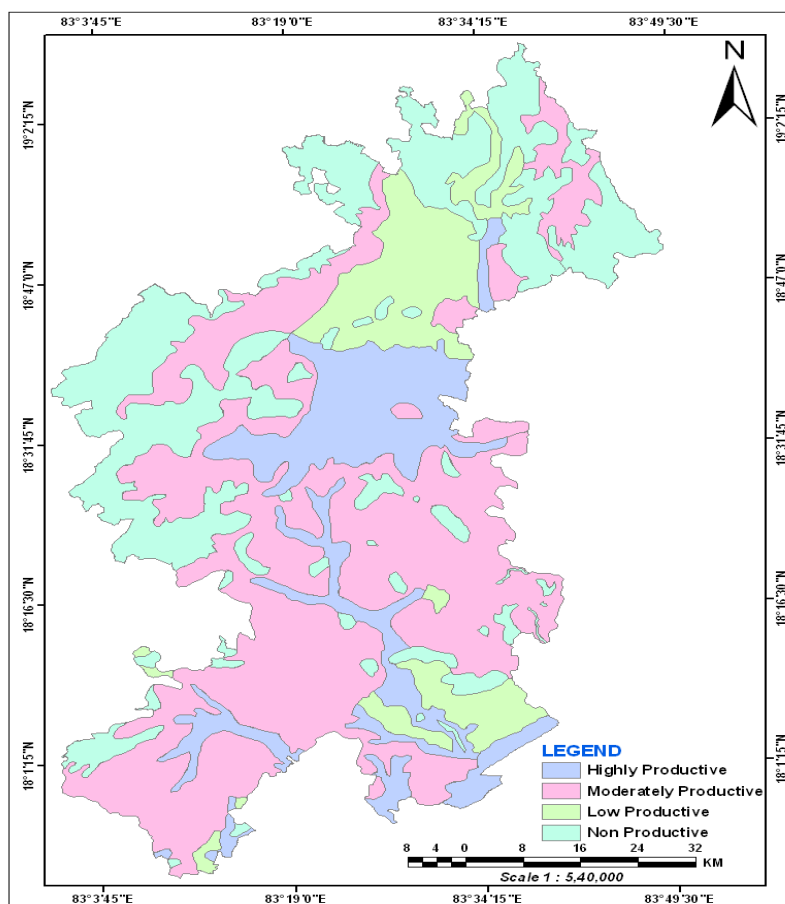
Fig 6. Land capability in Study area

The land suitability classes are four categories are indentified, i.e; highly suitable lands, moderately suitable lands, moderately suitable lands followed by unsuitable lands and unsuitable lands. Highly suitable lands are found at Seethanagaram, Bobbili, Baljipeta and Garugubilli mandals. They can be used for cultivation of Sugarcane and paddy. Moderately suitable lands are found at Gajapathinagaram, Jami, Vizianagaram, Gantyada, Bhogapuram, Mentada, Dattirajeru and Pusapatirega mandals. They can be used for paddy, groundnut,maize, blackgram, greengram and tobacco (Table.4). Unsuitable lands are found the Saluru, Kurupam, Pachipenta, Jiyyamvalasa, S.Kota, L.Kota, Kothavalasa, Bondapalli, Parvathipuram, Makkuva and Gearividi. They can be used for cashew nut, mango, casuarinas, and eucalyptus and grazing lands.

All these lands are suitable for cultivating irrigated rice, irrigated sugarcane, rainfed Ragi and rainfed Sesamum mainly. Other crops are also can be cultivated in limited areas under rainfed conditions. Unsuitable lands occupy forest areas.

Table 3. Land Capability Classification in the study area

Capability Class	Mandals
Class II (good cultivation)	Makkuva, Vepada, S.Kota
Class III (Moderately good cultivation)	Badangi, Parvathipuram, Saluru, Komarada
Class III (Moderately good cultivation) Followed by Class II (good cultivation)	Seethanagaram, Bobbili, Baljipeta, Therlam, Garividi, Nellimarla, Gantyada, Pusapatirega, Jami, Bhogapuram,L.Kota, Ramabhadrapuram, Garugubilli, Merakamudidam, Gajapathinagaram, Dattirajeru
Class IV (fairly good land)	Mentada
Class VII (suited for grazing/forestry)	Kurupam, Gummalaxmipuram, Pachipenta, Bondapalli, Kothavalasa

Table 4. Land Suitability Classification in the study area

Land suitability	Land unit (Mandals)	Suitable crops
1.HighlySuitable lands	Seethanagaram, Bobbili, Baljipeta, Garugubilli	Sugarcane, Paddy
2.Moderately suitable lands	Gajapathinagaram, Jami, Vizianagaram, Gantyada, Bhogapuram, Mentada, Dattirajeru, Pusapatirega	Paddy, Groundnut, Maize, Black gram, Greengram,Tobacco
3.Moderately suitable lands followed by unsuitable lands	Ramabhadrapuram, Gummalaxmipuram, Gurla, Nellimarla, Therlam, Badangi	Mesta, Blackgram, Ragi, Vegetables, Banana,
4. Unsuitable lands	Saluru, Kurupam, Pachipenta, Jiyyamma valasa, S.Kota, L.Kota,Kothavalasa, Bondapalli, Parvathipuram, Makkuva, Garividi	Cashewnut, Mango, Casuarinas, Eucalyptus, Grazing lands, forests

V. Conclusions And Suggestions

The analysis of land capability and Land suitability resources based on physical aspects using Survey of India topographic sheets, IRS P6 LISS-III data on scale 1:50.000 revealed that the whole basin could be divided into seven major classes. The standard of living of the people depending on agriculture which is often determined by the fertility and productivity of soils. Low organic matter content and less water holding capacity in majority of the red sandy soils of the district are identified. The district is not well placed in respect of irrigation facilities. Most part of the study region comes under the category of moderately good cultivation and few areas are highly productive/ good cultivation. Northern parts and small portion of southern part of the district comes under low productive category. Areas include G.L.Puram, Komarada and Kurupam in the north and Saluru and Parvathipuram in northwest come under non productive category on account of forest cover. The land suitability classes are divided four categories highly suitably lands, moderately suitably lands and unsuitably lands. Unsuitable lands are used for cashew nut, mango, casuarinas and eucalyptus and grazing lands.

Acknowledgement

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