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High resolution satellite data for optimal land use planning - A case study of Malkapur and Kummera Villages, Chevella Mandal, Rangareddy District, Andhra Pradesh

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ABSTRACT

Land use planning the key for judicious and optimum utilization of available natural resources is indispensable for development of any region from local to trans-national level. In the present paper remote sensing data combined with geographic information systems (GIS), an effective technology has been applied for land use planning in Malkapur and Kummera villages, Chevella mandal, Rangareddy District, Andhra Pradesh. Land use/land cover, land capability and groundwater potential generated on 1:25,000 scale. The maps are integrated after assigning weightage factors to the identified features in each of the thematic maps depending upon their characteristic features/ importance. On the basis of present investigation the study area could be classified into various optimal land use planning units. The results show that integration of all attributes provides more accurate information for optimal land use planning.

INTRODUCTION

The remote sensing technology and GIS tools have opened new paths in land use planning. GIS is a powerful set of tools for collecting, storing, retrieving at will, transforming and displaying spatial data from the real world (Burrough 1986).Spatial data from remote sensing enables optimal land use planning; whereas, GIS enables user-specific management and integration of multi-thematic data. The integration of remote sensing studies and GIS techniques has proved to be extremely useful, and an attempt is made to optimal land use planning in Malkapur and Kummera villages, Chevella mandal, Rangareddy District, Andhra Pradesh.

STUDY AREA

The study area covering 12.216 km^2 lies between North latitudes 17° 18' 00'' and 17° 21' 00'' and East longitudes 78° 08' 30'' and 78° 11' 30'' in Survey of India toposheet No. 56K/3/SE at 1: 25000 scale (Fig.1). The region experiences hot summer (March to May) with mean daily maximum and minimum temperatures of 28.6°C and 13.6°C respectively and normal annual rainfall of 781 mm. The climate is dry except for southwest monsoon (June to September). The total population of the study area is 2,858. The density of population is 234 per km^2 and the percentage of literacy is 49.9 (Census of India 2001).

DATA USED AND METHODOLOGY

Multi-thematic mapping is done by using primary and secondary data. False color composite satellite image (23.5m resolution) of Kharif season, IRS-P6, LISS-III path/row 99/60 of 11th June 2006 and QUICK BIRD Satellite image (0.6 m resolution) path/row 99/60 of December 2005 (Fig.2) are acquired from NRSC. Cadastral maps of two villages and rainfall data of Chevella mandal have been collected from the Mandal Revenue Office. Preparation and conversion of thematic maps into computer digital format, allocation of weightage factors and integration of thematic maps have been carried out for preparation of action plan for optimal land use planning. False color composite images are visually interpreted using standard photo-recognition elements viz., size, shape, shadow, location, texture,

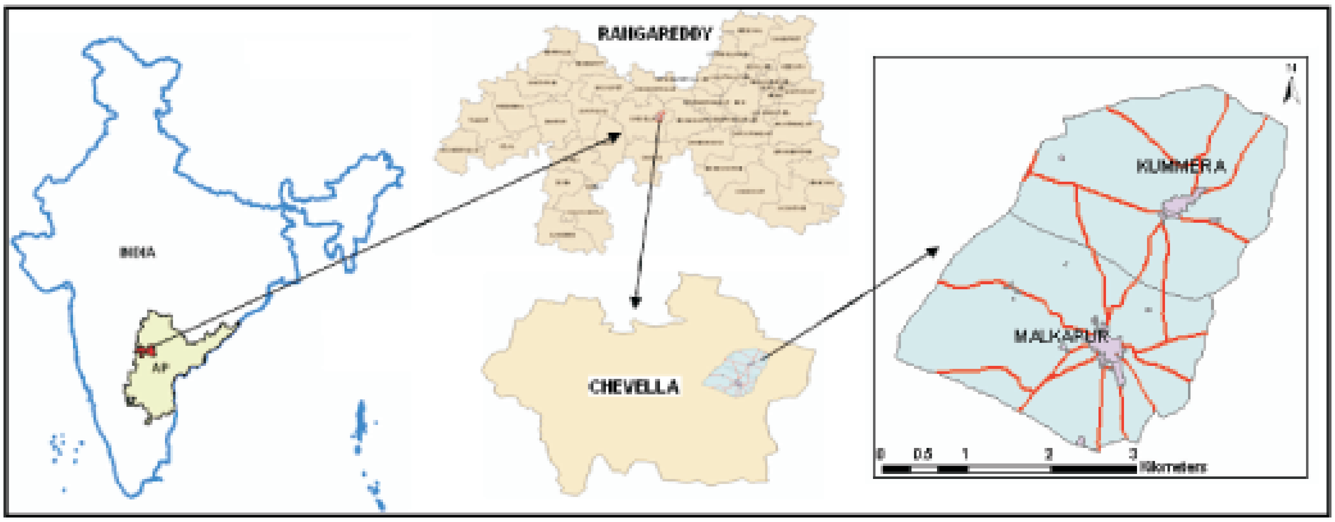
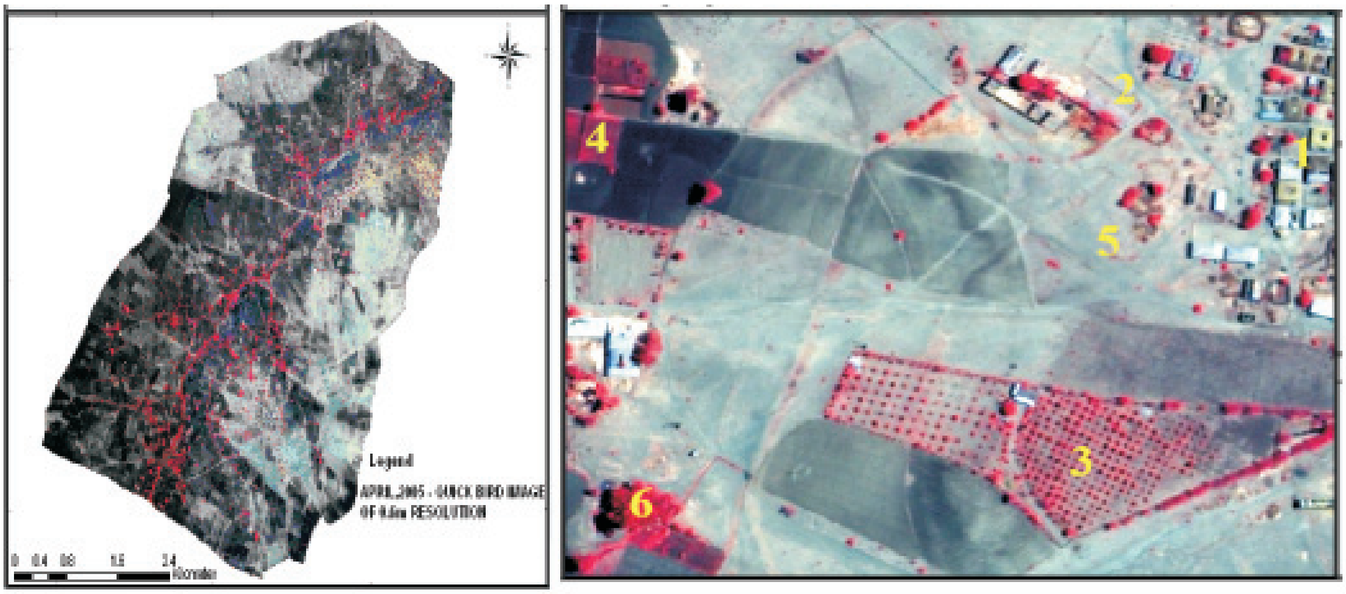


Figure 1. Location map of study area.



1: SETTLEMENTS, 2: UNMETTLE ROAD, 3: PLANTATION, 4: CROPS, 5: WASTE LAND, 6: TREES.

Figure 2. Quick bird image of Malkapur and Kummera village map.

tone/colour, pattern etc. The thematic maps of geomorphology, hydrogeomorphology, land use/land cover and ground water potential have been prepared. Geology and soil maps have been prepared from base maps of Geological Survey of India and National Bureau of Soil Survey and Land Use Planning. Maps of contour, drainage and slope have been prepared from the Survey of India topographical map. Ground truth survey has been conducted for confirmation of the features identified from remote sensing data. Ground water potential zones, land capability map and land use/land cover map are integrated in GIS domain for optimal land use planning.

DRAINAGE AND CONTOUR MAPS

Drainage map prepared from toposheet has been shown in Fig. 3. The drainage pattern is dendritic in granite terrain and parallel in Deccan traps. Survey of India toposheet on 1:25,000 scales has been scanned using A0 size flat bedded scanner and converted to uncompressed Tiff raster format. These maps have been projected to real world coordinate system. Elevation contours (Fig.4) (poly lines of equal elevation) have been digitized using ArcGIS 9.0 software. Drainage density is calculated as per the formula given by Horton (1945). The density is 2.59 km^{-1},which is an excellent type of drainage as per Deju (1971) classification signifies the faster runoff. Arc topology has been created by 'Clean' command. The coverage has been projected to polyconic projection after establishing tics to generate TIN, which is an essential part in surface modeling.

Slope map

Slope and relief are important for designing check dams, canal alignments, for assessment of land capability and formulating soil and water conservation measures and for transport planning. The slope has been measured by taking a ratio of difference in contour interval to horizontal distance between contours. In general, closely spaced contours represent steeper slope and sparse contours exhibit gentle slope, whereas in the elevation raster output every cell has a slope value. Here, the lower slope values indicate the flatter terrain (gentle slope) and higher slope values correspond to steeper slope. Most of the area is very gently sloping (Fig. 5). Some parts in the northern, north-western, north-central and southern areas are nearly level. The limits of each category of slopes are presented in Table 1.

Geology

The study area is covered to an extent of 79.82% by Deccan basalt formation (Fig. 6) comprising nearly horizontal lava flows (Dutt 1976). These flows have been considered to be a result of fissure type of lava eruption during the Cretaceous to early Eocene

Table 1. Slope categories.

Class	Slope value (degrees)	Slope Category
1	0-1.56	Nearly level
2	1.56-7.66	Moderately sloping
3	7.66-40.03	High sloping

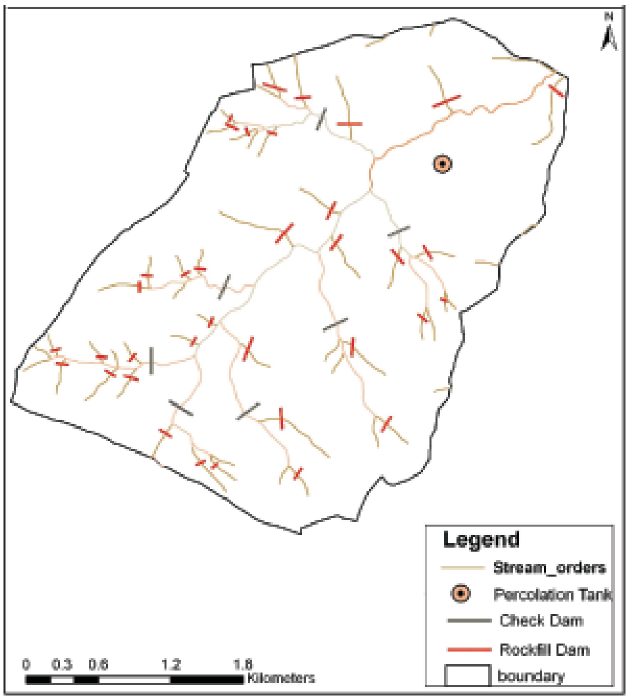


Figure 3. Drainage and Conservation map of study area.

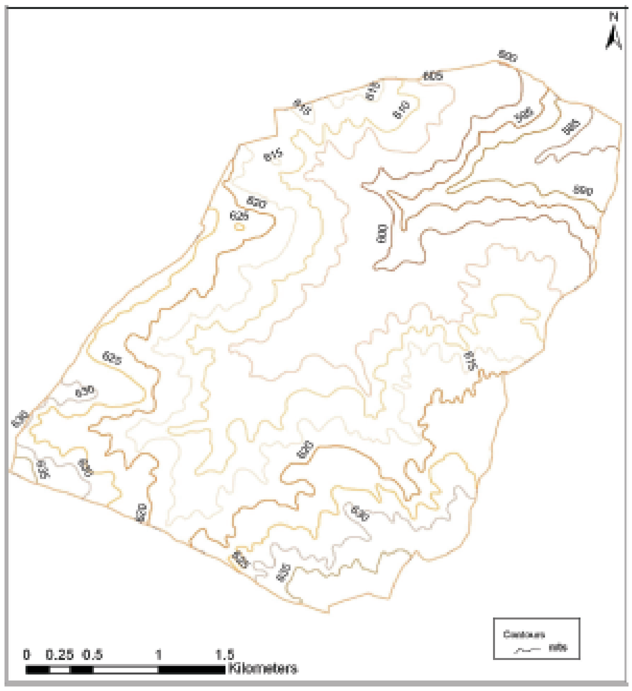


Figure 4. Contour map of study area.

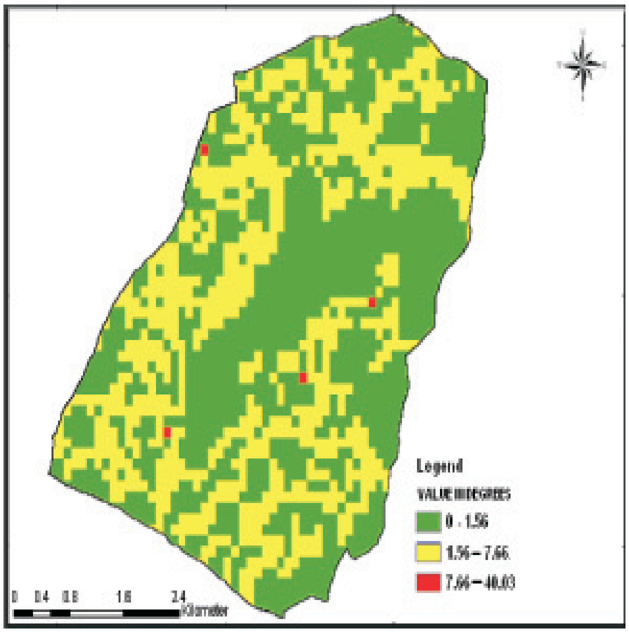


Figure 5. Slope map of study area.

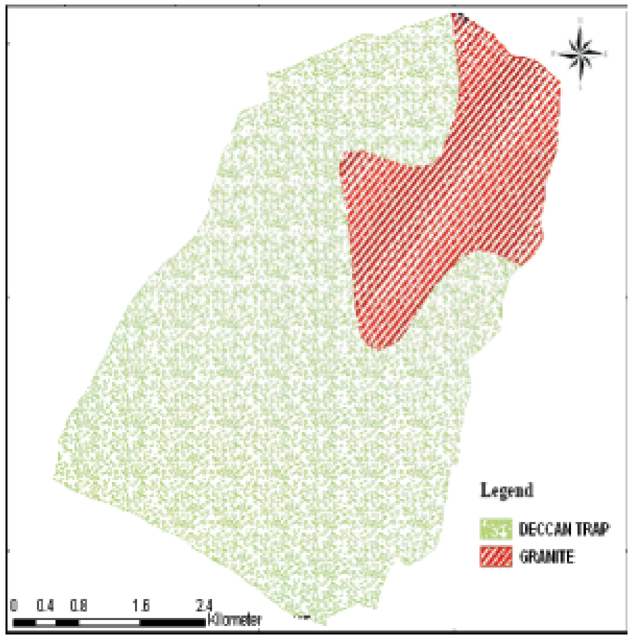


Figure 6. Geology map of study area.

period. The Deccan traps appear as step like terraces or plateaus occupying large areas**.** The types of basalts occurring in the area are compact basalt, vesicular, amygdaloidal basalt and red bole beds as observed in the well sections. Granites are covered in the surroundings of Kummera village. Basalts are the major litho units in the study area.

Geomorphology and Hydrogeomorphology

Landforms play a significant role in land resource mapping, watershed studies, terrain evaluation and soil classification in addition to groundwater studies. In the present study IRS P6 LISS-III path/row 99/60 11th June 2006 and SOI Toposheet no. 56K/3/SW on 1: 25,000 scale have been used to map various geomorphic features in order to delineate groundwater potential zones in the area.

The drainage pattern is dendritic in granite terrain and parallel in Deccan traps. The hard rocks viz., Deccan traps occupy 79.82%, granite occupies 20.18%. The depth to water table in granite varies from 5 m to 20 m. In Deccan traps, water occurs in fractures, crevices and joints. Ground water is moderately hard and it should be softened before use. The land forms in Malkapur village are the SW – NE direction around the stream flow and are moderately weathered plateau and in the surroundings of Malkapur, land forms are shallow weathered plateau. In the Northern and Southern parts there are undissected plateau land forms. In Kummera village, the stream surroundings are covered by pediplain moderate and the adjacent area of the landforms are pediplain shallow (Fig. 7).

Land use / Land cover

The land use classes identified in the study area using Quick Bird satellite image of Kharif season, path/row 99/60, December 2005 (Fig. 8) are built-up land, double cropped land, single cropped land, fallow land, Land without scrub, land with scrub, roads, settlements, water bodies (streams and tanks) and plantation (Table 2).

The double-cropped area is confined to major streams and the crops are cotton, jowar, ragi and vegetable crops such as onion, tomato; ornamental plants like some composites, roses etc. also are cultivated. The total double cropped area is 0.40 km^2, constituting 3.27 % of the study area. Single crop land area is extensively distributed through out. The total kharif un-irrigated or rain-fed i.e., single cropped area covers 6.07 km^2, accounting for 49.75% of the study area. The crops are cotton, chilies, jowar and pulses. Fallow land identified because of absence of crops during both the seasons extends over 1.68 km^2 or 13.75 % of total area. Scrub lands are generally prone to degradation or erosion. The total scrub land in the study area is 2.31 km^2, covering 18.8% of the study area. Land without Scrub is present at higher altitudes and hence prone to degradation or erosion. It is spread over 0.65 km^2, covering 5.32% of

Table 2. Distribution of land use/land covers classes.

S.No	Land use/Land cover unit	Area (km^2)	Percentage to total area
1.	Transportation	0.20	1.65
2.	Village Settlements	0.27	2.21
3.	Double Crop	0.40	3.27
4.	Single Crop	6.07	49.75
5.	Fallow Land	1.68	13.75
6.	Plantation	0.05	0.41
7.	Land with Scrub	2.31	18.80
8.	Land without Scrub	0.65	5.32
9.	Water bodies	0.58	4.74
Total		**12.21**	**100.00**

the study area.. The water bodies occupy 0.58 km^2, covering 4.74% and the land use classes transportation and village settlements occupy 1.65% and 2.21% of the study area respectively (Table 2).

Ground water potential zones

The Integrated Mission for Sustainable Development (IMSD) of NRSC, classified the ground water potential zones into five categories viz., zone I (very good), zone II (good to moderate), zone III (moderate to poor), zone IV (poor), zone V (very poor) on the basis of the ground water prospects(NRSC 1995). On this basis only zones II, III and IV are found in the study area.

a) Zone II

Zone II consists of geomorphologic units like moderately weathered uplands and moderately buried Pediplain. The moderately weathered uplands include lithostratigraphic units like feldspar and granites. The zone has a gently undulating plain with 5-15m deep weathering forming shallow aquifers. Plateaus are formed over horizontally layered rocks. The deeper aquifers occur along faults/fractures zones. It has good ground water prospects. The ground water prospects are good to moderate.

b) Zone III

Zone III consists of geomorphologic units like moderately dissected plateau and weathered uplands. It has gently undulating plain with 0-5m deep weathering and deep aquifers occur along fractures/ faults, bedding plains etc. The material lateritic in nature occurs as dissected flat upland, and plateau, which have potential for recharge. The ground water prospects are moderate to poor in this zone.

c) Zone IV

Zone IV consists of geomorphologic units mesa, butte and highly dissected plateau. Because of the topography these are not suitable for ground water occurrence. Limited ground water may occur as perched bodies in mesa and butte. Highly dissected plateau has deep valleys/gullies with sloping land developed due to stream/river erosion on plateau. The ground water prospects are poor in this zone.

Soils

Soil is the basic and non-renewable natural resource support for agriculture and various developmental activities and economic growth of a region. According to the soil mapping legend of All India Soil Survey Manual total Soil mapping units are 63 for Andhra Pradesh (AP), in that the study area comes under 22, 23, 24, 25, 26 and 27 (All India Soil and Land Use Survey Organization 1970). These are gravely clay soils (moderately eroded), gravely clay soils (severely eroded), gravely loam soils with stony surface, gravely loam soils (severely eroded), cracking clay soils and moderately deep, moderately well drained, cracking clay soils respectively.

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 (All India Soil and Land use Survey Organization 1970). Scientific soil surveys provide information on first two aspects. Land capability classification has eight classes. Classes I, II and III include the land suited for regular cultivation, class IV land is fairly good for cultivation, its use for cropping is limited by natural features such as slope, erosion, unfavorable soil characteristics and adverse climate. Class V, VI and VII are not suited for any cultivation but may be used for grazing or forestry, according to adaptability. Class VIII is suited for wildlife, recreation or watershed protection (All India Soil and Land Use Survey Organization, 1970). Table 3 shows soil mapping unit groupings for each of the land capability classes namely IV and VIII in the study area and occupancy of these units are shown in Fig.9.

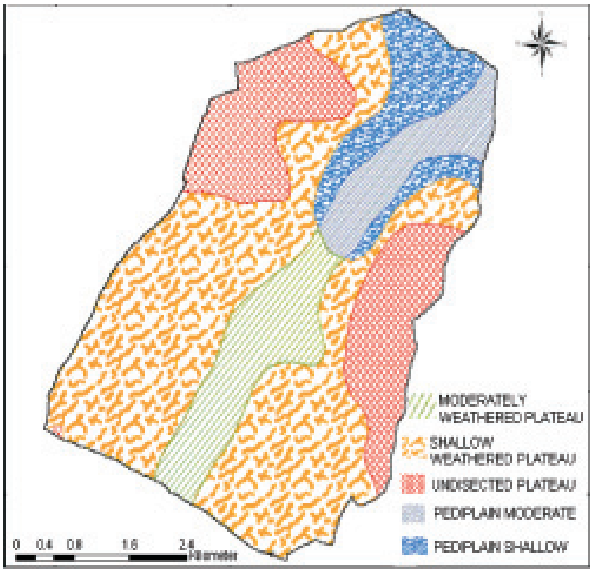


Figure 7. Geomorphology map of study area.

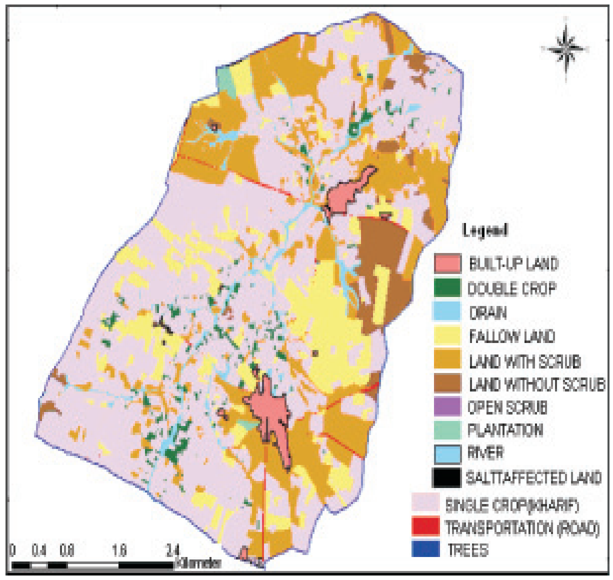


Figure 8. LULC map of study area.

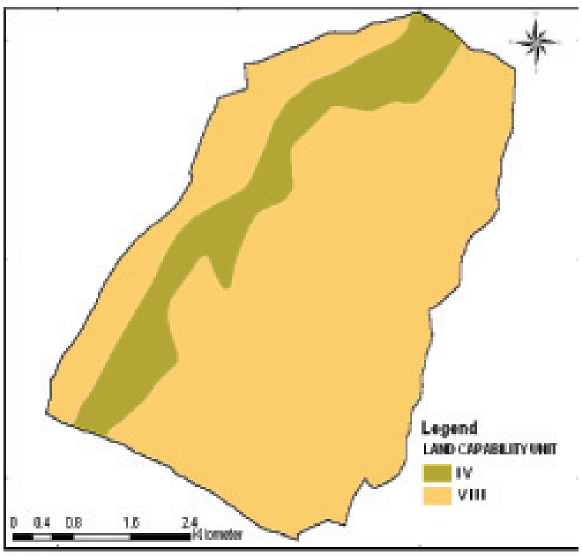
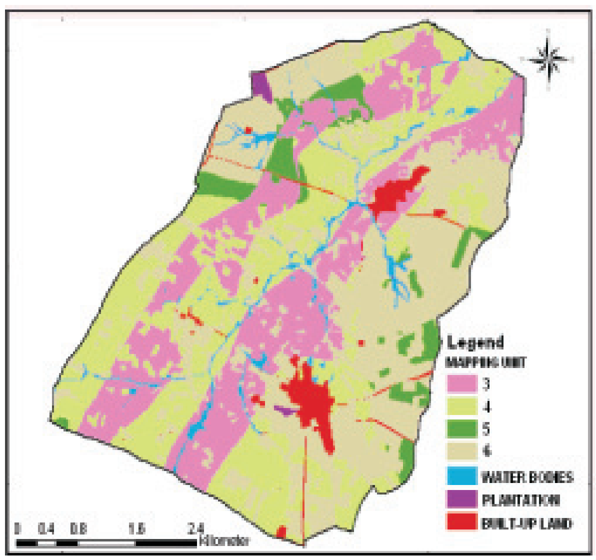


Figure 9. Land capability map of study area.



3. INTER CROPPING WITH SHORT AND LONG DURATION CROPS,
4. SHORT DURATION CROPS, 5. SILVIPASTURE / SILVIHORTICULTURE,
6. AGRO AND SOCIAL FORESTRY.

Figure 10. Land use plan map of study area.

Preparation of action plan

Remote sensing data is an effective input to GIS because of its capability to provide data of an area in temporal and real time mode. A different layer of information generated from remotely sensed data provides an authentic input when used in GIS. In the present study thematic layers were generated for land use, soil, groundwater potential and slope, along with base map. The soil map is taken as the base. All the layers were brought to a common coordinate system so that integration is possible and the accuracy of the output is maintained. The preparation of action plan for land resources involves the integration of layers such as land use, ground water potential, soil, and slope. The guidelines for land use planning (FAO 1989) followed for preparation of the action plan. Arc/Info GIS software is used for integration of the layers. The layers were integrated using the UNION command. Once the layers are integrated, a multi-criteria approach has been adopted to obtain information for different combinations of land use/ land cover, groundwater potential, and land capability (Table 4). Preparation of action plan involves the

Table 3. Soil grouping for land capability in the study area.

Land Capability class	Soil Mapping Unit	Capability
IV	6,13,20,**27**,29,30,35	Fairly good for cultivation, but its safe use for cropping is very limited by natural features such as slope, erosion, unfavorable soil characteristics and adverse climate
VIII	**22,23,24,25,26**	Wildlife, recreation or watershed Protection.

Table 4. Scheme of integration for action plan.

Land capability	Ground Water otential Zone (GWPZ)	Land-use/ Land-cover (LULC)	Action Plan Units*
IV	II	SC	3
	II, III	FL, LWWS	4
	III, IV	SC	3
	IV	FL, LWWS	5
VIII	II	SC	3
	II, III	SC	4
	II, III, IV	FL, LWWS	6
	IV	SC	5

Land capabilities:

IV- Fairly good for cultivation, but safe use for cropping is very limited by natural features such as slope, erosion, unfavorable soil characteristics and adverse climate.
VIII - Wildlife, recreation or watershed protection.

GWPZ:
II – Good to moderate
III – Moderate to poor
IV – Poor

LULC:
SC – Single crop
LWWS - Land with or without Scrub
FL -Fallow Land

*Description of action plan units from Table.
Unit 3 - Inter cropping with short and long duration crops.
Unit 4 - Short duration crops, Unit 5 - Silvipasture/Silvihorticulture.
Unit 6 - Agro and social forestry.

Table 5. Mapping units, their aerial extents, proposed conservation measures and the suitable agronomical practices.

Mapping Unit	Area in km^2	Proposed Control Measures	Suitable Agronomical Practices
3	2.88	Contour bunding, gully control measures (check dams), and farm ponds/ percolation tanks.	Inter cropping with short and long duration crops
4	3.64	Contour bunding, land leveling, gully control measures, farm ponds/ percolation tanks	Short duration crops
5	0.57	Staggered contour trenches, check dams	Silvipasture/ silvi horticulture
6	4.02	Catch pits and diversion drains.	Social forestry/ agro-forestry
	0.27	Settlements	
	0.58	River/stream/reservoir/ Tank.	
	0.06	Plantations	
	0.19	Road network	
	12.21	**Total**	

suggestions for alteration of present system of land use or alternate system, depending upon the prevalent socio-economic aspects.

Areas of the action plan (Land use plan) mapping units in the study area are shown in Fig.10. Table 5 shows areas of the mapping units, proposed control measures there in and suitable agronomical practices. For mapping units 3 and 4 with an area of 2.88 km^2 and 3.64 km^2 respectively, the proposed control measures are contour bunding, gully control, check dams and farm ponds/percolation tanks. For mapping unit 4 land leveling is also suggested. Short duration crops for unit 4 and inter cropping with short and long duration crops are suitable for mapping unit 3. For mapping unit 5 the suggested control measures are staggered contour trenches and check dams and for mapping unit 6, catch pits and diversion drains. For the former unit silvipasture / silvi horticulture and for the latter unit social forestry/agro-forestry are proposed.

CONCLUSIONS

Land use planning involves the inventory of the land resources. This is the first task to be under taken by the planners towards natural resources management, and the task of inventorying the natural resources is to be done with in a set time frame. The QUICK BIRD image with spatial resolution of 0.6m can be used to obtain information on land use. Landform mapping for water resources targeting can be carried out using the IRS-P6, LISS III data supported by sufficient ground truth. The approach has given good insight into the areas potential for alternate land use. The action plan prepared using this approach enables administrators to take decisions regarding resource use and planning. The action plan not only serves as a guide but also as a blue print for natural resource management for sustainable development.

Land use map is the first map which any planner would need to look at the extent of use to which the land is put. Depending upon the type of mapping unit 3 suitable soil and conservation measures and the location specific agronomical practices should be under taken.

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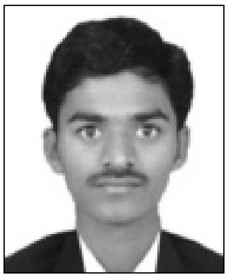

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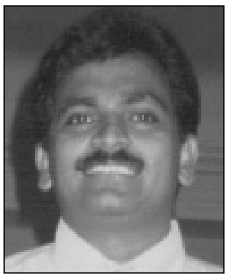

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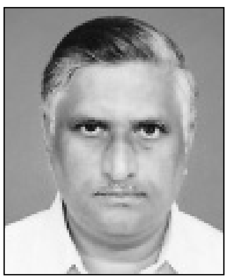

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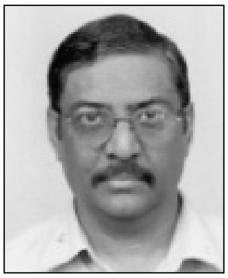

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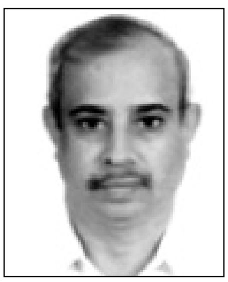

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