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GIS Based Integrated Land Use Planning For Optimum Natural Resource Management

[1]Prof Ashish Kumar Samal, [2]Prof V Madhava Rao
[1]Head of Department, [2]Research Professor
[1]GIET University, Gunupur, Odisha, India,
[2]GIET University, Gunupur, Odisha, India

Abstract - **Land is a natural resource and a pre-requisite for primary production system as well as for meeting social priorities such as shelter, communication, industrialization, infrastructure, agriculture, NRM and the like, however the scenario is changing due to soil erosion, salinisation, desertification, anthropogenic process, constructions, mining, industrialisation and other degradational processes, for which sustainable land development practices has become an urgent need. The land was looked as a physical entity in terms of its topography and spatial nature, now a renewed view with respect to atmosphere, climate, ground water, soil, terrain, hydrological, vegetative and land use taken predominance. In this context, a study was carried out to analyse the available land resource information and integrate them to generate action plans for land resource management, in Nalgonda distroict of Telengana State, India, with a primary aims of to evaluate the land resources, identify LULC and suggest a rational Action Plan, for optimizing the landuse without any adverse impact. The geological and geomorphological maps were prepared for providing alignment of transportation and communication routes and sites for irrigation, energy and industrial projects, delineating mineral and groundwater potential areas. Soil is a three dimensional continuum which depends on parent material, geomorphic processes, and environmental characteristics. Soil mapping showing soil erosion, excess salinity and alkalinity and water logging conditions prepared. Water resources mapping showing surface water and stream pattern, pre-flood and post-flood river configuration and flood plain mapping, water quality , irrigated areas, potential zones of ground water prepared. Crop identification and acreage estimation, crops growth, cropland, harvested fields, crop identification, prepared. Forest Maps showing extent of forest cover, type of forest tree species, vulnerable areas for forest fire, disease monitoring, excessive felling, clearing of forest for agriculture prepared. Based on all these layers, the land use planning is prepared for the future use of the land and the changing demands of the area and the communities. Suitable site specific recommendations for alternate land use and water conservation measures, for optimum land use keeping in view the requirements of present and future for the district of Nalgonda has been prepared to recommend the areas of human habitation, lands to be used for production of food, fiber, commercial and horticultural crops, areas having standing crops during July to September/October months, double-cropped areas, delineation of fallow land , which can be brought into productive use, forestry, scrub lands, waste lands, water bodies, ground water potential zones, broad soil types, slope, aspect, etc are prepared for developing the district. 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, which give an insight into the areas potential for alternate land use, for natural resource management for sustainable development.**

keywords - **Land Use and Land Cover(LULC), geomorphology, soil erosion, fallow land, NRM, sustainable development**

Introduction

Land is a natural resource, prerequisite for primary production system and social priorities such as shelter, communication, industrialization, road network, irrigation, energy, agriculture and the like. However due to anthropogenic pressure, rapid industrialization, infrastructure development, industrialization and economic activities, urbanization, mining, etc, the land resources are depleting in the world and also shrink due to soil erosion, salinisation, desertification and other degradational processes. Hence there is a renewed look for sustainable land use integrating the climate change parameters, optimum use, land characteristics and productive measures.

The land resources, may be physical, biotic, environmental, infrastructural, social and economic and the fresh water harnessed in major reservoirs outside or pumped from river at upstream sites and the underground geological resources (oil, gas, ores, precious metals etc.) are excluded from the group of components of the natural land unit (FAO, 1995). The land components are broadly identified as land surface, land cover (natural vegetation), surface hydrology (pond, tank, stream, lake, marshes, swamp etc.), soil (up to the rooting depth), substratum containing the ground water, organisms both micro & macro organisms, human settlement patterns representing population density, occupation, land rights, economic condition, etc.

Land resource management is the practice of using the land by human on a productive and sustainable way. However the land degradation, due to over grazing, climatic conditions, mismanagement of judicious land use practices, is a challenge, for which measures to counter the degradation process need to be adopted along with land use. Wastelands are the degraded and unutilized lands except current fallows due to different constraints, with poor land practices led to malnutrition and decline in production capacity of the soil, with areas affected by water logging, sheet and gully erosion, ravine, riverine lands, shifting cultivation, salinity and alkalinity, wind erosion, shifting sand dunes, extreme moisture deficiency, coastal sand dunes etc, ecologically

unstable with loss of top soil and unsuitable for cultivation due to decline in their quality and productivity.
Under various land development programmes of the Department of Land Resources, Govt of India, various action plans were adopted to counter the degradation process and reclaimed vast areas of waste lands, through watershed, soil conservation, moisture conservation measures like terracing, bunding, trenching, vegetative barriers and drainage line treatment., drainage line treatment by vegetative and engineering structures, development of water harvesting structures etc.
The study aims to analyse the available land resource information and integrate them to generate action plans for land resource management, to evaluate the land resources of the district, to create digital data for land use and land cover for the Nalgonda district and to generate rational land use plan for the study area.

Methods:

Geological and Geomorphological Maps

Geological maps with satellite remote sensing help in the preparation of small scale reconnaissance maps of unmapped inaccessible areas, updating the existing geological maps, preparation of tectonic maps and identification of features favourable for mineral localization. The geomorphological maps find their utility in planning, management and monitoring of several other resource aspects. Satellite data has been successfully used in the preparation of regional geomorphological maps and change detection in exclusive domains like sand-dune movements in deserts, coastal morphology etc., through monitoring by repetitive coverage. The geological and geomorphological maps provide preliminary base for providing alignment of transportation and communication routes and sites for irrigation, energy and industrial projects, delineate mineral and groundwater potential areas.

Soil Mapping

Soil is a three dimensional continuum which depends on parent material, geomorphic processes, and environmental characteristics, out of which, surface manifestation (geomorphic) is studied by satellite Remote Sensing and effectiveness of soil survey have improved considerably. Detection and delineation of soil hazards and soil limitation are important in soil survey and soil mapping and proved useful in mapping erosion, excess saline (salinity and alkalinity) and water logging conditions in soils.

Water Resources

Remote Sensing mapping, both satellite and airborne, have been observed to be useful in surface water and stream pattern mapping, pre-flood and post-flood river configuration and flood plain mapping, water quality studies, irrigated areas studies, determining potential zones of ground water , watershed run-off modeling etc.

Agriculture (Crops)

Crop identification and area measurement or acreage estimation, in agriculture, is potential applications of satellite remote sensing, which provides assessing crop yield, mapping cropland, harvested fields, wet lands etc.

Forestry and Vegetation Mapping

Information about extent of forest cover, type of forest tree species, detection of forest hazards like fire, disease, excessive felling, clearing of forest for agriculture etc, are handled by the use of satellite remote sensing.

Land use Mapping

Satellite data provides detail information on areas and the temporal data and can be utilized for change detection and updating old data, which includes landuse classification system such as water bodies, forest, grass land, agricultural land, barren land, and scrub land, settlements, etc.

Study Area

Location and Extent

The Nalgonda district lying between $16^0 25'$ and 17^0 50' of the northern latitude and $78^0 40'$ and $80^0 5'$, divided into 11 Taluks and 15 Community Development Blocks for administrative purposes, with a geographical area of sq.kms comprising of 1158 Revenue villages, 1178 Gram Panchayats, 59 Mandals administered by 4 Revenue Divisions located at Nalgonda, Bhongir, Miryalguda and Suryapet and has a population of 34.89 Lakhs in 2011 Census.

Climate

The climate is very hot during the months of April and May and in August and September. The annual normal rainfall in this district is only 702 millimeters, with bulk of the rainfall received through the south-west monsoon during June to September, while some rainfall is also received through the north-east monsoon between October and December.

Soils

The soils in this district are mostly chalka, (sandy loam) and Dubba (loamy sands), with about 47 percent of the area in the district have predominantly Dubba soil, 44 percent of the area has sandy loam soils, and only 9 percent of the area has black soils.

Minerals

The district is poor in mineral wealth, with extensive deposits of limestone, used for manufacture of Cement, coloured lime stones used for polishing and decorative purposes and granite in various shapes and texture.

Natural Vegetation

The District does not contain large or important forests. The district has the smallest proportion of forests to the geographical area. The percentage of area under forests to the geographical area being as low as 5.8. The forest vegetation of the district belongs to the dry, deciduous, tropical forest type of the Krishna basin. The wood from the forests of this region is useful only for fuel and for agricultural implements like ploughs.

Agriculture

The people of the district overwhelmingly depend on agriculture for their sustenance. Out of the total number of workers 13,24,843 about 4,21,882 are cultivators. There are around 57,3771 agricultural labours. The principle crops in the district are paddy, jowar, bajra, groundnut, redgram and castor.

Water Resources

The district is drained and watered by the rivers Krishna, Musi, Aleru, Pedavagu, Dindi, Halia and Kangal. The most important river is Krishna. Musi river a tributary of the Krishna is the next important river in the district. Pedavagu and Dindi flow in this district and merge into the Krishna river. Halia river which rises in the hills west of Narayanpur flows in south eastern direction for and continues in the same direction and falls into the Krishna river. Aleru flows in south eastern direction and joins Musi. All these are for irrigation purposes. The mighty Nagarjunasagar Project is constructed across the river Krishna, near Nandikonda village of about 45 miles and it is joined by Kangal river near Kangal village and continues in the same direction and falls into the Krishna river. Aleru flows in south eastern direction and joins Musi. All these are for irrigation purposes. The mighty Nagarjunasagar Project is constructed across the river Krishna, near Nandikonda village of this district. The other important irrigation projects worth mentioning are the Musi project across the Musi river and Dindi project across the Dindi.

Land Use Planning

Land use planning in rural areas has received scant attention in comparison with town planning until recently. This can hardly be justified in a country like India, which is predominantly agricultural. The planning of agricultural sector in rural areas has been carried out in laissez faire manner. Very few deliberate and cautious attempts were made to improve the countryside. The development of land use planning is not recent in its origin but its practice is truly recent. A land use map gives s thorough and clear picture of land to the planners for the determination of future use and planning the agricultural sector to maintain the land potentials. In this way, land use planning is concerned with the future use of the land and the changing demands of the society.
An accurate assessment of the existing land use pattern is best carried out from an appraisal of complete vertical photography of the project area or satellite data at a scale of around 1:250000. Such an initial appraisal giving the overall land use pattern enables the specialist concerned to see the framework on which they will have to work.
The various natural resources themes like land use / land cover, soils, Ground water prospects and surface water bodies was carried out following a systematic visual interpretation. For land use / land cover mapping two season data for Kharif and Rabi were used. In case of ground water prospects and soils both rabi and summer data were used. The slope map is derived using Survey of India topographical sheets at 1:250000 scale with 100-meter contour interval. The soil map is taken as the base for integration.
A scheme for thematic data integration and recommendation for various combinations of land parameters was evolved by observations in the field. Following the scheme of data integration, action plan maps were generated giving suitable site - specific recommendations for alternate land use and water conservation measures. While formulating the locale-specific action plan, the earlier research carried out by various research centers in the field of agriculture etc, were taken into consideration along with the prevailing socio-economic conditions.
The analysis carried out in the present study uses primarily information generated from remotely sensed data. Layers were generated for land use, soil, ground water, slope along with base map. All the layers were brought to a common coordinate

system so that integration is possible and the accuracy of the output is maintained, for land resources, by integration of layers such as land use, Ground Water, soil, and slope. 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.

Land Use/ Land Cover

The land use/ land cover categories of the district have been grouped into six Level-I classes Viz., built-up area, agricultural lands, forest lands, wastelands, water bodies and others .These Level-I classes have been further sub-divided into 11 Level-II classes , along with their extend areal extent.

Built-Up Land

These are the areas of human habitation developed due to intensive non-agricultural use. The major towns and cities in the District are Nalgonda, Miryalguda, Suryapet,Bhongir,Kodad,Devarkonda,Yadagirigutta and other villages. The settlements cover an area of 13.662 sq km.

Agricultural Land

These lands are primarily used for production of food, fiber, commercial and horticultural crops. This category is by and large is dependent on agro-climatic conditions and it is the dominant category in the study area. The use of multi temporal satellite data enabled sub-dividing this category into Kharif and double cropped areas.

Kharif Crop Land

These are the areas which generally have standing crops during July to September/October months that coincides with south-west monsoon. The data selected for delineating these areas generally commensurate with the standing crops in the peak growth stage i.e. before harvesting as on the date of satellite overpass. This category is seen as regular-shaped patches with red colour of varying hue in the black soil background exhibiting parceling pattern .An estimated 6892.093 sq km land is used under Kharif crops. The major crops that are grown during this season are paddy, jowar, bajra, groundnut, redgram and castor.

Double-Cropped Area

These are the lands which support crops during both Kharif and Rabi seasons. This category is associated with fertile soils with irrigation facilities from diverse sources to support the crop growth.. The spatial distribution of these areas is almost the same as rabi and kharif crops described in the Kharif cropland. Double crops are taken in an area of 3480.371 sq km of land. It occupies around 24.48% of the total area of the district.

Fallow Land

These are the agricultural lands temporarily allowed to rest uncropped during the agricultural year. This category could be delineated using temporal satellite data wherein the signature of crops in the cropped areas are conspicuous by their absence as on the data of satellite overpass. There may be various reasons that may be attributed for keeping the land fallow – like social, economic and natural factors. This category occurs as small isolated pockets within crop land and cover an area of 215.684 sq km. It covers around 1.52% area of the total area of the District.

Deciduous Forests

These are areas associated with trees and other natural vegetation types within the administrative / notified forest boundaries capable of producing timber fuel wood and other forest produce. The forests of the district could be categorized as deciduous, which generally shed their leaves once in a year. It covers an area of 26.517 sq km and around 0.19% of the total area of the District.

Scrub Forest

This category includes the vegetated areas with a crown cover of less than 10% owing to over increasing pressure of population on land. Covering a geographical extent of 801.420 sq km. It cover around 3.12% of the total area of the District.

Wastelands

It is described as degraded land which can be brought under vegetative cover with reasonable effort and which is currently under utilized and land which is deteriorating for lack of appropriate water and soil management or on account of natural causes (NRSA. 1991). Three categories of wasteland have been identified and mapped in the study area. A brief description of which is given below:

1) Land With/ Without Scrub

The land with scrub are the lands with soils that are too shallow; skeletal or chemically degraded lands with moderate to steep slope and are mostly covered with scrubs of different densities and varying height. Land with out scrub is the counter part of the previous category, but with out any vegetation cover on the land. The total area under this category is 1835.448 sq km .It covers around 12.91% of the total area of the District.

2) Barren Rocky/Stony Waste/Sheet Rock Area

These lands are characterized by exposed massive rocks, sheet rocks, stony pavements for excessive surface accumulation of stones that render them unsuitable for production of any green biomass. This category appears distinctly on the satellite data as various shades of bluish green/greenish blue colour. The spatial extent of this category is 0.8580 sq km. It covers around 0.86% of the total area of the District.

3) Sandy Area

The sandy area are the lands that appear bright white to yellow with bluish to reddish tone on the satellite imagery. They occur in varying sizes with regular to irregular shapes. They have smooth to mottled texture and occur as continuous or linear pattern. These lands are generally occur near to River-beds and natural leeves. The spatial extent of this category is 140.972 sq. Kms. It cover around 0.99% of the total area of the District.

4) Water Bodies

The streams/rivers, tanks, jheels and reservoirs are included in this category. The major rivers flowing in the study area are the Krishna river and its tributary Musi river. In addition to the four major reservoirs Nagarjunasagar, Dindi, Musi, Paleru. there are a good number of tanks of varying sizes spread over throughout the District. These are being used for irrigation and drinking purposes. Water bodies cover an estimated area of 699.002 sq km.

5) Ground Water Pottential Zones

Salient features of various Ground water potential zone units, delineated in the District are given hereunder.

Zone I :

It consists of geomorphologic units like Valley fill, Intermundane valley and Structural valley. The material in Valley fill is formed of Gravel, Sand, Silt and Clay of river sediments. It consists of unconsolidated sediments. It consist of a narrow stretch of alluvium 1-8m deep along the streams/rivers. These are suitable for shallow aquifers with good recharge depending on the thickness of alluvium. Structural valley is made up of peninsular gneiss and granite. It has a structure of faults, fractures and other weaker zones. It occurs as linear valleys, which are formed along faults/fractures etc. It is highly suitable both for shallow and deep aquifers with good recharge. The material in the intermundane valley is made up of Srisailam Quartzite. It has a structure with gently dipping beds with faults and fractures. It occurs as narrow valleys surrounded by hills all around. It is highly suitable for shallow and deep aquifers with very good recharge. The area of ther Zone is around 663.322 sq. Kms. It is around 4.47% of the total area of the District.

Zone II :

It consists of geomorphologic units like Shallow Weathered Pediplain with lithostratigraphic units like Narji limestone and peninsular gneiss and granite. Narji Lime Stone has a thin-bedded structure with gently dipping strata with faults, fractures and cavarens. It has a gently undulating plain with 0-5m deep weathering. It is suitable for moderate to deep aquifers. The contact zone with underlying Banaganapally Quartzite is more favorable. The shallow weathered Pediplain under canal command has gently undulating plain with 0-5m deep weathering due to intensive irrigation from Nagarjuna Sagar Left Canal. It is favorable for both shallow and deep aquifers due to good recharge from canal irrigation. The peninsular gneiss and granite is made up of foliated gneisses interspersed with massive granite. It occurs as gently undulating plain with 0-5m deep weathering, which is covered by canal irrigation. It is favorable both for shallow and deep aquifers due to good recharge from canal irrigation. The total area of the Zone is 2634.659 sq. Kms. It is around 19.03% of the total area of the District.

Zone III :

It consists of geomorphologic units like Shallow Weathered Pediplain and Dissected plateau. The material in the shallow weathered Pediplain is formed of Banaganapally Quartzite. It has a structure with gently dipping beds with faults and fractures. It has gently undulating plain with 0-5m deep weathering. It has deep aquifers, which occur mostly along fractures/faults bedding plains etc. The material in the dissected plateau is made of Srisailem Quartzite. It has a structure with gently dipping beds with faults and fractures. It occurs as dissected flat upland, which is bounded by escarpments/steep slopes. In this unit deeper aquifers occur along faults/fractures bedding planes etc., which are subjected to recharge. The total area of the Zone is 465.327 sq. Kms. It is around 3.28% of the total area of the District.

Zone IV :

It consists of geomorphologic units like Shallow Weathered Pediplain and Moderately weathered Pediplain. The material in the shallow weathered pediplain is made of peninsular genesis and granite. It has a structure of foliated gneisses interspersed with massive granite. It occurs as gently undulating plain with 0-5m deep weathering. It has weathered zones along the valleys from shallow aquifers. The zone with faults/fractures is favorable for deeper aquifers. The material in the moderately weathered pediplain is made up of peninsular gneiss and granite. It is made up of foliated gneisses interspersed with massive granite. It occurs as gently undulating plain with 5-20m deep weathering. The-weathered zones forms shallow aquifers. The deeper aquifers occur along faults/fracture zones. The total area of the Zone is 7004.088 sq. Kms. It is around 49.05% of the total area of the District.

Zone V:

It consists of geomorphologic units like Mesa and Butte with lithostratigraphy like Banaganapally Quartzite and Srisailem Quartzite. The material in the Banaganpally Quartzite has structure with gently dipping beds with faults and fractures. It has flat-topped hills bounded by escarpment/steep slopes. These are not suitable for ground water occurrence. Limited water may occur as perched bodies in mesa. The material in the Srisailam Quartzite has a structure with gently dipping beds with faults and fractures. It exits as dissected flat upland, which is bounded by escarpments/steep slopes but are limited in aerial extents. It is not suitable for ground water occurrence. But limited ground water may occur as perched bodies. The total area of the Zone is 132.643 sq. Kms. It is around 0.93% of the total area of the District.

Zone VI:
It has geomorphic units like Residual hills, Inselbergs and Pediment Inselberg Complex. The material in the units is made up of peninsular gneiss and granite. It has a structure of foliated gneisses interspersed with massive granite. Residual hills occur as group of massive hills interspersed with narrow valleys. Limited water occurs in the weathered/fractured zones along the valleys. Inselbergs occur as small isolated hills. It is not suitable for ground water occurrence. Pediment Inselberg occur as gently undulating terrain dotted with small hills and rock outcrops. It has shallow aquifers only in the highly fractured zones along valleys. It has deeper aquifers along major faults/fractures. The total area of the Zone is 2790.494 sq. Kms. It is around 19.53% of the total area of the District.

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. For Optimal utilisation of available land and water resources, information on soil with respect to nature, physico-chemical characteristics, potential and inherent limitations is pre-requisite. Conventional soil surveys provide this information. Such approach however, is not only tedious and time-consuming but also at the same time cost-prohibitive. In early sixties, the development of aerial photo-interpretation technique and availability of aerial photographs opened a new vista in soil resources mapping programme in our country. Subsequently, the availability spaceborne multispectral data especially from the Indian Remote Sensing series of satellites further augmented this process and has enabled soil scientists generating timely and cost-effective information on soil resources. The IRS -1C/1D multi-spectral and panchromatic stereo data with improved spatial resolution will further enhance this capability.

Slope:
The slope map is generally prepared using the contour information, In this study, the slope map has been prepared using Survey of India topographical maps on 1:250000 scale with 100 meter contour interval using tan method. The different classes of slopes have been categorized as per the guidelines suggested by the All India Soil and Land Use Survey (1970). Generally, there are seven classes as shown below. However, in the hilly region further classification can be made above 35% category based on local conditions and its importance in climatic and land use/ land cover changes.

Results & Discussions:
Action Plan
Land Use Planning
Based on careful integration of information on soil, land use/ land cover, ground water potential and slope, the following action plan have been formulated in development of land, soil and water conservation. Different themes on land resources of the study area were integrated and the management needs of different landscape units were assessed. The scheme of integration is given in Table 5.1. A resource based action plan package was evolved for the development, conservation and management of the area on a sustainable basis. The different mapping units and the suggested action plan package along with their areal extent are furnished in Table 5.2 & 5.3. The action plan will aid planners as well as other executing agencies in implementing various developmental programmes in the district.

Agricultural Lands
Most of the area in the district is cultivated either during one or both the cropping seasons (depending up on potential / limitation of soils). These areas provide the maximum scope for development since they are under - utilized at present and are not fully exploited for crop production. With the adoption of few management practices, cropping intensity on these lands can be increased considerably. Consequently, the crops could be raised every year in the same piece of land.
The alternate land use proposed for agricultural productivity is as follows: Chillies is proposed in the soil units 2,4,5,6,9,15,32 in the combination of ground water prospects and present land use as shown in the Table 5.1. The total area proposed for chillies crop is 4281.714 sq. kms. Groundnut is proposed in the soil units 1,8,27 with combinations of ground water prospects, land use, slope as shown in the Table 5.1 The total area proposed is 2093.072 sq .kms. Paddy is proposed in the soil units 13,17 18,19 and 20. The combinations of ground water prospects, land use, slopes are shown in the Table5.1. Area recommended in the district is 3799.953 sq. kms. Cotton is proposed in the soil units 16, 21, 30 and 31. The combinations of ground water prospects, present land use and slope are shown in the Table 5.1. Cotton is proposed in an area of 485.630 sq. kms.
Castor is proposed in soil unit 7 in the zones of II, III, IV of the ground water zones. It is proposed in the soils having 1-3% slope. Present land use are single crop, double crop, land with or with out scrub. It is proposed in an area of 191.656 sq. kms.

Agro-Forestry
For marginally cropped areas, some permanent vegetative cover in the form of fodder, fuel wood and small timber-yielding tree species has been recommended. This practice, known as 'agro-forestry', not only stabilizes such lands by controlling soil erosion but also improves the fertility of the soil. The tree component under agro-forestry is preferably nitrogen fixing, fast growing, drought-tolerant and multi-purpose in use. The multipurpose tree species recommended areLeucaena Leucocephala, Glyricidia

Sepium, Cassia Siamea, Sesbania Sp., Albizia Lebeck.
Intervention of tress/ woody crops with annual crops, has the basic features conceived and formulated as improvement of existing land use rather than transformation of land use, new opportunities for raising income levels of small farmers without in any way putting agriculture in jeopardy, and emphasis on the sustainability aspects. Trees and shrubs apart from directly providing useful and basic products protect the soil against erosion, provide organic matter to maintain soil fertility, bring up nutrients from deeper soil layers, prevents build-up of pests, weeds and diseases and create a more favorable microclimate. About 636.917 sq. kms of area has been recommended for agro-forestry.

Silvipasture:
Silvipasture essentially consists of a top feed tree species and grasses or legumes as understorey crop, most suited to marginal drylands and is preferable where fodder shortages are experienced frequently, increase fodder supply in rural areas and to improve effective interaction between livestock raising/ animal husbandry and crop production, grazing and fodder resources should be created in areas accessible to villages. Effective method to introduce silvipasture land use is fast growing fodder shrubs and trees in crop lands and pasture lands, pastures in plantations, orchards, and pastures in forest tree plantations. About 339.113 sq. kms of area has been recommended for silvipasture.

Afforestation:
Due to ever growing population pressure, these forests are also dwindling resulting ultimately in soil erosion. Hence, the Forest Department should immediately take up for gap plantation as well as adoption of soil and water conservation measures on priority basis. Gap plantation can be undertaken using the indigenous species already existing in the study area.
About 500 trees per ha. Would be planted, as far as possible, in contour ditches. The species would consist of associated of teak. Soil working would consist of ripping manually or mechanically to form shallow contour ditches, 1 m wide, and 5 m apart. Thick vegetative barriers of local grasses and shrubs would be estimated on contour ditches. A cordon wall should be erected around the area to protect from animals. The vertical distances between the contours will depend on the slope. Where existing tree/scrub vegetation is to be preserved. For the contour planting preparation, a flat terrain or a small inward sloping terrace in the hills could be used. Structural works have been excluded to introduce vegetative reinforcements where appropriate. Fire lines would be maintained in and around the area as per specifications of State Forest Department.

Soil and Water Conservation Measures
Bunding
In agricultural lands, contour bunding is the most widely practiced soil conservation measure for mildly sloping lands. Contour bunds are designed as mini-earthen dams with emphasis on height of bund and cross – sectional areas depending on texture and depth of the soil. The contour cultivation – a supporting practice, is effective on land with very gentle slopes. This not only reduces the soil loss but also helps in increasing soil productivity.
Bunds are small earthen barriers provided in agricultural lands with slopes ranging from 1 to 6 percent, and control the effective length of slope and thereby reduce the gain in velocity of runoff flow to avoid rill and gully formations.

Contour Bunds:
Contour Bunds are essentially meant for storing rain water received during a period of 24 hours at 10 years recurrence interval. The major considerations are maximum depth of water to be impounded, design depth of flow over waste weir and desired free board.
The depth of water expected to be impounded against the bund will largely depend upon rainfall factor, rate of infiltration of the soil and vertical interval between bunds. The actual height of the bund is decided after allowing adequate free board nearly 20% of the depth. Usually water storage equivalent to 50 mm of rainfall is considered adequate for design of contour bunds at most of the places. Of late, design criteria have been simplified for different soil types. Further, the bund sections can be reduced, where farmers are likely to extend adequate cooperation by exercising proper care in bund maintenance.

Farm Pond
Farm ponds are bodies of water, made either by constructing an embankment across a watercourse or by excavating a pit or the combination of both. Dugout ponds are generally created by excavating pits in areas having flat topography and mostly in situations where water table is close to the ground level. On the other hand, impounding type farm ponds are common feature wherever there are well-defined waterways with rolling type of topography. It is possible to achieve high water storage-earth work ratios with embankments/bunds constructed in narrow and deep valleys, while the ponds are constructed by excavation only have this ratio mostly less than unity. In the case of impounding type, preference is given to locations with a low soil permeability.

Broad Bed Furrow Trenching
Adoption of broad bed and furrow system a land management technology developed by International crops Research Institute for the Semi Arid Tropics, (ICRISAT), Hyderabad for deep black soils is recommended for these soils. It is a system of semi-permanent broad beds and furrows that are laid out on a gradual slope - usually 0.4 - 0.8 %. Each bed approximately, 100 cm wide, is slightly raised, acting as an 'in situ' bund for good moisture conservation and erosion control. The furrow (about 50 cm in width) is shallow (about 15 cm) and provides good surface drainage to prevent the water logging of crops grown on the bed. Excess water is let off through a system of field drains. Some land smoothing is usually necessary to remove small depressions and high spots. Another feature of broad bed and furrow system is that the run-off water can be harvested in a tank,

which subsequently could be recycled for supplemental irrigation.
Once the drainage conditions improve, these areas become suitable for intensive agriculture like sequential cropping in kharif and rabi seasons or inter cropping during kharif season. A wide range of cropping systems is available to be adopted in the district. Some of the recommended systems are jowar/ maize/ soybean/ green gram/ Black gram followed by wheat/chickpea/mustard/lentil/linseed. Red gram can also be inter-cropped with the kharif crops.
The graded broad bed and furrows followed by improved cropping systems increase the profits by about 30% compared to the flat cultivation system of growing a single season crop. (ICRISAT, 1981). In addition to the improved land management and crop management practices, adoption of other cultural practices like improved genotypes, optimum fertilizer use, pest and wed control, etc., reported to increase.

Vegetative Barriers
Vegetative barriers are closely space gross hedges or plantations – usually a few rows of grasses or shrubs – grown along contours or with little grade for erosion control in agricultural lands. Of late, opinions are gaining ground that vegetative barriers (eg. Vetiver hedgerows or leucaena, lemongrass, Cenchrus ciliaris) alone at suitable vertical interval may be sufficient for runoff and erosion control in relatively flat and slightly undulating topography. But it is, safer to have vegetative barriers only as inter-terrace treatments. Vegetative barriers can be easily established across a wide spectrum of soil-climatic conditions except in class VII lands and desert conditions. Selection of species depends upon site-specific conditions, particularly soil and climatic variables. The major constraint experienced in their sustenance is stray cattle grazing.

Grass Waterways
Grass Waterways are drainage channels either developed by shaping the existing drainage ways or constructed separately for effecting drainage of agricultural lands. They are aligned along the major slope to handle runoff discharge from contour/graded bunds, bench terraces, contour trenches and contour furrows. As far as possible, waterways are located along valley lines. But, sometimes it may be necessary to construct waterways along field boundaries for safe disposal of excess rainfall from agricultural fields. Waterways may be located in all classes of lands except bare rocks, where construction may be difficult. However, vegetative waterways should not be used for handling continuous flows, like that from tile drains as problem of wetness may result in poor vegetal growth and soil protection.

Gully Control Measures
Depending on the severity of erosion, different types of mechanical protection measures have been recommended for arresting soil erosion and surface water run-off.

Contour Trenching
The trenches may be staggered or of continuous type. Their spacing or vertical interval depends on the slope of the land. Spacing may vary from 30-60 meters. Normally, continuous trenches are with a cross – section not exceeding 60 cmX30cmX60cm. The cross-section is designed to collect and convey the run-off expected from the inter spaces between two successive trenches. Staggered trenches are of shorter length from 4-15 m with a cross section of 30 cm X 30 cm. In the alternative row, the trenches are located directly below one another. On the excavated soil piled on the downhill slope, grass seeds may be sown and saplings may be planted.

Check dams
These structural measures are desirable for medium and large – sized gullies. Small gullies (depth < 1.0 m) can be controlled by improvement of gully catchment and diversion of run-off above the gully area. Depending on the site characteristics and availability of low cost material, either temporary or permanent check dams can be constructed. Temporary check dams – which include earthen, brushwood, loose stones or boulders, stone slabs, etc, are able to retain major portion of the run-off discharged from drainage area within specified period. However, a series of check dams will be more effective in erosion control, where multiple gully system exists.
The water resources development and management influence to a great extent the land resource management. Therefore, it is necessary to develop, conserve and efficiently utilize the available surface and ground water. To this end, excess rainwater need to be conserved/stored in different storage structures which could be directed to artificially recharge the groundwater for its use later.
Currently, the ground water exploitation is less, compared to the potential exists in the district. There is a need to educate the farmers to use the efficient irrigation systems like sprinkler irrigation, drip irrigation, etc. Keeping in view the requirements and land resources potential, the following structures have been suggested for improving the water resources potential, the following structures have been suggested for improving the water resources conditions.

Gully Plugs
These are, generally, small structures constructed across the first order/second order streams with the available local material to arrest the velocities of surface water flow and thereby reducing the soil erosion and improve the soil moisture profile. This practice also helps the eventual growth of vegetation on the stream banks thereby stabilizing of the stream banks.

Percolation Tanks
The criteria for locating these structures is similar to check dams except that the catchments area is larger and benefit is more in terms of land that can be irrigated either through surface or ground water utilization. These structures are primarily useful for

surface water irrigation by gravity and augment the ground water recharge.

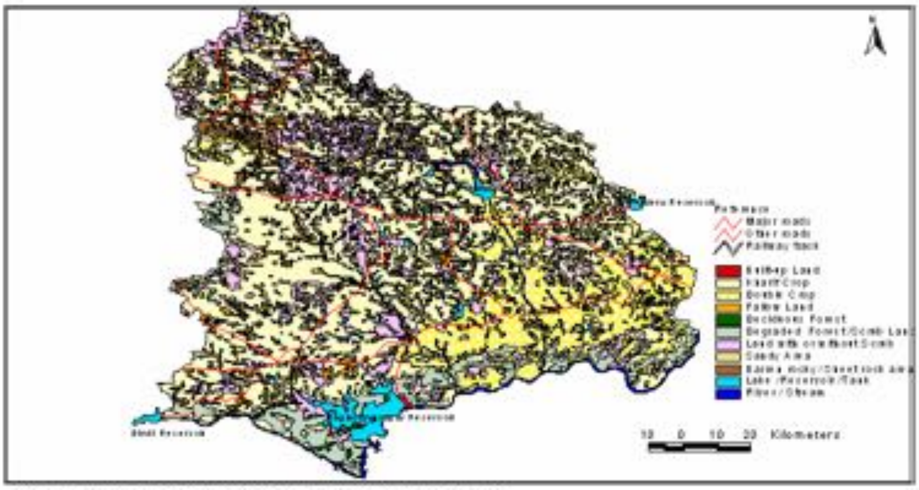
CONCLUSIONS

Land use planning involves the inventory of the land resources and taking stock of the present scenario. This is the first task to be taken by the planners towards attaining the goal. This inventory shows the land use pattern in the Drought Prone Area Development(DPAP) Blocks identified by the Govt. of India for a prompt action. The remotely sensed data prove to be an ideal choice for it's technical and economical viability. The satellite information with ground truthing of large areas can be accurately surveyed on land use over two seasons, provide
potential use of land, and feasibility of improving agriculture yield.

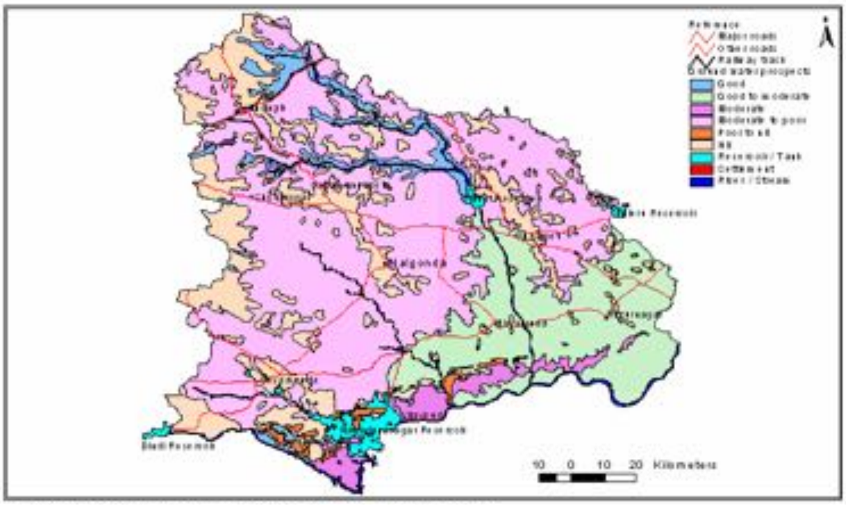
Land use planning does not only involve suggesting alternate land use but also should consider factors, which affect the other types of land use, namely the reclamation of wasteland to forest plantation conserve the soil and stop soil erosion and help improve the moisture profile and in turn the productivity of the land. 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 and has given good insight into the areas potential for alternate land use. The action plan prepared help local bodies and government departments for judicious and optimum resource use for sustainable development.

Compilation and collation of information of the area for land use planning, NRM, soil and hydrogeomorphology map generated from the satellite imagery, by integrating and analysing the derivative maps finally result into the Optimum Land Use Action Plan maps.

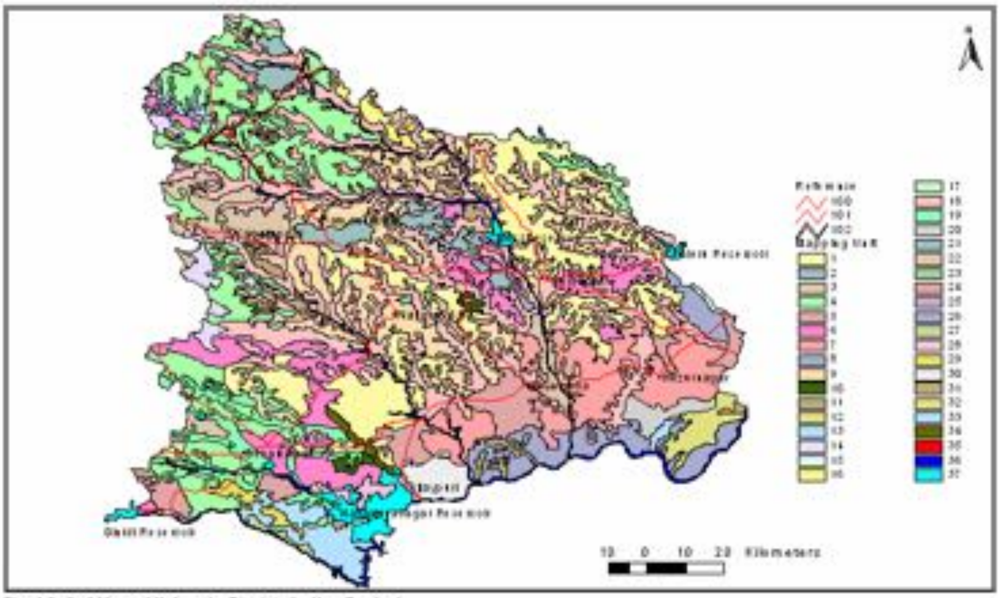
LULC Maps



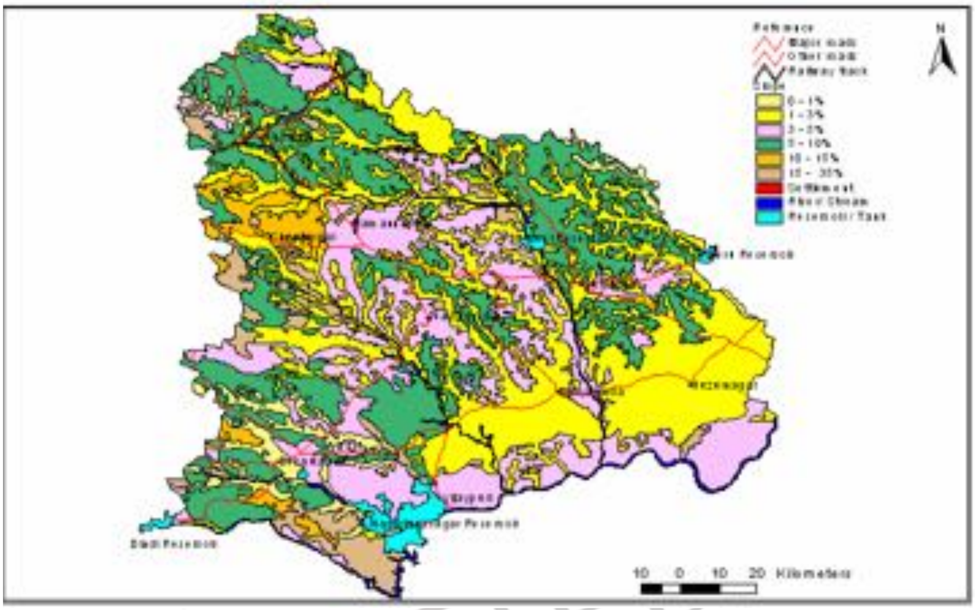
Ground Water Prospects Map



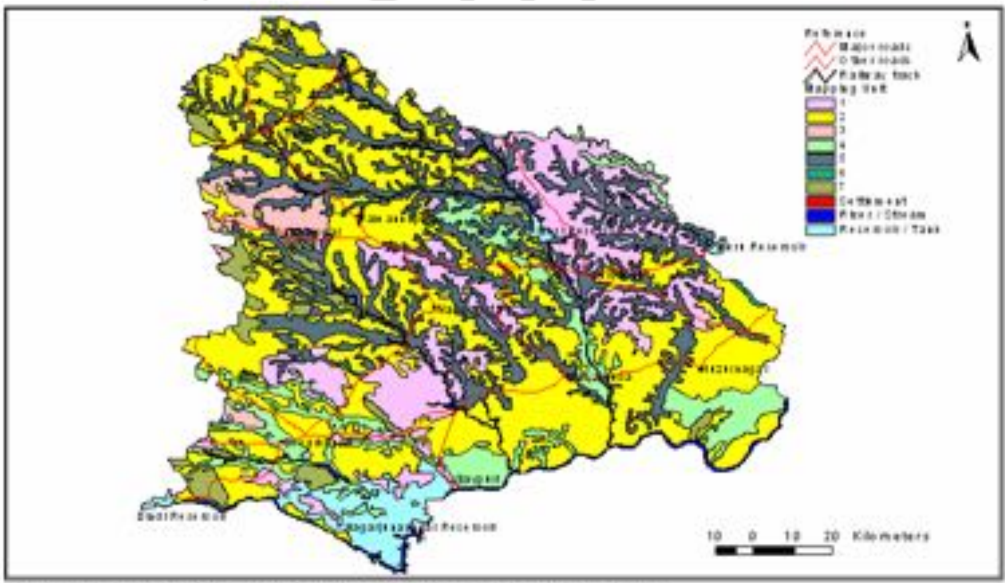
Soil Map



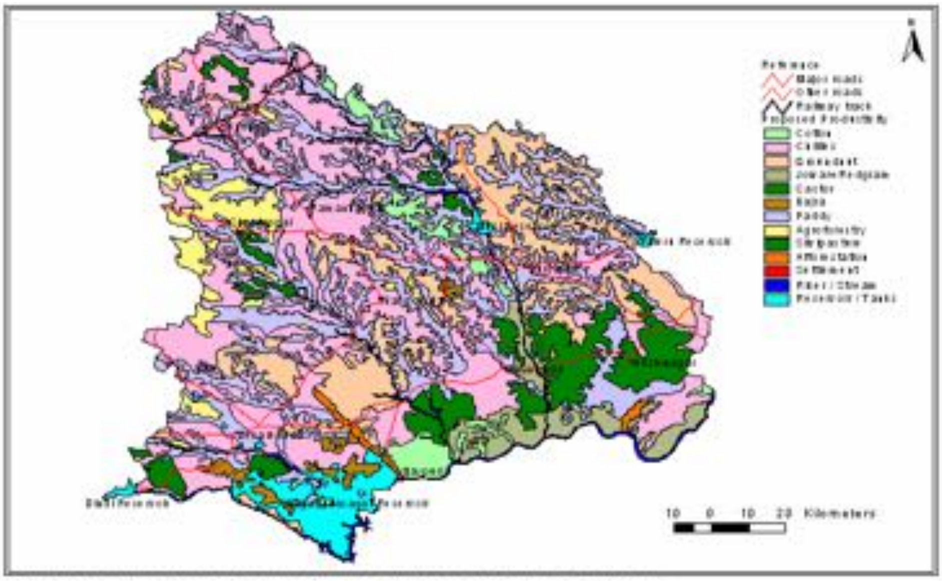
Slope Map



Soil and Water Conservation Measure Map



Action Plan Map for land resource development



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