International Journal of Multidisciplinary Research and Development
Online ISSN: 2349-4182, Print ISSN: 2349-5979, Impact Factor: RJIF 5.72
www.allsubjectjournal.com
Volume 4; Issue 7; July 2017; Page No. 18-25

Delineation of ground water potential zones in Lingala Mandal, YSR District, Andhra Pradesh, by using remote sensing and GIS

*** G Sudharsana Raju, R Siddiraju, M Rajasekhar**

Department of Geology, Yogi Vemana University, Kadapa, Andhra Pradesh, India

Abstract

Integration of remote sensing data and the geographical information system (GIS) for the exploration of groundwater resources has become a breakthrough in the field of groundwater research, which assists in evaluating, monitoring, and preserving groundwater resources. In the present study area, various groundwater potential zones for the assessment of groundwater availability in Lingala mandal, Kadapa district, Andhra Pradesh has delineated using remote sensing and GIS techniques. Survey of India toposheets and IRS-P6 LISS III satellite imageries are used to prepare various thematic layers viz. drainage, geology, and hydro-geomorphology and land-use & land-cover. Shuttle Radar Topography Mission (SRTM) data is used for preparing DEM and slope. From 1995 to 2016 rainfall data has been analyzed and correlated with groundwater level data. The groundwater potential zones classified into four class i.e., ‘‘good (15.4%), moderate (40.9%), moderate to poor (31.2%) and poor (12.4%) covering an area of 45.69, 121.51, 92.75 and 36.95 respectively. These maps represent hydrogeomorphological aspect, which are essential for planning, development, management and extraction of groundwater. The present information depicted is very useful for planner and local authority in respect of site selection of well types, depth of well, success rate of wells and as well as groundwater development and management.

Keywords: ground water potential zones, hydro geomorphology, DEM, LU/LC, remotesing and GIS

1. Introduction

Groundwater is an imperative natural resource for the reliable and economic condition of potable water supply in both urban and rural environment. Hence it plays a fundamental role in human well-beings, as well as that of some aquatic and terrestrial ecosystems. At present, groundwater contributes around 34% of the total annual water supply and is an important fresh water resource. So, an appraisal for this resource is extremely significant for the sustainable management of groundwater systems. GIS and remote sensing tools are widely used for the management of various natural resources (N.S.Magesh *et al*., 2011; Dar *et al*., 2010; Krishna Kumar *et al*., 2011 ;). Delineating the potential groundwater zones using remote sensing and GIS is an effective tool. In recent years, all-embracing use of satellite data along with conventional maps and rectified ground truth data, has made it easier to establish the base line information for groundwater potential zones (Tiwari and Rai, 1996; Das *et al*., 1997; Thomas *et al*., 1999; Harinarayana *et al*., 2000;). Remote sensing not only provides a wide-range scale of the space-time distribution of observations, but also saves time and expensive (Leblanc *et al*., 2003; Tweed *et al*., 2007). In addition it is widely used to distinguish the earth surface (such as lineaments, drainage patterns and lithology) as well as to observe the groundwater recharge zones (Sener *et al*., 2005). Applications of remote sensing and GIS for the exploration of groundwater potential zones are carried out by a number of researchers around the world, and it was found that the involved factors in determining the groundwater potential zones were different, and hence the results vary accordingly relied only on the lineaments for groundwater exploration and others merged different factors apart from lineaments like drainagedensity, geomorphology, geology, slope, land-use, rainfall intensity and soil texture (Sander *et al*., 1996; Das, 2000; Sener *et al*., 2005; Ganapuram *et al*., 2008). The derived results are found to be satisfactory based on field survey and it varies from one region to another because of varied geo-environmental conditions. Development of groundwater in the study area is through construction of dug wells, dug-cum-bore wells and bore wells. However, recharging those groundwater sources is condensed by frequent dry seasons and failure of monsoons. The minimum depth of the water table in the study area is 30m favorable localities adjoining rivers, canal system and abutting tanks, whereas the water table in remote areas is found very deeper up to 150-200m resulting in acute water shortage. Exploitation of groundwater resources has increased in the past decades, leading to the over-consumption of groundwater, which eventually causes ecological problems such as decreased groundwater levels, water fatigue, water pollution and decline of water quality. Integration of remote sensing with GIS for preparing various thematic layers, such as lithology, drainage density, lineament density, rainfall, slope, soil, and land-use with assigned weightage in a spatial domain will support the identification of potential groundwater zones. Therefore, the present study focuses on the identification of groundwater potential zones in Lingala mandal, Kadapa district, Andhrapradesh using the advanced technology of remote sensing, and GIS for the planning, utilization, administration, and management of groundwater resources.

2. Study area

The study area lies between $14^{0}\ 22^{|}\ 30^{||}$ to $14^{0}\ 36^{|}\ 00^{||}$ North latitude and $77^{0}\ 52^{|}\ 30^{||}$ to $78^{0}\ 13^{|}\ 20^{||}$ East longitudes, covering an area of 296.91 km^2 (Fig. 1). The annual average rainfall in the study area is around 536.05 mm and monthly maximum, minimum and means temperature of the study area is 44^{0}c, 21^{0}c and 28^0 c respectively. Study area is partially covering in topographical maps of 57/F14, 57/J02 and 57/J03 of Survey of India. The area is mainly composed of Basic Flows from vempalle formation, Tadpatri shales, dolomite, and quartzite from Chitravathi group. In which, most of the area is covered with Tadpatri shales.

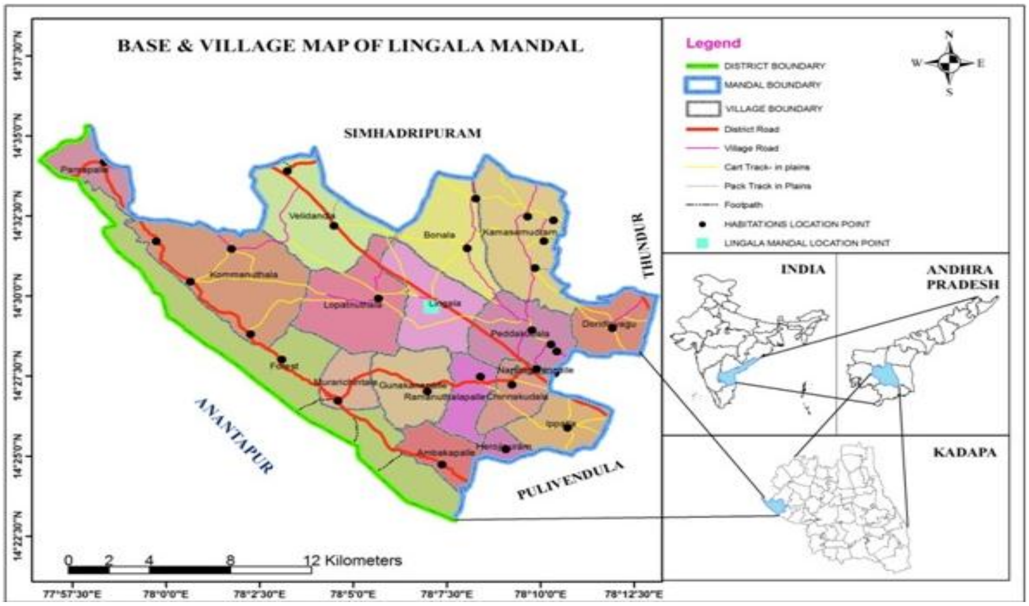


Fig 1: Location map of the study area

3. Methodology

The methodology adopted for the present study is shown in Fig. 3. The base map of Lingala Mandal, Kadapa district, Andhra Pradesh was prepared based on Survey of India topographic maps 57/F14, 57/J02 and 57/J03 on a 1:50,000 scale. The drainage network for the study area was scanned from Survey of India (SOI) toposheets and digitized in ArcGIS 9.3 platform. The study utilized digital data from Indian Remote Sensing (IRS P6) LISS III having a spatial resolution of 23.5 meter was acquired from National Remote Sensing Centre, Hyderabad and a standard FCC was generated (Fig 2). The slope map was prepared from SRTM DEM data in ArcGIS Spatial Analyst module. The rainfall data has been obtained from the Chief Planning Office Kadapa district. In this study to target potential sites for tapping ground water by using remote sensing technique has been applied. Integration of drainage, geology, geomorphology, LU/LC and other meteorological data finally hydro-geomorphology maps prepared by using ArcGIS 9.3 platform.

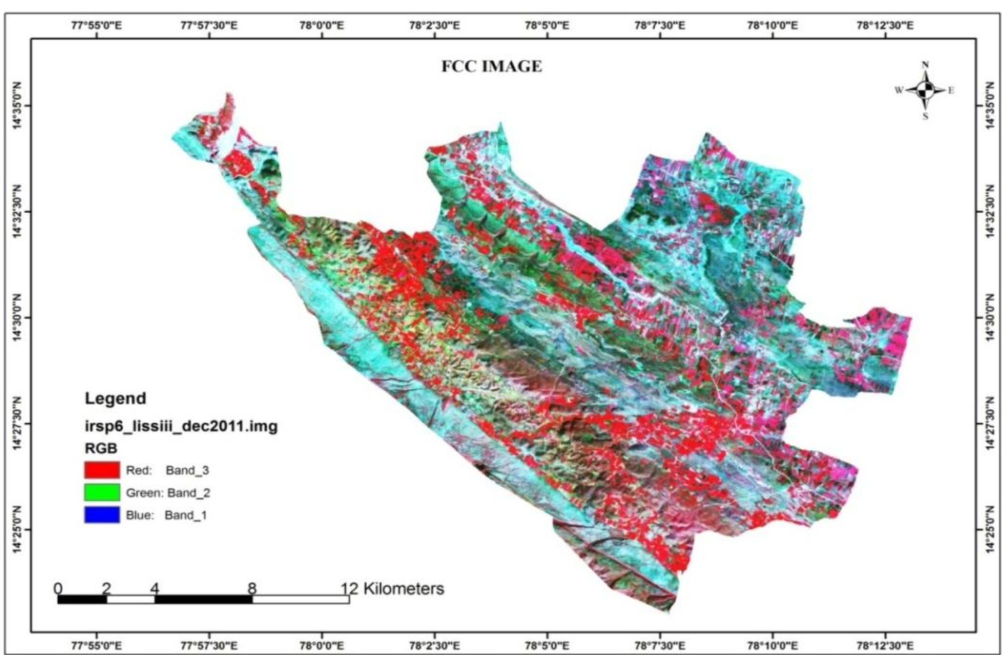
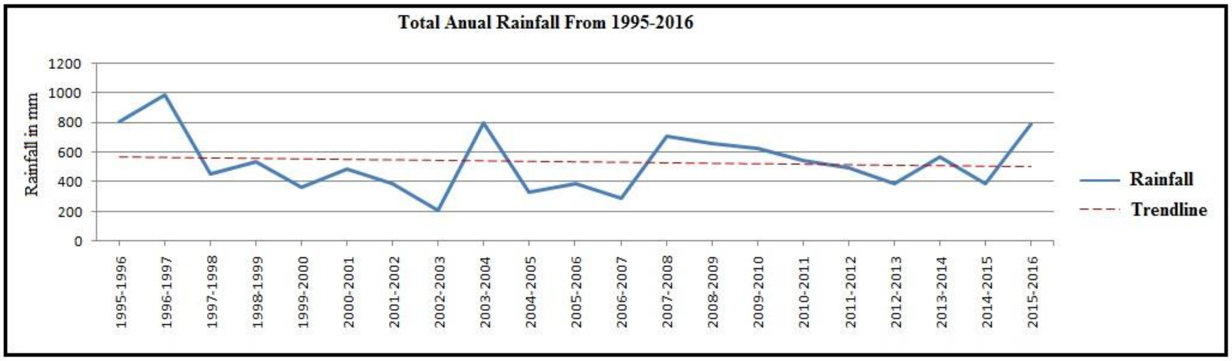


Fig 2: FCC Satellite image of the study area

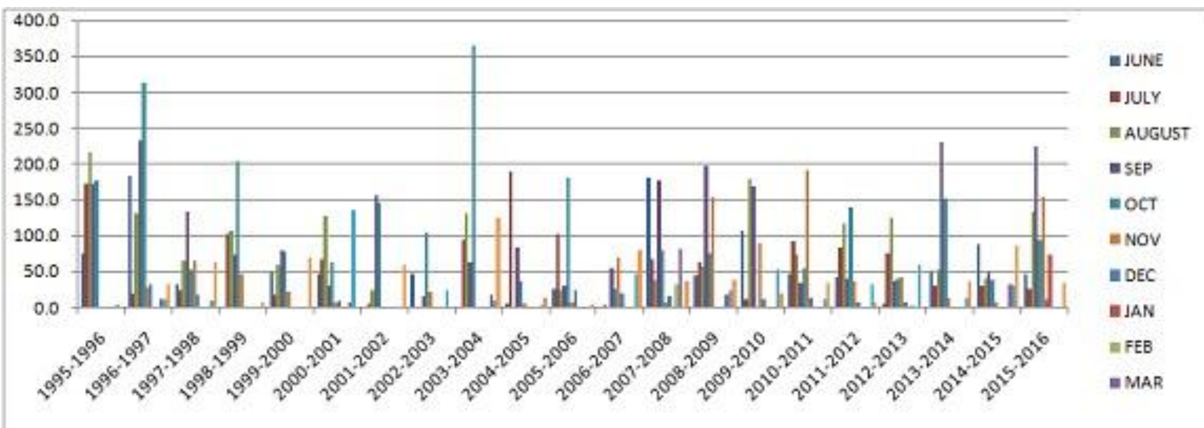
4. Results and discussion

4.1 Climate & rainfall

Climatically the study area is located in the semi-arid region. The mean annual rainfall of the study area is <536.05 mm. The monthly maximum, minimum and mean temperature of the study area is 44^0c, 21^0c and 28^0 c respectively. Four seasons are recognized the period from January to February belongs to the cool dry season or winter season, period from June to September belongs to the hot wet season, south west monsoon or advancing monsoon season and period from October to December belongs to the cool wet season, north west monsoon or retreating monsoon season. Maximum rain fall in the study area is in between June to November (graph). The period from March to May belongs to the hot dry season. As such there is rarely much rainfall till the end of the May.



3A



3B

Fig 3: 3A & 3B are showing Graphical representations of rainfall 1995-2016 of the study area.

4.2 Geology

Geology and mineral resource map of Kadapa district is used for preparing geology thematic layer and also updated to the satellite image in the Arc GIS environment. Geologically the area is comprised of Cuddapah super group of rocks upper Proterozoic age.

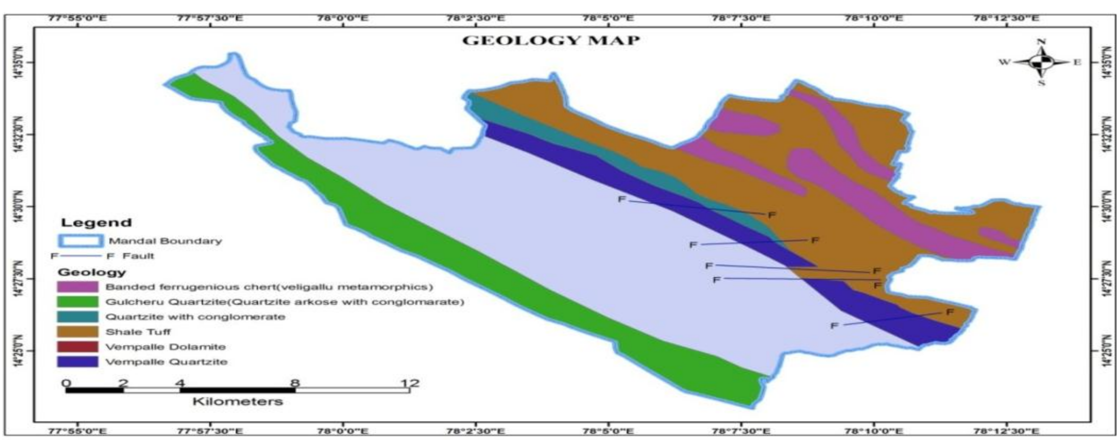
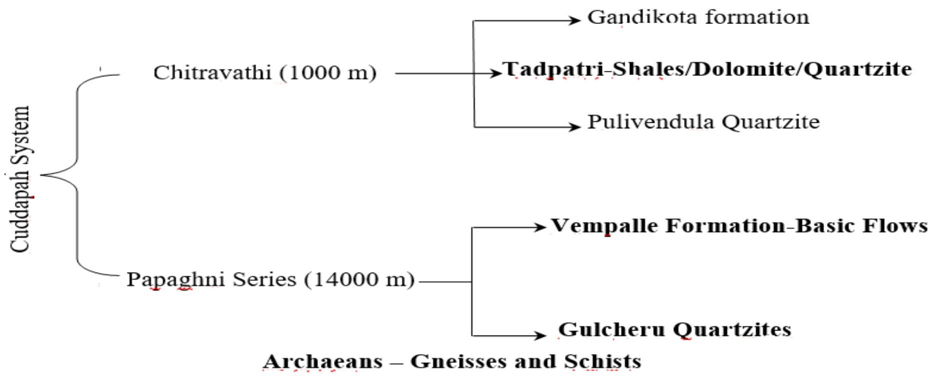


Fig 4: Geology Map of the study area



The storage capacity of the rock formations depends on the porosity of the rock. Water moves from areas of recharge to areas of discharge depending up on the hydraulic conductivity and permeability in the rock formation. The study area is mainly composed of Basic Flows from Vempalle formation, Tadipatri shales, dolomite, and quartzite from Chitravathi group. In which, most of the area is covered with Tadipatri shales (Fig-4).

4.3 Slope analysis

Slope factor plays a vital role in identification of groundwater potential zones. Higher degree of slope results in rapid runoff and increased erosion rate with weak recharge potential (Magesh *et al*., 2011ab).

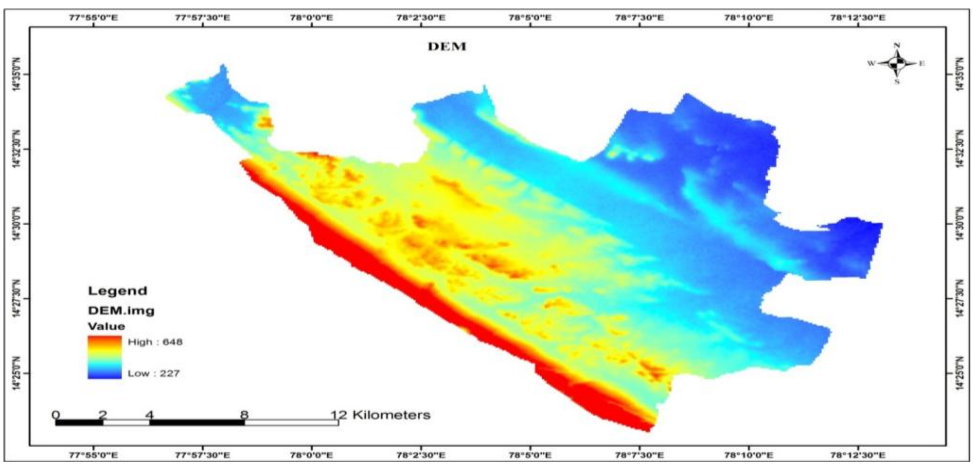


Fig 5: SRTM DEM map of the study area

The slope map of the study area was prepared based on SRTM data using the spatial analysis tool in ArcInfo 9.3. Slope grid is identified as "the maximum rate of change in value from each cell to its neighbours" (Burrough, 1986). Based on the slope, the study area can be divided into six slope classes. The areas having $0-3^0$ slope fall into the 'very good' category because of the nearly flat terrain and relatively high infiltration rate. The areas with $3-16^0$ slopes are considered as 'good' for groundwater storage due to slightly undulating topography with some runoff. The areas having a slope of $16-26^0$ cause relatively high runoff and low infiltration, and hence are categorized as 'poor' and the areas having a slope $>26^0$ are considered as 'very poor' due to higher slope and runoff.

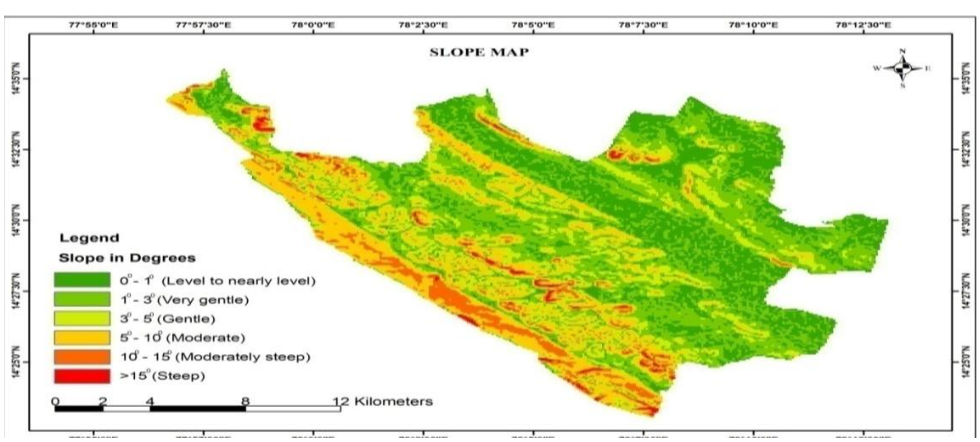


Fig 6: Slope map of the study area

4.4 Land use / land cover

Land use changes are feasible to alter hydrogeomorphic variables, including hydrological and sedimentalogical connectivity, largely through modifications of infiltration capacities and soil erodabilities as well as hill slope micro topographic characteristics and water balance attributes associated with vegetation changes. The propensity for alter and the capacity of a system to absorb change, together describing the 'sensitivity' of a system to change (Brunsden and Thornes, 1979), may vary between systems, among system elements, and in time (Brunsden and Thornes, 1979; Knighton, 1998; Brunsden, 2001, Downs and Gregory, 2004).The IRS-P6-LISS III, FCC satellite data was visually and digitally interpreted by using the image interpretation elements such as tone, texture, shape, pattern, association etc. and ArcGIS software was used for processing, analysis and integration of spatial data to reach the objectives of the study. Passable field checks were made before conclusions of the thematic maps. The main objective of this study is to extract the land use/land cover and its categories of the study area. Classification of land use/cover for analysis was done based on their character to infiltrate water in to the ground and to hold water on the ground. Usually settlements are found to be the least suitable for infiltration (Fig.7 & Table 1).

4.4.1 Agricultural land

Kharif, Rabi and both two seasonal crops lands and also plantation areas are identified in the study area results are shown in the figure 7. The agricultural conditions vary not often within the study area. Agriculture suffers from drought conditions, inadequate irrigation facilities and overall mismanagement of water resources. The total agricultural land covers 142.86 (48.11%) in which is mostly covered in the study area. In the study area the crop lands have wet cultivation and dry cultivation. Wet cultivation includes food crops were noticed in. Dry cultivation includes trees or chards, groundnut, etc and the areas which have this type of cultivations are noticed at etc (Table 1).

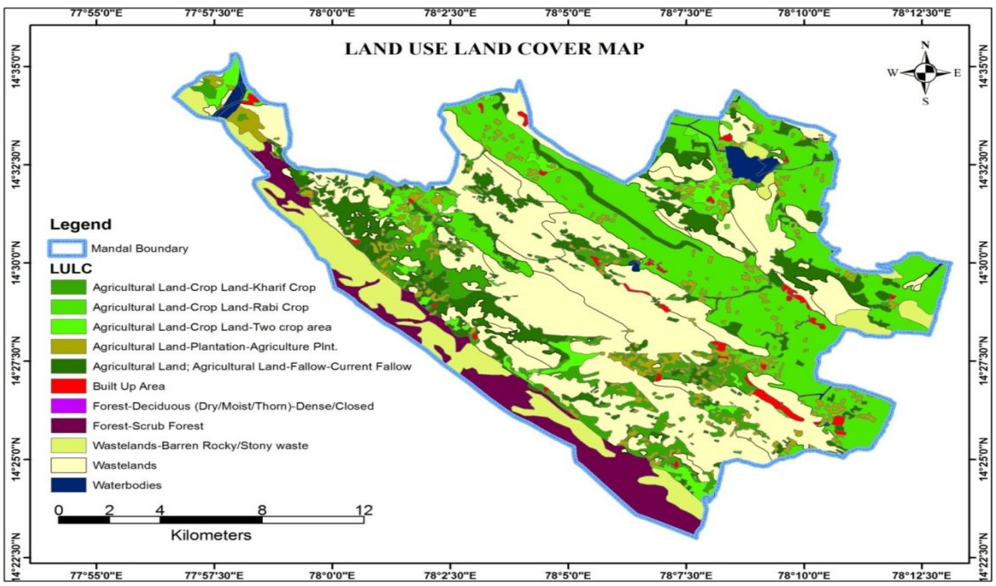


Fig 7: Land use land cover map of the study area.

4.4.2 Built-up land

The built-up land occupies 3.27 Sq. km (i.e., 1.10 %). Built up land is composed of areas of intensive with much of the land covered by structures. Included in this category are cities, towns, villages, industrial and commercial complexes and institutions. In the study area major towns or villages are Ambakapalle, Bonala, Kommanuthala, Lingala, Parnapalle etc. The transportation facilities in the study area are roads and Dondlavagu, Kondareddipalli, Parnapalli, Pulivendula etc.

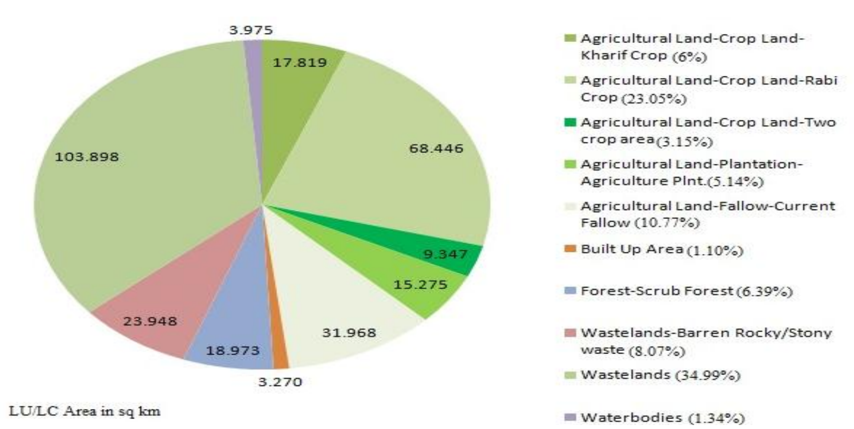


Fig 7: Pie-Chart representation of Land use land cover map of Study area

4.4.3 Forest land

Forest, comprises of thick and dense canopy of trees. Delineation of forest land is easy with FCC (False Color Composition) Satellite image. These lands are identified by their red to dark red tone and varying in size. They are irregular in shape with smooth texture. The forests are found on the south south-east and western part of the study area. In this area covers mostly the deciduous and scrub forest. The relative concentration of scrubs, bushes and smaller trees are predominant in this category. In the satellite image such forest are identified by red in tone with smooth texture. The total forest land occupies 18.97.km (i.e., 6.38%) of the study area (Fig 7).

Table 1: Areal extent of various Land use/Land cover categories

LU/LC	Area in sq km	%
Agricultural Land-Crop Land-Kharif Crop	17.82	6.00
Agricultural Land-Crop Land-Rabi Crop	68.45	23.05
Agricultural Land-Crop Land-Two crop area	9.35	3.15
Agricultural Land-Plantation-Agriculture Plnt.	15.28	5.14
Agricultural Land-Fallow-Current Fallow	31.97	10.77
Built Up Area	3.27	1.10
Forest-Scrub Forest	18.97	6.39
Wastelands-Barren Rocky/Stony waste	23.95	8.07
Wastelands	103.90	34.99
Waterbodies	3.97	1.34

4.4.4 Water bodies-river and stream

The water bodies-rivers and streams are occupies 3.97 sq.km (i.e., 1.33%) of the total study area. Both manmade and natural water features are included in this category they are rivers, streams, lakes, tanks and reservoirs. In the satellite image deep water features appear in black tone and shallow water feature appears light blue in color. Utilizing agricultural and drinking purpose, it is located in the north eastern part of the study area on map. Numerous major and minor tanks, streams are identified. The availability of water with in the tank or reservoir they may be wet or dry.

4.4.5 Wastelands-barren rocky/stony waste

Wastelands-Barren Rocky/Stony waste occupies 34.34 Sq.km (i.e., 13.03 %) of the study area. It covers all lands which are uncultivable like mountains, bare exposed rock, gravel pits etc.

4.5 Hydrogeomorphology

Hydrogeomorphology map has been prepared in the process of integration of geology and geomorphology. The Synoptic view of satellite imagery facilitates better appreciation of geomorphology and helps in mapping of different landforms and their assemblage. The photo interpretation criteria, such as tone, texture, shape, size, location, association, physiographic, genesis of landforms, nature of rocks/ sediments, associated geological structures, etc., are to be used for identification of different landforms/ geomorphic unit's. Initially, the entire image has to be classified into three major zones, i.e. Hills &plateaus, Piedmont Zones, and Plains considering the physiographic and relief as the criteria. Then, within each zone, different geomorphic units have to be mapped based on the landform characteristic, their aerial extent, depth of weathering, thickness of deposition etc. Subsequently, with the study area flood plain, valley individual landforms have to be mapped and represented on the map using alphabetic codes. Every group in the thematic layers was placed into one of the following categories viz.: (i) Good, (ii) Moderate and (iii) Poor, depending on their level of groundwater potential. In view of their behaviour with respect to groundwater control, the values assigned to the lithology layer take into account the hydrogeological implication of the rock types. The characteristics considered for lithology are: thickness of weathering, rock type, type and fracture density, occurrence of dykes, etc.The present study area has six geomorphologic units of bedrock, such as cuesta, structural hills, pediments, pediplains shallow, pediplain moderate, flood plain, pediments are identified. In which the Meta sediments of Cuddapah basin that are shales tuff, Dolomites, Basic Flows and quartzite's (fig-9 & Table 2).

Table 2: Ground Water Potential zones of Study Area

Groundwater Potential	Area(sq km)	%
Good	45.70	15.39
Moderate	121.51	40.93
Poor	129.71	43.68

i) Good groundwater potential zones

The High groundwater potential zones shares about 45.7 sq.km (15.39%) of the total study area. So far geomorphology is concerned, Tanks, River, Flood plain and Pedi Plain Moderate (PPM) has been considered as good for groundwater potential. PPM is positioned in side off PPS in the These are characterized by the presence of relatively thicker weathered material are shown in the hydrogeomorphology map. It is a gently sloping nearly flat and smooth surface of Vempalli formations of Papagni group, with less than 20m deep weathered material. Most of the area under this unit is agriculture land. Depending upon the thickness of the weathered zone, the groundwater potential is good and important for construction of dug well and dug-cum-bore well. It is belonging to good groundwater potential zones.

ii) Moderate groundwater potential zones

The moderate groundwater potential zones shares about 121.51 sq.km (40.93%) of the total study area. Shallow weathering Pedi Plain (PPS) and Pediment (PD) comes under this zone. An extensive, multi concave, thinly alleviate rock cut erosion surface formed in a desert region by the coalescence of two or more adjacent pediments and occasional desert domes, and representing the end result of the mature stage of the arid erosion cycle from Pedi plains. The present study area Pedi Plain Shallow (PPS), Pedi Plain Moderate is identified based on the thickness of the bed rock having moderate groundwater potential map.

iii) Poor groundwater potential zones

The moderate groundwater potential zones shares about 129.71sq.km (43.68%) of the total study area. So far geomorphology is concerned, Structural Hills, cuesta and Inselberg has been considered as poor groundwater potential. Most of the area is covering under poor groundwater potential zones.

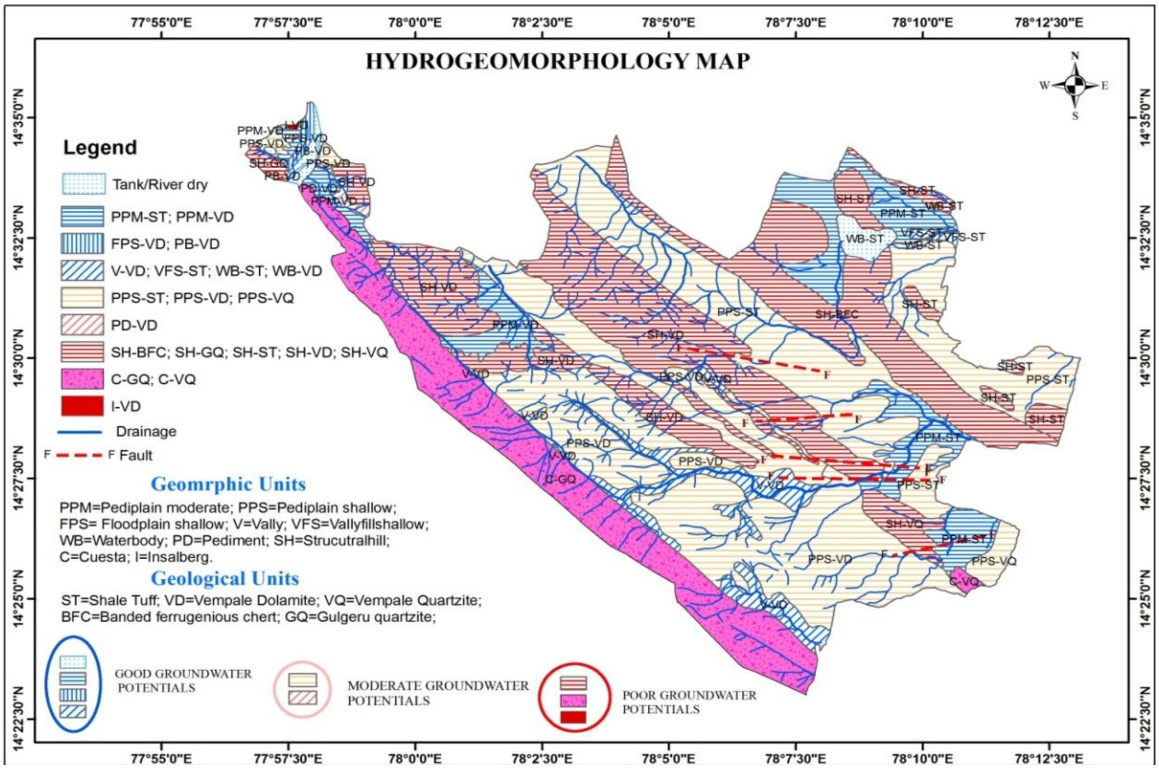


Fig 9: Hydrogeomorphology map of study area

5. Conclusion

The overall study most of the villages are within the moderate potential zones and very few villages are good that are in potential zone hydro-geomorphology, land use/land cover evidences are most important in the planning of action plan for natural resources management, correlations and environmental 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 groundwater resources development and conservation. Action plan is generated based on the integrated natural resources of existing of land use practices, water bodies and ground water resource potentials, land capability, geology, geomorphology and topography settings of the study area. Applications of remote sensing techniques for groundwater targeting has taken a definite role to understand the hydro potentialities of different terrain in terms of hydro geomorphic units and fracture trace analysis. According to Land Use Land Cover 48.11% of the land covered with Agricultural Land-Crop Land, 1.10% of Built Up Land, 6.38% of Forest land, 1.33% of Water bodies and 13.03% of wastelands-Barren Rocky /Stony waste. Further, it is concluded that the integrated approach of geological, hydrological and Satellite Image interpretation in GIS Environment should be applied for sustainable development and management of groundwater resources.

6. References

1. Ballukraya PN. Hydro geophysical investigations in Namagiripettai Area, Namakkal district, Tamil Nadu, jour.Geol.Soc India. 2001; 58:239-249.
2. CGWB water portal. Website. http://www.india-wris.nrsc.gov.in/
3. Harinarayana P, Gopala Krishna, Balasubramanian GS, Remotesensing A. data for ground- water development and management in Keralapura watersheds of Cauvery basin, Karnataka. In: Proc. National seminar on earth Resources. Mangalore University; (abs) Jones, H.C The iron ore deposits of Bihar and Orissa. Mem.GSI. 2000; 63(22):167-302. 1934, 7-8.
4. Kar AJ. Climatic aberration and role of groundwater in sustainable growth of agriculture and mitigating Drinking water need in Drought prone Bolangir district, Orissa. In. proc of seminar on ", Ground-water resources of Orissa for 2020" Central ground- water Board, Bhubaneswar, Orissa. 2000; 197-214.
5. Magesh NS, Chandrasekar N, Soundranayagam JP. a Delineation of groundwater potential zones in Theni district, Tamil Nadu, using remote sensing, GIS and MIF techniques Geoscience Frontiers. 2011-2012; 3(2):189e-196.
6. Mahalik NK. Groundwater provinces of Orissa. Institute of engineers, Technological Session. Bhubaneswar, Orissa, 1980; 22:11-14.

7. NRSC, Remote Sensing applications, 2010. NRSC Bhuvan website http://www.nrsc.gov.in/
8. Prasad PR, Pekdeger A, Ohse, W.Geochemical. Geophysical studies of salt water intrusion in coastal regions, Proc, Hembrug symposium, IAHS. Publ. 1983; 146:209-218.
9. Prithvi Raju N. geomorphic studies in Sarada river basin, Visakhapatnam district, Andhrapradesh, India. Awarded Ph.D thesis, Andhra University, Visakhapatnam, India, 1980.
10. Sahu PC. Hydro geological studies in the Bonai subdivision of Sundergrh district, Orissa, India Ph.D Thesis, (unpublished), 2004.
11. Salwa Farouk Elbeih, An overview of integrated remote sensing and GIS for groundwater mapping in Egypt. Ain Shams Engineering Journal Ain Shams University. 2015; 6:1-15.
12. Sankar K, Venkataraman S, Geological, Geomorphological. mapping in and around Bharathidarsan University; A Remote Sensing approach. Jour. of appl. Hydrology. 2002; (1):15-22.
13. Saraf AK. A report on land use modeling in GIS for Bankura district, project sponsored by DST,NRDMS Division, Govt of India, 1999.
14. Sudarsana Raju, Micro G. level evaluation of water resources in parts of YSR District, AP, India by using Remote Sensing and GIS. International journal of Remote sensing and Geoscience. 2014; 3(6).
15. SRTM data from https://earthexplorer.usgs.gov/
16. Manjare BS. Identification of groundwater prospecting zones using Remote Sensing and GIS techniques in upper Vena river watersheds Nagpur district, Maharashtra, India. 15th Esri India User Conference, 2014.