Geo Environmental Studies of Ganganeru River Basin, Kadapa District, Andhra Pradesh, India

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Abstract*: Geo environmental studies aim to predict geosystem response to various types of active interactions; it is an in-depth treatment of the relations between man and his geologic, geomorphic, physical and cultural environments. The study was conducted on the Ganganeru River basin. Remote Sensing and GIS techniques have been proved to be very efficient in delineation of resources information of the study area, i.e. geological, hydrological and physical-environmental aspects. IRS-P6-LISS-III geocoded, FCC, three seasons data has been used, the final output of the maps are generated, those are hydrogeomorphology, land use/land cover, slope and soil, on 1:50,000 scale in the ARC-GIS environment, finally all thematic layers are integrated, analyzed and deliberate the geoenvironmental resource's up-to-date positions. These studies are delivered more precise magnitudes in identification, spatial distribution and managing of geoenvironmental resources and its characteristic's.*

Keywords: Geo environments, Natural Resources, Spatial Distribution, Remote Sensing, GIS and Integration Study.

1. Introduction

Geo environmental studies aim to predict geosystem response to various types of active interactions. It is an in-depth treatment of the relations between man and his geologic, geomorphic, physical and cultural environments. Environmental geology is essentially the geology of interactions amongst various geofactors, environmental geological assessments of landscape recognizes potential hazards and natural resources potential and deals in both the site-specific or theme-specific aspects of environmental impacts. Investigations on geologic environments include: river basins or hydrological systems, contamination of groundwater, dry land environments such as the deserts and desertification; coastal environments and processes of erosion and deposition; cold environments and glaciers, earthquakes, active faults, volcanic eruptions, mud flows, landslides and mass-wasting events, etc. and above all the bio-geochemical cycles and human health. Anthropogenic activities and changing land use practices have accelerated the pace of environmental degradation in rural and urban areas. Mining and processing of minerals and rocks have posed another set geoenvironmental problems that required their impact assessment and suitable remediation. Geoenvironmental investigations are multi-disciplinary and require a comprehensive and integrated approach. These include flood hazards, landslides, and earthquake-related natural

hazards, water-logging and salinity/alkalinity aspects, urban and rural development, environmental degradation due to resource exploitation, mining areas and soil erosion and watershed management, environmental impacts of surface water reservoirs, dams and barrages, coastal dynamics and shore-line changes, medical geology and geotourism studies etc. (GSI, 2011)

1.1 Study Area

The present study is oriented for investigations and development of geo-environmental resources, as per the literature review of Geological survey of India (GSI, 2011), Central Ground Water Board (CGCB, 2007), Directorate of Economic and statistics of Andhra Pradesh (DES, 2001) and Indian Remote Sensing Satellite -P6 LISS-III sensor Data product and statistics are displays the Ganganeru river basin falling in the drought exaggerated, erratic rainfall, soil eroded, tanks siltation, groundwater depleted, low productivity of crop yield and degradation of forest and land capability are common problems in the Ganganeru River basin.

Ganganeru River rises in the south-eastern and south-western part of Kadapa district, Andhra Pradesh, India. It is a tributary of Mandavi River; Ganganeru River basin. Located in the Survey of India toposheet nos. 57J/11, 57J/12, 57J/15 and 57J/16, and lies between East longitude 78^0 35' 22'' to 78^0 52' 30'' and North latitude 14^0 04'30'' to 14^0 18'40'' on 1:50,000 scale. Location map (Figure: 1). The catchment of the Ganganeru River basin is 494 Sq. km, partially covered in Lakkireddypalli, Ramapuram, Veerabelli, Pendlimarri, Rayachoti, Galevedu and Chintala- Kommadine mandals of Kadapa district. Under this command area 30 revenue villages and around 300 habitations are covered. The river catchment falls under southern and scarce rainfall zone on the basis of agro climatic conditions, the average annual rainfall of the basin is 667 mm, most of the area comprising large dry tracts and topographically the Ganganeru River basin encompassing of undulating terrain, the maximum mean see level is 800 meters and minimum is 140 meters.

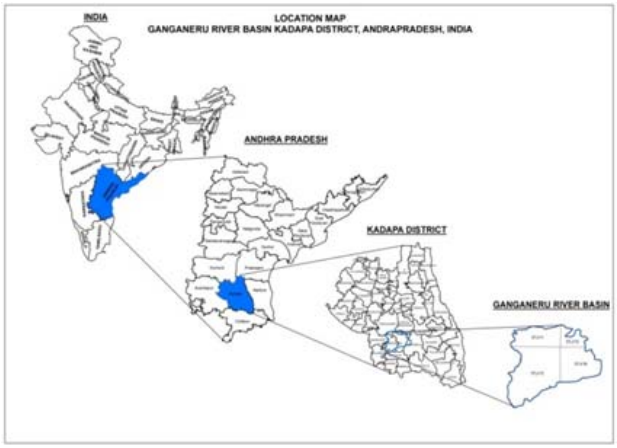

Figure 1: Location Map

2. Literature Survey

2.1 Systematic geo-environmental studies in Geological Survey of India

Systematic geo-environmental studies in Geological Survey of India were initiated in 1968 for environmental problems associated with Quaternary geological and geomorphological investigations on the Brahmaputra river basin to aiding flood-control planning. Further diversification took place in 1970-71 with initiation of studies on urban geology and regional development and district-level multi-disciplinary studies on 1:250,000 scale, beginning with drought-prone and rural areas of Anantapur district in Andhra Pradesh and Puruliya district in West Bengal (GSI, 1979 and 1980). Consequent to Indian adherence to the formal declaration of United Nations Conference on Human Environment at Stockholm on 5th June 1972, geoenvironmental investigations in GSI were given due importance in formulation of its annual programmes of investigations. Urban geological and related geoenvironmental investigations were initiated in 1974 for the Delhi Metropolitan Area and the twin cities of Hyderabad–Secunderabad in Andhra Pradesh (GSI, 1978). Geoenvironmental studies involve preparation of thematic maps and delineation of hazards vulnerability, due to natural and anthropogenic causes. Accordingly, maps are generated on geology, lithology and mineral/rock resources, geomorphology and landscape evaluation including drainage pattern and slopes; soils types and distribution, geotechnical attributes and neotectonic features, geohydrology: groundwater distribution depth-to-water status and quality and surface water resources; landuse - landcover aspects. Several derivative and synoptic maps are then prepared based on these basic data sets. Such thematic maps help in improved understanding of the natural geo-factors leading to preparation of appropriate landuse maps for sustainable growth and development.

2.2 Integrated Mission for Sustainable Development

Study was initiated in the year 1987 with specific reference to find scientific and lasting solutions aims at generating natural resource based sustainable development plan for the study area. The underlying concept of sustainability is the sustainability of productivity and quality of environment of the natural resources/ecological set up. This can be achieved through a set of production functions/ activities which mutually balance the impact of depletion and replenishment of the producing potential (productivity) within the resilience, the natural resources set up starts degrading though in the initial years higher productivity may be recorded, in the long run, the degradation is inevitable. The main objective of technical guidelines is to ensure uniformity of approach and standardization of the end products deliverable under the study. Scientists, specialized in the fields of resources study like geology, geomorphology, groundwater, soils, forest, land use, agriculture etc. with adequate training, skill and experience in remote sensing applications, will be involved in the project. These guidelines are intended for orienting them to execute the project action plan.

2.3 Padmaja Vuppala, et.al applied "Remote sensing and GIS for land and Water resource management"

The focused on Racherla mandal of Prakasam district for developing methodology for use of GIS for the management of land and water resources. IRS 1D LISS III geocoded FCC'S on 1:50,000 scale and other collateral data were used in this study for extracting thematic information such as soil, land use/land cover and hydro geomorphology etc., of the study area slope was prepared using SOI topographic maps on 1:50,000 scale. The various thematic layers were input, analyzed and integrated in arc info, GIS package. In water resource development plan 19 check dams and three percolation tanks are recommended to regulate the surface water flow thereby increasing its influence over the command area and the ground water levels in land resources development plan various cropping patterns in the water shed are suggested based on the soils, existing land use practices, available surface water and ground water potential morphology of the area, slope etc., they concluded that by adopting suitable soil and water conservation measures like contour bunding, lands with poor productivity and serious soil erosion can be brought under fodder, silvipasture and also by applying remote sensing and GIS in management of land and water resource and optimum development can be achieved.

2.4 Arun Kumar (1984 -91) Geo-Environmental Studies of Manipur River Basin Department of Earth Sciences, Manipur University"

Under this study of GEO-Environmental studies is selected the main objective of the work to apply remote sensing data to study of natural resources including landforms, soil, vegetation, slope for geo-environmental investigations of resources, from the geo-environmental appraisal point of view highlighted the significant impact on the Manipur river basin for geo-environmental deterioration. The results were various magnitudes and seemed to be very complex and their impact had the changes in vegetative cover, soil erosion and land degradation

3. Methodology

The steps mentioned here under are implemented for mapping, modeling, analysis and development of an action

plan for the Ganganeru river basin. All the work was carried out using Arc GIS software. NRSC standard thematic mapping methodology to be followed, Indian Remote Sensing satellite, IRS-P6 LISS-III sensor, three seasons' data of 2006 with a spatial resolution of 23.5 m covering ***Ganganeru River basin*** is analyzed. Satellite image onscreen interpretation is carried out delineating geo environmental resource boundaries i.e. River basin boundary, surface water bodies, drainage, Geomorphological landforms, lithological formations, geological structures, hydrogeomorphological units (NRSC, 2007), Land use/land cover map is prepared followed by satellite data based mapping guidelines adopted by NRSA (2006)., soil, slope maps followed by (IMSD, 1985) guidelines and Ground truth information is integrated and finalizing the themes. All the above said parameters were integrating (NRSA, 2008), and generated study area action plan map for development of geoenvironmental resources. A detailed description of action plan units is given in the project report (IMSD, 1985) (Figure 2).

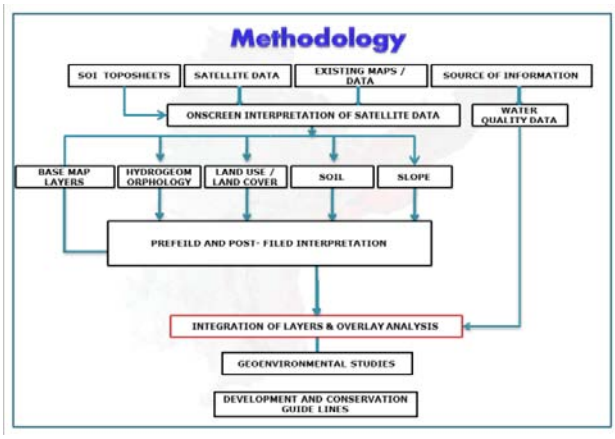

Figure 2: Flow Chart of Methodology

3.1. Climate and Rainfall

The area experiences humid tropical climate. The summer months are very hot and the mercury rises to + 42^0 Celsius, winter months are pleasant, when the night temperature is about 13^0 C to 15^0 C. The Ganganeru River catchment falls under southern and scarce rainfall zone on the basis of agro climatic conditions. The district experiences as an uneven, isolated rainfall in different parts of the study area with large dry tracts. The rain fall is mainly influenced by the South-west monsoon of the Ganganeru River basin viz. Rayachoti and Lakkireddy Palli Mandals receive the rain due to the influence of North-East monsoon. The normal rainfall of the basin is 660mm, against the district average rainfall.

3.2. Geology

Geology is playing key role in the enhancement activity of the society, surface water capitals, subsurface water resources, climatic conditions; soil origin, runoff etc. are mainly contingent on the regional geology. Geologically Ganganeru River basin is underlined by various geological formations i.e. Cuddapah Super group, Lower Proterozoic and Archeans age of rocks. 92% of the Ganganeru River basin is underlined by Peninsular gneissic complex, represented by Granite, Granodiorite, Granite gneiss and Migmatites, and Northern part of the River basin emphasized by the Gulcheru Quartzite of Gulcheru formation, Eastern part is emphasized by Vempalle dolomites of Papagni Group and Bairenkonda Slates of Nallamalai group of rocks. Peninsular gneissic complex of rocks are intrusived by dolerite dykes and quartz veins of lower Proterozoic age of rocks. GSI, 2002 (Figure: 3).

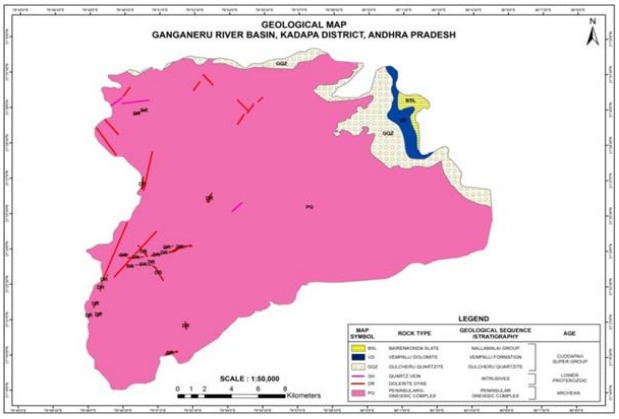

Figure 3: Geology Map, Ganganeru River Basin

3.3. Hydrogeomorphology

The combined units in which the lithology, landform, structures and recharge conditions are unique are called hydrogeomorphic units, they are considered as three dimensional homogenous entities with respect to hydrological properties and recharge condition. In other words, they are treated as the aquifers (NRSC, 2007). In the present study hydrogeomorphological mapping is carried out using IRS P6-LISS-III satellite data. The landforms in the study area are broadly divided into three categories namely fluvial, structural and denudational landforms (Fig.4). As per the depth of weathering and nature of soil cover plays a major role in the groundwater prospecting, the pediplain is further sub-divided into pediplains with shallow and moderate weathering and seventeen geomorphic units are delineated. They are valley fill under fluvial category. In case of denudational landforms, shallow weathered pediplain, moderately weathered pediplains, pediment, pediment inselberg complex, inselberg, residual hill and denudational hill and structural hill on peninsular gneissic complex. Structural hills on Bairenkonda slate, structural hill on Vempalli dolomite, structural hill on Gulcheru quartzite, dolerite dyke ridges are intruded in peninsular gneissic complex Groundwater prospects view Fluvial landforms i.e. Valley Fill is very good aquifer for groundwater storage and given very good groundwater prospects, denudational landforms i.e. hills, pediments, inselberg, pediment inselberg complex, are given negligible to poor groundwater prospects, and pediplain shallow weathered and pediplain moderately weathered are given good groundwater prospects (Figure: 4)

3.4. Structures

All the structures are to be interpreted from the satellite image, the lineaments may not be a single continuous line, and rather it has to be shown as discontinuous line segments.

Lineaments from remote sensing data can be identified mainly based on their linear nature, presence of moisture, alignment of vegetation, alignment of ponds, straight stream segments(NRSC, 2007), etc. However interpretation of lineaments is to be done in conjunction with other diagnostics criteria such as channel offset, bank erosion and down-cutting of channel along lineaments, warping and displacement of sediment layer, and branching of river course, channel rejuvenation and land subsidence, (GSI, 2010) In the Ganganeru River basin consisting various types of structures likes faults, lineaments and fractures. The structures are distributed in North-East and South-West direction of the Ganganeru River basin, Structures are playing a key role in ground water prospects in the hard rock crystalline area, Ganganeru river basin is underlined by peninsular gneissic complex of rocks, hard rock isn't consisting any primary porosity, consisting secondary porosity, structures or fractures are acting as secondary porosity for recharging and storage of groundwater, where the fractures is there that is good for groundwater prospects in the area (Figure: 4).

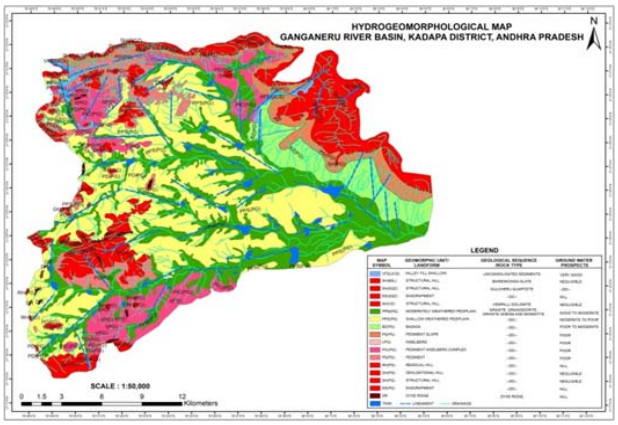

Figure 4: Hydrogeomorphology Map, Ganganeru River

3.5. Land use /Land cover

Land use / land cover and pattern of their spatial distribution forms the basis for any developmental planning. The current land use has to be assessed for its sustainability in the light of land potential before suggesting alternate land use practices. In the present study land use / land cover broadly classified into five categories, which include built-up land, agricultural land, forest land, waste land and others (Figure 5). Agricultural category consists of Agricultural land kharif crop, two crop area and plantation. Forest land category includes dense forest, dense forest closed, open and scrub forest while the waste lands, land with open scrub, barren rocky/stony waste, salt affected land and. Tanks, rivers and streams are grouped under water bodies; detailed areal extending is displays in the table:1

Table 1: Land use / Land cover areal extents

S.NO	LAND USE / LAND COVER	AREA (Sq.km)	% to Total Area
1	Built Up area	5	1
2	Agricultural Land- Land-kharif crop	196	40
	Agricultural Land- Land-Two crop area	76	15
	Agricultural Land-Plantation	8	2
3	Forest dense / Closed	35	7
	Forest dense / Open	14	3
	Forest-Scrub forest	81	16
4	Waste land - Barren Rocky Stony Waste	5	1
	Waste land - Salt Affected Land	5	1
	Waste land - Open scrub	54	11
5	Water Bodies	15	3

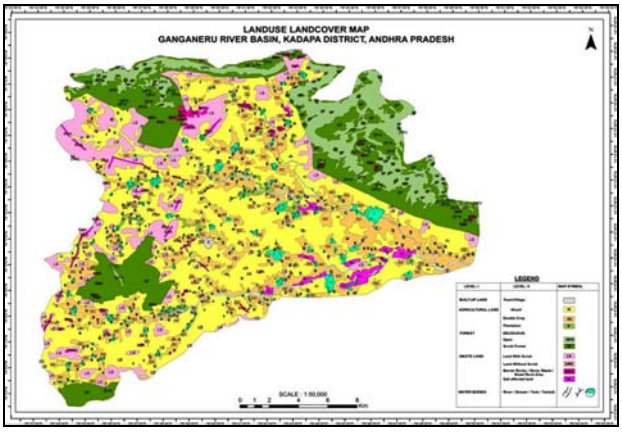

Figure 5: Land Use / Land Cover Map, Ganganeru River

3.6. Slope

Slope is one of the most important terrain characteristics and plays a vital role in geomorphological runoff processes, soil erosion and land use planning. So it is very important to have understanding of spatial distribution of slopes for development and planning of both land and water resources. The slope maps of Ganganeru river basin have been prepared on 1:50,000 scale using Surveyof India topographical maps. The study area has been categorized as per the guidelines suggested by All India Soil and Land Use Survey (AIS & LUS). According to AIS & LUS the slope of the study area is categorized into seven classes. They named as nearly level sloping, very gentle sloping, gently sloping, moderately sloping, strongly sloping, moderately steep to steep sloping, and very steep sloping. In this categories 59% of the Ganganeru River basin, predominantly occurring in the slope class 2 very gentle sloping category. Details of the Ganganeru river basin slopes presenting in the map and table 2 & Figure: 6

Table 2: Slope Category and Areal extent of Ganganeru River basin

Slope class	*Slope category*	*Slope %*	*Area in sq.km*
1	Nearly level	0-1	10
2	Very gentle sloping	1-3	289
3	Gently sloping	3-5	36
4	Moderately sloping	5-10	55
5	Strongly sloping	10-15	35
6	Moderately steep to steep sloping	15-35	24
7	Very steep sloping	>35	45

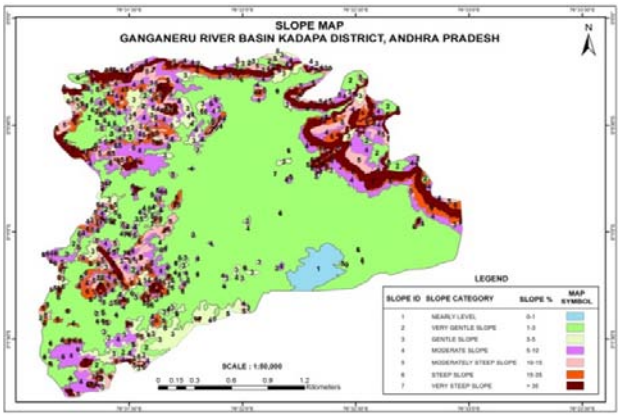

Figure 6: Slope map Ganganeru River basin

3.7. Soil

Soils of Ganganeru River basin area are classified as per the soil taxonomy system of USDA standards enunciated in SMSS technical monograph no 19 of 1982 are followed, for classifying the soils of Ganganeru River basin under soil taxonomy. General description of soil series is provided in below the map. Figure: 7

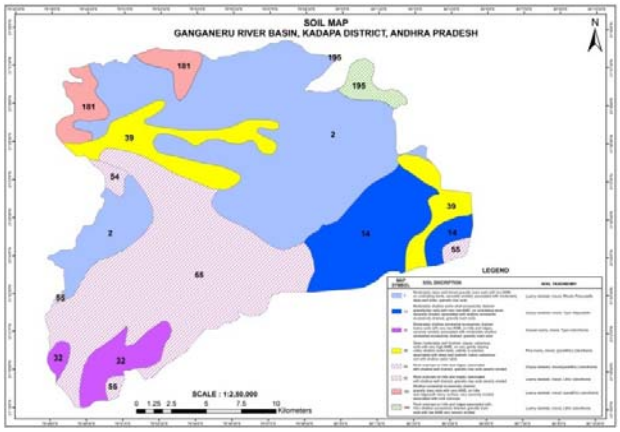

Figure 7: Soil Map of Ganganeru River Basin

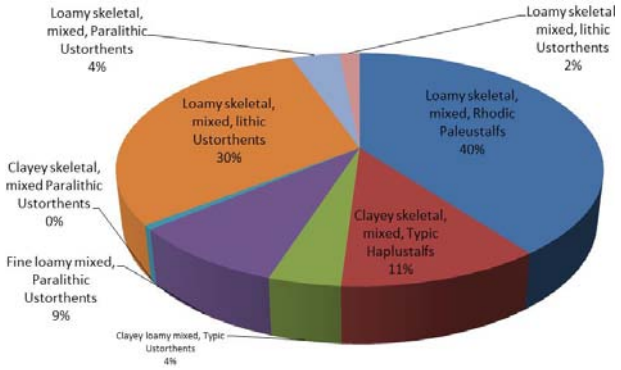

Figure 8: Spatial Distributions of Soils in Ganganeru River basin

Table 3: Soils Descriptions in Ganganeru River basin

Map Id	SOIL TAXONOMY	DESCRIPTION
2	Loamy skeletal, mixed, Rhodic Paleustalfs	moderately deep well drained gravelly loamy soils with low availability of water storage on undulating lands, severally eroded and associated with moderately deep, well drain gravelly clay soils
14	Clayey skeletal, mixed, Typic Haplustalfs	Moderately shallow somewhat excessively drained gravelly clay soils with very low availability water storage, on undulating lands severally eroded, associated with shallow somewhat excessively drained, gravelly loam soils
32	Clayey loamy mixed, Typic Ustorthents	Moderately shallow somewhat excessively drained loamy soils with very low availability water storage, on hills and ridges, severally eroded, associated with moderately shallow somewhat excessively drained, gravelly loam soils
39	Fine loamy mixed, Paralithic Ustorthents	Deep moderately well drained, clayey, calcareous soils with very low availability water storage, on very gently sloping valley shallow water table, salinity in patches associated with deep well drained, loamy calcareous soil with shallow water table
54	Clayey skeletal, mixed Paralithic Ustorthents	Rock outcrops on hills and ridges associated with shallow well drained, gravelly clay soils severely eroded
55	Loamy skeletal, mixed, lithic Ustorthents	Rock outcrops on hills and ridges associated with shallow well drained, gravelly clay soils severely eroded
181	Loamy skeletal, mixed, Paralithic Ustorthents	Shallow somewhat excessively drained gravelly loam soils very availability water storage, on hills and ridges with stony surface, very severely eroded associated with rock outcrops
195	Loamy skeletal, mixed, lithic Ustorthents	Rock outcrops on hills and ridges associated with, very shallow excessively drained gravelly loam soils with low availability water storage very severely eroded

3.8. Action Plan:

Thematic maps of hydrogeomorphology, slope, soil, and land use/land cover maps are integrated in Arc-GIS software and basic integrated land and water resources units are derived and to propose a suitable and sustainable action plan table: 2.regarding the alternate of land and water resources management, taking the resources management potential and limitations, basic needs of the people into consideration for the Ganganeru River basin of Kadapa district of Andhra Pradesh. Table:3 & Figure: 8 the study area land is suitable for agro horticulture 276 sq.km, agroforestry 22.79 sq.km fodder & fuel wood plantation 37.96, sq.km , grazing land with economic tress grasses, intensive agriculture 2.3 sq.km, silvipasture 63 sq.km

Table 4: Integrated and Action Plan of Ganganeru River Basin

RECOMMENDED DROUGHT WORKS	LAND FORM	SLOPE	LAND USE / LAND COVER	SOIL MAP ID	WATER RESOURCES
Intensive Agriculture	Valley Fill	1 & 2	Double Crop	2, 181	Very Good
Agro Horticulture	Pediplain, Pediment, Pediment Inselberg Complex	1, 2, 3	Agricultural land, Kharif crop, Plantations and Scrub land	14, 39, 55, 2, 32, 54, 181, 29, 181	Good to Poor
Agro forestry	Pediplain, Pediment, Pediment Inselberg Complex	3	Agricultural land Kharif crop, Land with Scrub	2,32,39,55,181	Moderate to Poor
Fodder & Fuel wood development	Pediplain, Pediment, Pediment Inselberg Complex, Residual Hills and denudational Hills	4, 5	Agricultural land Kharif crop, Land with Scrub	2, 181, 55, 32	Poor to Negligible
Grazing land with economic tress	Denudational Hills, structural Hills, pediment, Bazada,	3, 4, 5, 6, 7	Scrub Forest land	2, 39, 14, 181	Poor to Negligible

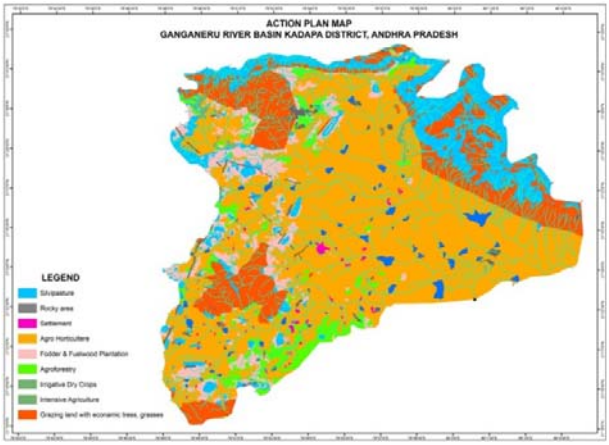

Figure 8: Action Plan Map, Ganganeru River Basin

4. Results and Discussion

The following observations are made in the Ganganeru River basin. The Ganganeru River catchment falls under southern, scarce rainfall zone and draft effected. Geologically Ganganeru River basin is underlined by various geological formations, 92% of the Ganganeru River basin is underlined by peninsular gneissic complex, represented by Granite, Granodiorite, Granite gneiss and Migmatites. Groundwater prospects view Fluvial landforms i.e. Valley Fill is very good aquifer for groundwater storage and given very good groundwater prospects, denudational landforms i.e. hills, pediments, inselberg, pediment inselberg complex, are given negligible to poor, groundwater prospects, and pediplain shallow weathered and pediplain moderately weathered are given moderate to good groundwater prospects. Structures or fractures are acting as secondary porosity for recharging and storage of groundwater resources. 57% of the Ganganeru River catchment is covered agricultural crop land, 26% forest land, 13% waste lands and others are 4%. Based on soil taxonomy the soils are distributed in the basin i.e. Loamy skeletal, mixed, Rhodic Paleustalfs 40%, Loamy skeletal, mixed, lithic Ustorthents 30%, Clayey skeletal, mixed, Typic Haplustalfs 11%, and others soils is 19% Physiographically the relief of the Ganganeru river basin consisting varies, 1 to 7 slope categories are distributed. Based on the integrated thematic layers, action plan is prepared for the development of natural resources, by adopting suitable soil and water conservation measures like contour bunding, lands with poor productivity and serious soil erosion can be brought under fodder, silvipasture and social forestry development. These developmental activities help in reduced soil erosion, increased moisture conservation and improved productivity of the soil

5. Conclusion

Hydrogeomorphology, land use/land cover, soil, slope evidences are most important in the planning of action plan for natural resources management, correlations and environemntal studies of the study area. GIS and Remote sensing technology is an important key to tackle the management of environmental associated difficulties and spatial distribution of environmental resources. The methodology is helped in the management of soil erosion, groundwater resources development and conservation. Various cropping patterns in the Ganganeru River basin are suggested based on action plan of the area. Action plan is generated based on the integrated natural resources of existing of soil types, land use practices, water bodies and ground water resource potentials, land capability, geology, geomorphology and topography settings of the basin area

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Authors Profile

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