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Optimal Land Use Planning by using GIS

A case study of cuddapah district

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***Abstract*—Land use planning in rural areas has received scant attention in a country like India, which is predominantly agricultural. Land use planning is concerned with the future use of the land and the changing demands of the Society. The availability of satellite data for large areas to assess the natural resources and reconnaissance surveys within a short period of time has forced us to use the information of planning and development. This will indicate land capability, after which a land development plan indicating the best land use pattern for the area covered and taking into account all the relevant factors can be prepared.**

In the present study use of GIS for Optimal Land Use Planning, a case of Cuddapah District is taken. A scheme for thematic data integration and recommendation for various combinations of land parameters was evolved. The preparation of action plan for land resources involves the integration of layers such as land use and soil. Preparation of action plan involves the suggestion of alteration of present system of land use or alternate system, depending on the local condition of prevalence of practice and socio-economic conditions. The present study has successfully proved the validity of the adoption of GIS for optimal land use planning and development.

***Index Terms*: Land Use / Land Cover, GIS, Remote Sensing, Hydrogeomorphology**

I. Introduction

Most developing countries are very largely dependent on the utilization of natural resources for their immediate advancement. This Advancement involves a change in existing use of resources to higher levels, or more complete use of resources, which are at present only partially used or completely neglected. Each country has its own sociological, economical and cultural hopes and ambitions. To make decisions wisely and to establish an order faced for national efforts, a thorough knowledge of a country's natural resources, their nature, geographic distribution and magnitude, limitations, present stage of utilization and scope for better use is essential. Presently the information on Soil, Ground Water and land use/land cover in Cuddapah district is available at 1:250,000 scale. To begin with the action for optimal land use planning and its management it is worthwhile to analyze the available information and integrate for the process of generating suitable action plan.

II. Objectives

The study is designated with the following objectives:

- To evaluate the land resources of the district using satellite data.
- To Create and organize an error free digital data for all the natural resources in the form of separate layers for the Cuddapah District.
- To analyse the land resource data and integrate in GIS domain for generation of action plan.
- To generate optimal land use plan in GIS Domain.

III. Study Area

Cuddapah District is in Rayalaseema Region of Andhra Pradesh situated within the geographical co-ordinates of 13º 50' to 15º 15' of North latitude and 78º 0' to 79º 20' of eastern longitude included in Survey of India toposheets 57 J, K, N, O, I and M. Cuddapah District is in the eastern part of the Rayalaseema Region with a geographical area of 15,380 sq km with a Population of 25,73,481 as per 2001.

IV. Geology, soils, geomorphology and hydrogeology

The oldest rocks of the area belong to late Archaean or early Proterozoic era which is succeeded by rocks of Dharwarian age and both are traversed by dolorite dykes. The olden rocks are overlain by rocks of the Cuddapah Supergroup and Kurnool Group belonging to Middle and Upper Proterozoic age. Black clay is the most fertile soil and found in Jammalamadugu, Pulivendla, Proddatur and Kamalapuram areas. Red loam is found extensively in Rajampet and Badvel areas. The Red sand occurs in Rayachoty and nearly places. The district is drained mainly by the river Pennar and its major tributaries like Cheyyeru, Kunderu and Stagier. The southern granitic terrain is drained by Mandvi River, a tributary of Cheyyeru. The drainage is parallel to subparallel in nature and controlled by structure. Groundwater occurs under water table conditions in the weathered zones of granites, schists and dykes. Wells dug into these rocks yield water from the numerous joints, fractures and fissures present in them.

International Journal of Advanced Research Foundation
Website: www.ijarf.com, Volume 2, Issue 1, January 2015)

V. METHODOLOGY

A. Land Use Planning

Land use planning in rural areas has received scant attention in comparison with town planning until recently. The land use/ land cover categories of the District have been grouped into Six Level-I classes Viz., built-up area, agricultural lands, forestlands, wastelands, water bodies and others. A detailed description of each of the land use/land cover class is described in the *TABLE I*. with sub sections. Find the Land Use / Land Cover Map in the given figure (Fig.1).

B. Brief Description of Various Ground Water Potential Zones

Salient features of various Ground water potential zone units (Fig.2), delineated in the District are given here under.

1) Zone I

It consists of geomorphologic units like Flood plains, Piedmont zone, Bazada, Moderately weathered pediplain with black soil & canal irrigation and Intermontance valley. The Piedmont zone has a narrow strip of gently sloping plain along foot hills. The ground water prospects are Very good to good.

2) Zone II

It consists of geomorphologic units like Moderately Weathered Pediplain, Moderately weathered pediplain with black soil cover, Deeply weathered pediplain and Shallow dissected pediplain. The ground water prospects are good to moderate.

3) Zone III

It consists of geomorphologic unit Shallow Weathered Pediplain. The shallow weathered Pediplain has a structure with massive granite and foliated gneiss with joints, faults and fractures. It has gently undulating plain with 0-5m deep weathering. The ground water prospects are moderate to poor.

4) Zone IV

Mesa/Butte has flat-topped hills bounded by escarpment/steep slopes. These are not suitable for ground water occurrence. Butte exits as dissected flat upland, which is bounded by escarpments/steep slopes but are limited in aerial extents. But limited ground water may occur as perched bodies. Cuesta hills capped by gently dipping quartzite beds. The ground water prospects are poor.

5) Zone V

It has geomorphic units like Residual hills, Structural hills, Linear Ridge and Inselberg. Residual hills occur as group of massive granite and foliated gneiss with joints, fractures and faults. Limited water occurs in the weathered/fractured zones along the valleys. The ground water prospects are poor to nil.

C. Soils

Soil is the basic and non-renewable natural resource support for agriculture and various developmental activities and economic growth of a region. More so, it is true for a drought-prone area wherein the ecosystem is fragile and the sustainable development requires a very careful and optimal utilisation of available land and water resources while maintaining a good harmony with the environment. A brief description of soil series identified in the District based on Soil Survey Manual.

D. Land Capability Classification

Land capability classification is an interpretative grouping of soils mainly based on a) the inherent soil characteristics, b) external land features, and c) environmental factors that limit the use of land. Scientific soil surveys provide information on first two aspects. In the land capability classification there are eight classes. Classes II and III include the land suited for regular cultivation. Class IV land is fairly good for cultivation, but its safe use for cropping is very limited by natural features such as erosion, unfavorable soil characteristics and adverse climate. Classes VI and VII are not suited for any cultivation but may be used for grazing or forestry, according to adaptability. Class VIII land is only suited for wildlife, recreation or watershed protection. The following table shows the soil mapping unit groupings for each of the 6 land capability class namely II, III, IV, VI, VII and VIII in the study area. Detailed soil grouping of land capability is described in the *TABLE II*.

VI. RESULTS AND CONCLUSIONS

A. Preparation of Action Plan

The strength of GIS is the integration of multi-layered data from different sources and various scales. Database management systems integrated with graphic interface have a powerful query capability. This will finally give the analytical ability to pose complex query and extract information spatially.

B. Land Use Planning

Based on careful integration of information on soil, land use/ land cover, the following action plan has been formulated in development of land, soil and water conservation. Find the Proposed Land Use Map in the given figure (Fig.3) and Proposed Treatment in figure (Fig.4). Detailed description of the proposed land and proposed treatment along with mapping units are tabulated in the given tables *TABLE III* and *TABLE IV* respectively.

International Journal of Advanced Research Foundation
Website: www.ijarf.com, Volume 2, Issue 1, January 2015)

C. Conclusions

The IRS–1B LISS II sensor with spatial resolution of 32.5m is used to obtain information on land use over two seasons. Landform mapping for water resources targeting is also carried out using the IRS-1B data. The present study helped in the reconnaissance survey of the area as well as integrating the information to look at different scenarios in the landscape and plan for sustainable use of the land. The approach has given good insight into the areas potential for alternate land use. The action plan prepared using this approach shall help the administrators in taking decisions regarding resource use and mobilization of support for a change. The action plan not only serves as a guide but also as a blue print for natural resource management for sustainable development. Integration of information being the sole operation involved in this study and an action plan is formulated for development of land resources and eventually land use planning.

TABLE I. AREAL EXTENT OF VARIOUS LAND USE/LAND COVER

Mapping Unit	***Land use/Land cover category***	***Area Sq.Km***	***% Area***
1	Built-up land	9.10	0.059
2	Kharif	4553.02	29.603
3	Rabi	16.60	0.107
4	Double Crop	1940.38	12.616
5	Fallow Land	0.72	0.004
6	Plantation	228.37	1.484
7	Deciduous forest	3250.01	21.131
8	Degraded forest/Scrub land	1479.00	9.616
9	Forest Blank	2.54	0.016
10	Forest plantations	32.23	0.209
11	Land with or without Scrub	3121.40	20.295
12	Salt Affected Land	13.15	0.085
13	Sandy Area	25.62	0.166
14	Barren Rocky/ Stony Waste/ Sheet rock area	181.15	1.177
15	Res. / Lake/Tank/Canal	255.41	1.660
16	River/stream	268.87	1.748
17	Mining Area	2.43	0.015

TABLE II. SOIL GROUPING FOR LAND CAPABILITY

Land Capability	***Soil Mapping Unit***	***Capability***
II	9, 29, 30	Regular cultivation.
III	1, 2, 3, 4, 5, 14, 15, 18, 20, 23, 28, 31, 32, 33	Regular cultivation.
IV	6, 19, 24, 25	Fairly good for cultivation, but it's safe use for cropping is very limited by natural features such as slope, erosion, unfavorable soil characteristics and adverse climate
VI	7, 8	Grazing or forestry, according to adaptability
VII	16, 17, 21, 22, 26, 27	Grazing or forestry, according to adaptability
VIII	10, 11, 12, 13, 34, 35, 36	Wildlife, recreation or watershed protection.

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International Journal of Advanced Research Foundation
Website: www.ijarf.com, Volume 2, Issue 1, January 2015)

TABLE III. PROPOSED LAND USE

Mapping Unit	*Class*	*Proposed land use*	*Area sq km*
I	1	Double crops with preferably with ID crops. Except in saline & water logged patches.	1940.38
II	3, 7	Orchards like Mango, Citrus, Tamarind etc.	505.64
III	2, 6, 8	Long duration crops like Cotton, Chillies, Red gram, Sugarcane etc.	3006.69
IV	4, 9, 10	Short to medium duration crops like Groundnut, Sunflowers.	806.77
V	5, 11, 12	Short duration crops like Jower, Ragi etc.	400.20
VI	13, 14	Short duration crops like Horse gram, Fodder jower etc.	1014.00
VII	15, 16	Dry land Horticulture like Ber, Guava, and Pomogramet.	61.79
VIII	17, 18	Silvipasture forestry (Eucelyptus).	3104.37
IX	19	Afforestation programme with suitable species.	3000.01
X	20	Rehabititation, Stone Quarries etc.	1540.14

TABLE IV. PROPOSED TREATMENT

Mapping Unit	*Class*	*Proposed treatment*	*Area sq km*
I	1	Systematic water management with periodic soil testing for salinity.	1940.38
II	2, 10	Soil and moisture conservation by Agronomic measures and Farm ponds with sufficient drainage network.	2050.07
III	5	Soil and moisture conservation by Agronomic measures (Contour ploughing) and Farm ponds.	30.20
IV	3, 6, 7, 8, 9, 12, 14	Contour bunding, Earthen / Rockfill check dams & Farm ponds – Percolation tanks.	2625.70
V	4, 11, 13	Contour bunding, masonry check dams and Farm ponds, Percolation tanks	1027.33
VI	15, 16	Staggered contour trenches.	61.79
VII	17, 18	Diversion drainages, catch pits, etc.	3104.37
VIII	19	Reserved Forest (Not in).	3000.01
IX	20	Rocky Area	1540.14

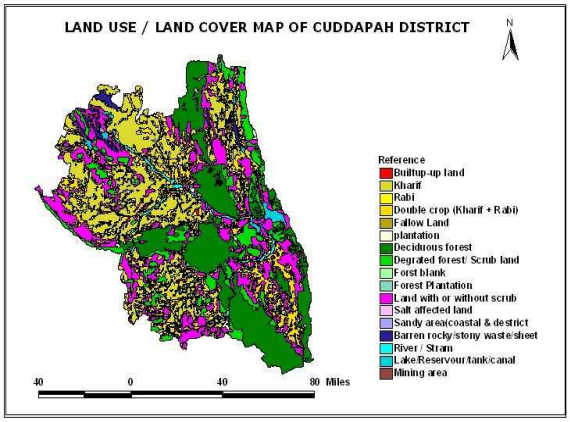

Fig. 1. Land Use / Land Cover Map of Cuddapah District

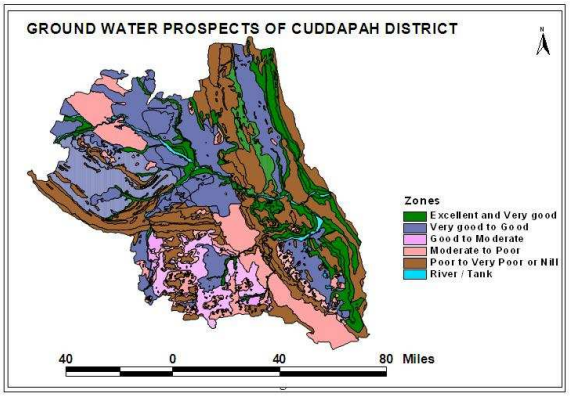

Fig. 2. Ground Water Prospects of Cuddapah District

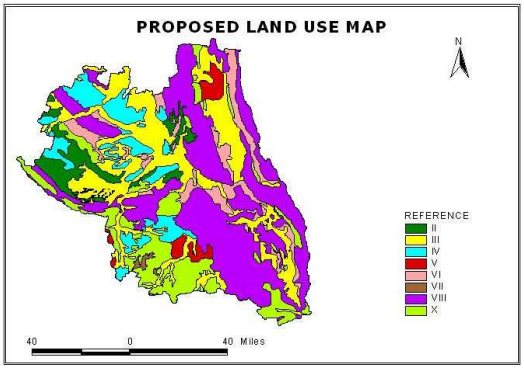

Fig. 3. Proposed Land Use Map of Cuddapah District

International Journal of Advanced Research Foundation
Website: www.ijarf.com, Volume 2, Issue 1, January 2015)

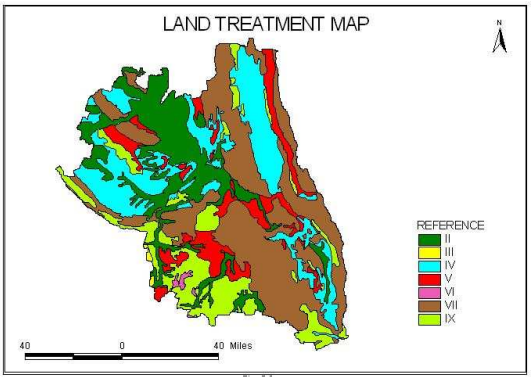

Fig. 4. Proposed Treatment Map of Cuddapah District

AUTHORS PROFILE

Dr. M. Sunandana Reddy obtained M.Tech (Remote Sensing & GIS) from Bharathidasan University, Trichy, T.N. in the year 2004 and awarded Ph.D in Water Resources Development by using Remote Sensing and GIS Applications from Sri Venkateswara University, Tirupati, A.P. in the year 2011. He has vast experience in the field of Remote Sensing and GIS applications in various natural resources and worked under various organizations for different research projects. Presently working as Associate Professor in the department of Civil Engineering, CMR Technical Campus, Hyderabad.