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REMOTE SENSING AND GIS BASED WATER QUALITY ESTIMATION FOR THIMMAPALLY WATERSHED

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ABSTRACT

Groundwater resources are dynamic in nature as they grow with the expansion of irrigation activities, industrialization, urbanization etc. As it is the largest available source of fresh water lying beneath the ground it has become crucial not only for targeting of groundwater potential zones, but also monitoring and conserving this important resource. The expenditure and labour incurred in developing surface water is much more compared to groundwater, hence more emphasis is placed on the utilization of groundwater which can be developed within a short time. In the study about the area we have learned about the archean rocks, structure, sub-surface lithology, geomorphology, hydrology, identifying the ground water potential zones.

Key words: Geomorphology, Identifying the ground water potential zones, ground water use, ground quality map.

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1. INTRODUCTION

Rivers are the main source of surface water in the country. People of India have a sentimental bondage with many holy rivers of the country such as Ganga, Yamuna, Godavari, Krishna, Kaveri, Narmada and Brahmaputhra, presumably, owing to our long dependence on them as sources of water for drinking, irrigation and industrial purposes and their utility as drainage courses. Rivers also support navigation, fishery development, hydro-electric power generation and propagation of wild life environment. Efficient and economic exploitation of these water resources is, thus, essential not only for agricultural and industrial development of the country but is also required for the very survival of the mankind. The study area falls in low ground water use category. The depth to water table in the watershed ranges between 5-15m bgl. For determining the chemical quality of groundwater occurring in the watershed, water samples have been collected. These are subjected to detailed chemical analysis. The results of analysis are presented and the chemical quality has been described in terms of its suitability for drinking/ Industrial purposes. The study indicated that medium air and low water polluting industries can be setup towards East of Cherial, South-west of Keesara and high air and low water polluting industries towards North of Ghatkesar. The watershed is covered by 21 villages covering parts of three mandals. The major portion of the study area is covered in Keesara mandal (97 sq.km) fallowed by Shamirpet (7.60 sq.km) and Gahtakeswar (3.70 sq.km).

1.1. Description of Study Area

Keesara, an important town of study area is a place of great sanctity of Hinduism, enshrined with mythological glory of Lord Shiva belongs to medieval period and is renowned throughout the state. The study area lies in the North Eastern portion district of Ranga Reddy which is situated at the heart of Dakshinapatha of the Deccan Plateau of the Indian subcontinent an epitome of ancient Nizam culture and with latest edition of Information Technology. Both these ancient and modern cultures have to some extent contributed, directly or synergistically, for betterment of human life in this otherwise chronic drought-prone area. A long term planning strategy has been devised with the consequent study of the area under, 'Remote Sensing and Geographical Information System based Natural Resources Inventory and Management plan for Erimulli Vagu catchment, Musi River Basin, in order to make the study area survive as a viable, better inhabited and economically self-sustained entity. The term "development" assumed a new meaning after the Brundt land Report which called for a change in economic world order to reduce the destruction of environment and solve social problems. The term" sustainable development" has finally emerged as a code phrase to focus the need for harmonious development of land, water, vegetation and other natural resources of the area in such a way that the changes proposed to meet the needs of the development are brought about without diminishing the potential for meeting their future needs as well as those of the future generations. Systematic planning is indeed, prerequisite for the proper management and development of the land resources, which are highly stressed in the area as a result of frequent droughts causing water scarcity and overall poor life-style of the people. Sustainable development requires a holistic approach maximizing the crop yields after taking into account the precarious environment conditions

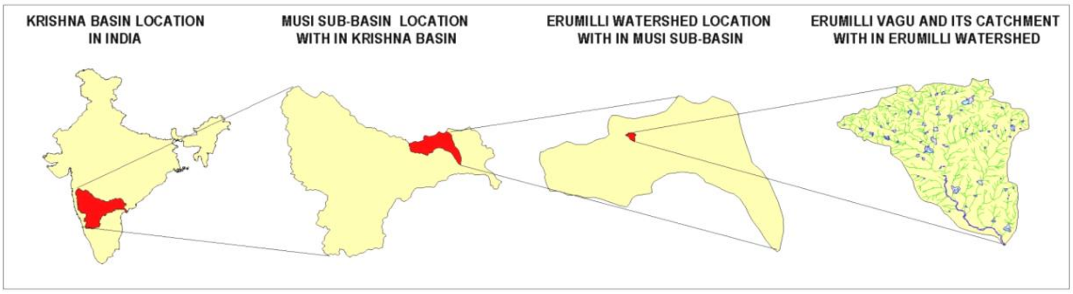

Figure 1 Location of study area map

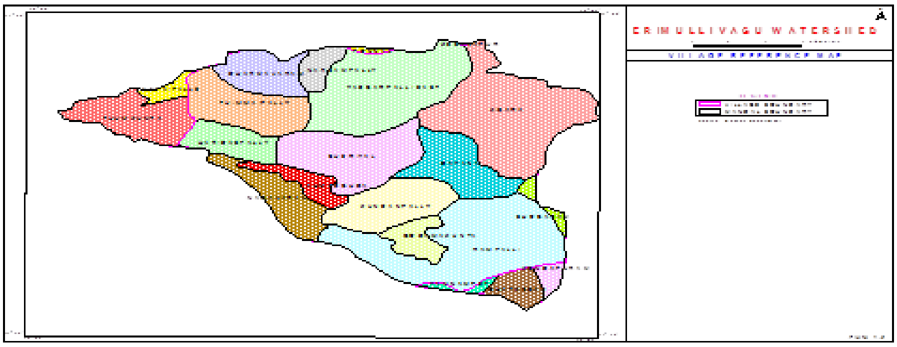

Figure 2 Village reference map

2. OBJECTIVES

The main objectives of the study area:

- Analysis of ground water samples for the data collection of amount of dissolved oxygen, hardness, presence of calcium, magnesium, chlorides, sulfates, fluorides, etc,.
- Study of geomorphology, ground water potential zones, hydrogeology, ground water use map, ground water quality map,
- Generation of physiography, ground water potential map, geomorphology.

3. METHODOLOGY

3.1. Data collection

Different data products required for the study include satellite data and SOI toposheets are collected. The satellite data of IRS-P6, LISS III, 2011 and 2016 years data was geometrically corrected and enhanced using SOI toposheets with scale 1:50000 and ERADAS software satellite imagery are printed in FCC. Collateral data collected from related organizations, comprises of ground water quality and demographic data.

3.2. Database Creation

Satellite imageries are georeferenced using the ground control points with SOI toposheets as a reference and further merged to obtain a fused output in EASI/PACE Image processing software using the LISS III of 2011 and 2016 data of IRS P6. The study area is then delineated and subsetted from the fused data based on the latitude and longitude values and a final hard copy output is prepared for the generation of thematic maps using visual interpretation technique. The GIS digital database consists of thematic maps like land use/land cover, drainage, road network using Survey of India (SOI) toposheets and fused data of IRS – P6 PAN and IRS-ID LISS-III satellite imagery.

3.3. Spatial Database:

Thematic maps like base map and drainage network maps are prepared from the SOI toposheets on 1:50,000 scale using Arc/Info GIS software to obtain a baseline data maps of the study area was prepared using visual interpretation technique from the fused satellite imagery (IRS P6 + LISS III of 2011 and 2016) and SOI toposheets along with ground truth analysis. All the maps are scanned and digitized to generate a digital output.

3.4. Attribute Database

Fieldwork is conducted and ground water samples are collected from 19 predetermined locations based on the land use and drainage network maps in the study area. Care is taken in collecting the ground water samples for uniform distribution and density of sampling locations. The ground water samples were analyzed for various physico-chemical parameters adopting standard protocols (APHA, AWWA, WPCF 1998). The ground water quality data thus obtained forms the attribute database for the present study (Table 1).

3.5. Integration of Spatial and Attribute Database

The spatial and the attribute database generated are integrated for the generation of spatial distribution maps of selected water quality parameters namely pH, alkalinity, chlorides, sulphates, nitrates, TDS, total hardness and fluorides. The ground water quality data (attribute) is linked to the sampling location (spatial) in ARCGIS and maps

3.6. Archaean Rocks

The prominent enclaves are seen at Shamirpet, near Yadgiripalli, Keesara gutta and Ismail Khan guda ranging in size from a few cm to a few meters and show NW – SE trend with fracturing and boulderisation at places.

3.7. Structure

The non-planar structures observed include minor folding, folded foliations, links in the older metamorphic and migmatite rocks. Granites/gneisses exhibit NNW-SSE, NNE-SSW, N-S and E-W prominent joints. These joint are more or less vertical in general, rarely dipping steeply. Horizontal and sheet joints are common features in the migmatites as well as in granites. Generally joints and fractures in massive, porphyritic granites are more planar in form and appear to have greater areal extent than those in gneisses. As a result, massive porphyriitic granites appear in outcrop as large columnar blocks or slabs, whereas gneisses appear as rounded domes or smaller boulders. Foliation joints are developed in the older amphibolite enclaves and trend NW-SE. Joints and fractures are denser along the sides and bottoms of narrow linear valleys, which have developed in granitic terrain than those of in the upland areas. In outcrops, joint openings range up to several millimeters, closing generally at depth. The trends of the prominent lineaments are WNW-ESE, NE-SW, NNE-SSW and N-S. Among these N-S lineaments are considered to be the youngest.

3.8. Sub-Surface Lithology

The sub surface lithology of this predominantly granitic area shows a thickness of soil cover ranging from 0.4 to 1.0m., and weathered granite thickness varies from 0.4 to 28.20m. The first semi confined, fractured and weathered aquifer is met with locally in the depth range from 11.50 to 27.00m. and second semi confined fractured aquifer is reported in the depth range 32.00m to 37.00 m below ground level in a larger part of the area along structural valleys.

3.9. Geomorphology

The main geomorphic units in the study area are Pediment Isenberg Complex (PIC), Shallow weathered Pediplain (PPS) and moderately weathered Pediplain (PPM).

3.10. Ground Water Potential Zones

Based on the map the area is divided into 'High', 'Medium' and 'Low' potential areas / zones. The high potential areas represent areas with adequate ground water resources. The low potential areas represent areas where ground water is scarce or not available. The medium potential areas represent areas where excessive with drawls may lead to ground water depletion. This map is prepared based on interpretation of satellite imagery and the area is divided into areas /zones of high/medium/low ground water potential.

3.11. Hydrogeology

Groundwater exploration carried out in the study area indicates the presence of 2 to 4 aquifer zones upto a depth of 100m. in granites. Ground water in the weathered zone of granites occurs under water table conditions. The yield of dug wells in weathered granites ranges from 35 to 70 Cu.m/d and that of bore wells to 1000 to 3000 GPH (4.5 m^3 to 13.6 m^3 per hour) in weathered and fracture zones. The topography and landforms have strong influence on well yield, especially of shallow wells, as they influence the thickness of the weathered zone. The influence of landforms on well yields is also demonstrated by Perumal (1990) from a study of granite- gneiss in the Athur valley of Tamil Nadu. The availability of water and the demand varies considerable in different seasons. Actually at the time of peak demand, the availability of water is minimum.This is more adverse in hard rocks where surface water runoff is more and infiltration is limited. Thus inequitable demand of water in time and space has further made the matter more complex both for planners and users.

3.12. Ground Water Use Map

This map has been prepared based on the well inventory data collected and based on environmental considerations (CPCB, 1996). The ground water use sensitivity can be defined as to what extent the use of ground water is affected by the siting of a particular water polluting activity. The map includes 'High', 'Medium' and 'Low' zones based on use as below:

High:

- Areas within 2 km radius around all wells used for potable water supply or planned for such use.
- Areas with well distributed bore wells that are used for potable water supply or planned for such use.
- Areas depending mainly on shallow ground water (open wells, bore wells fitted with hand pumps) of good quality (potable) Ground water recharge areas.
- Areas which are known to be wholly dependent on ground water supplies

Medium:

- Areas depending on shallow water but the quality of water is unfit for drinking
- Areas dependent on ground water for irrigation purposes.

Low:

- Areas with only limited extraction of ground water
- Areas known as ground water polluted or unfit for consumptive use; and
- The areas less dependent or not at all dependent on ground water such as wastelands and scrub forests etc.

3.13. Ground Water Quality Map

The ground water quality of different areas can be decided using both the primary and secondary data. The Central Ground Water Board and the State Ground Water Departments, responsible for identifying ground water protection needs, provide the data on quality of ground water in a study area and the State Pollution Control Board provides the data on polluted / contaminated areas. Field surveys have been carried out to collect additional data on ground water quality, wherever required. The relevant water quality criteria are presented in Table 1 and analytical results of Ground Water samples collected during field surveys are presented in Table 2. Depending on the data on ground water quality, the map is divided into High, medium and Low quality areas based on the drinking water standards as under:

High - The ground water quality is very well within standards
Medium- The ground water, although not polluted, there is some stress
Low - The ground water quality exceeds the standards and hence is polluted.

4. RESULTS AND DISCUSSIONS

1. The map has been generated based on the parameters. The maximum area 77.4 Sq.km falls under high quality category covering the villages of Dharmaram, Malkaram, Haridaspalli, Cheriyal, Bandlaguda, Kundanpalli, Godumkunta, Rampalli Diara, Lalanguda etc. . It is observed that the samples analysed for Ph showed values from 6.6 to 7.2, TDS ranges from 470-920 mg/l, Chlorides ranges from 110-238 mg/l, Dissolved Oxygen ranges from 3.5 to 4.0 mg/l and fluoride ranges from 0.8 to 1.25ppm. The ground water quality around Keesara, Yadgarpalli and Timmaipalli occupying 31.8 Sq.km is found to be having medium quality ground water as per standard norms. The dissolved oxygen of the ground water samples analysed ranges from 1.6 to 1.8 mg/l.

2. The High use areas should be protected from pollution. Hence, disposal of any type of waste should not be allowed in these areas. However, based on micro-level studies, the disposal of S3 category of waste on land may be considered. In Medium use areas, disposal of not easily biodegradable and toxic effluent or hazardous waste (S1 category) on land should not be allowed. However, disposal of S2/S3 categories of waste on land may be considered. In low use areas, disposal of all types of wastes on land may be considered. As a whole 48% of the area is being wastelands and forest the ground water usage is under low use category. Keesara and Malkaram towns form the Low ground water usage areas comprising 54.33 Sq.Km. Medium ground water usage in Yadgarpalli, Gandi Narsimhapalli, East of Keesara and West of Ghatkesar villages occupying 21.34 Sq.km reflects the quality as per drinking water standards. The high ground water usage is observed along Erimulli vagu and its tributaries around Cheriyal, Bandalguda, Godamkunta, Rampalli and lalanguda villages which occupies about 32.63 Sq.km.

3. The location of ground water polluting activities, viz. disposal sites of effluents on land, solid/hazardous waste dumps are marked. The monitoring stations where the results of the water quality are available are marked. Based on the sources of pollution, monitoring data, field experiences, social surveys and public complaints, the zones of 'Low', 'Medium' and 'High' ground water quality are categorized. In the 'Low' quality areas, since the ground water is polluted, no further ground water polluting activities should be located. In the 'Medium' quality areas, hazardous or toxic wastes (S1 category) should not be disposed. However, disposal of S2/S3 category of waste may be considered. In 'High' quality areas, siting of ground water polluting activities may be considered with adequate safeguards to protect ground water quality and with monitoring facilities for periodic checking of ground water quality.

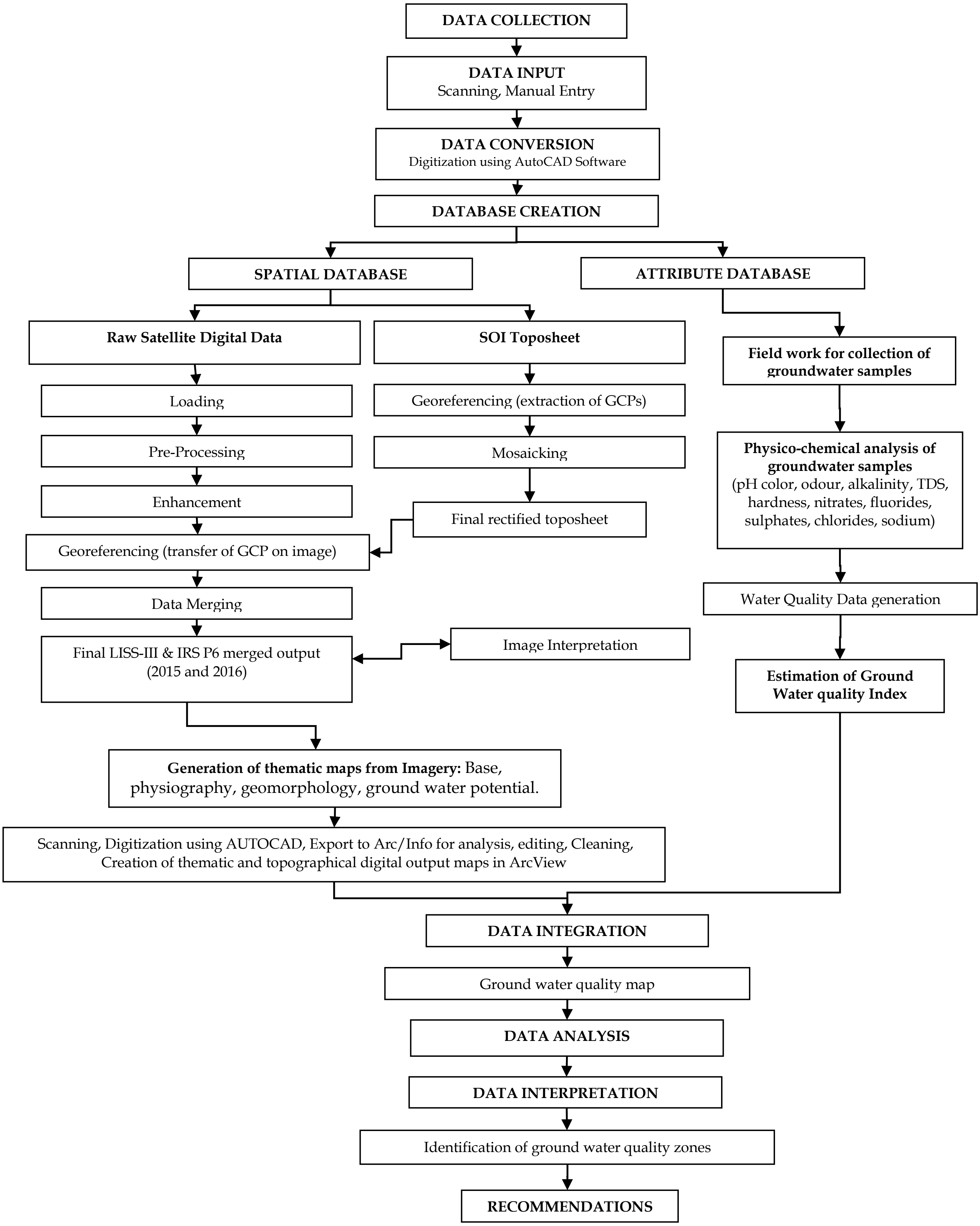

Figure 3 Flow chart showing the methodology adopted for the present study

Table 1 Water Quality criteria for ‘‘E’*’ Class

(Specified by CPCB, 1979 and the Bureau of Indian Standards, 1982)

S.No	Parameter	High Quality	Medium Quality	Low Quality
1	Dissolved Oxygen (DO) mg/l	> 3	1.5 – 3	< 1.5
2	Total Dissolved Solids (TDS) mg/l	0 – 1050	1050 – 2100	> 2100
3	Chlorides (Cl-) mg/l	0 – 300	300 – 600	> 600
4	Sulphates mg/l	< 500	500 – 1000	>1000
5	Conductivity 25° Micro mho/cm	< 1250	1250 – 2500	> 2500
6	pH	6.5 – 8.5	4.5 – 6.5	<4.5 & >8.5

‘E’***** class water is designated best use water for irrigation, industrial coding and controlled waste disposal

Table 2 Water Quality Sample Data

LOCATION CODE		GW-1	GW-2	GW-3	GW-4
PARAMETERS	**UNIT**	**RESULTS**			
Essential Characteristics					
Color	**Hazen units**	**<5**	**<5**	**<5**	**<5**
Odour	-	Un-objectionable	Un-objectionable	Un-objectionable	Un-objectionable
Taste	-	Agreeable	Agreeable	Agreeable	Agreeable
Turbidity	NTU	1	8	1	2
pH value	-	6.61	6.79	6.63	7.20
Total hardness, as $CaCO_3$	mg/l	380	450	225	480
Iron, as Fe	mg/l	0.10	0.40	0.12	0.15
Chlorides, as Cl	mg/l	174	128	110	238
Dissolved Oxygen (DO)	Mg/l	1.6	1.8	4.0	3.5
Desirable Characteristics					
LOCATION CODE		**GW-1**	**GW-2**	**GW-3**	**GW-4**
Dissolved solids	mg/l	880	830	470	920
Calcium, as Ca	mg/l	108	122	60	136
Magnesium, as Mg	mg/l	27	35	18	34
Copper, as Cu	mg/l	BDL	BDL	BDL	BDL
Manganese, as Mn	mg/l	BDL	BDL	BDL	BDL
Sulphate, as SO_4	mg/l	144	58	15	78
Nitrate, as NO_3	mg/l	60	56	16	54
Fluoride, as F	mg/l	1.25	1.10	0.80	1.00
Mercury, as Hg	mg/l	BDL	BDL	BDL	BDL
Cadmium, as Cd	mg/l	BDL	BDL	BDL	BDL
Selenium, as Se	mg/l	BDL	BDL	BDL	BDL
Arsenic, as As	mg/l	BDL	BDL	BDL	BDL
Cyanide, as CN	mg/l	BDL	BDL	BDL	BDL
Lead, as Pb	mg/l	BDL	BDL	BDL	BDL
Zinc, as Zn,	mg/l	BDL	BDL	BDL	BDL
Chromium, as Cr^{+6}	mg/l	BDL	BDL	BDL	BDL
Alkalinity, as Al, as $CaCO_3$	mg/l	280	340	170	240
Boron, as B	mg/l	0.12	0.10	0.07	0.13
Biological parameters					
Coliform	MPN/100 ml	Nil	Nil	Nil	Nil

W-1 : Ghatkesar (Bore well)　　W-3 : Bandlaguda (Bore well)
W-2 : Keesara (Bore well)　　W-4 : Yadagiripalli (Bore well)

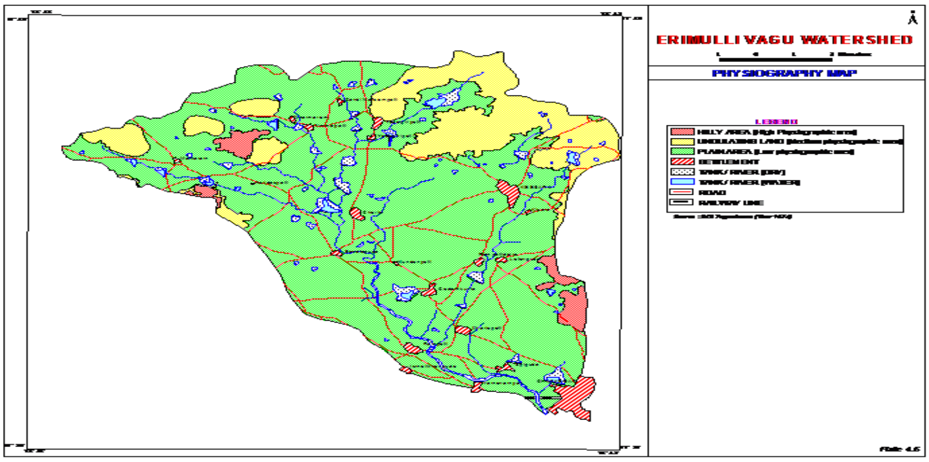

Figure 4 Physiography Thematic map

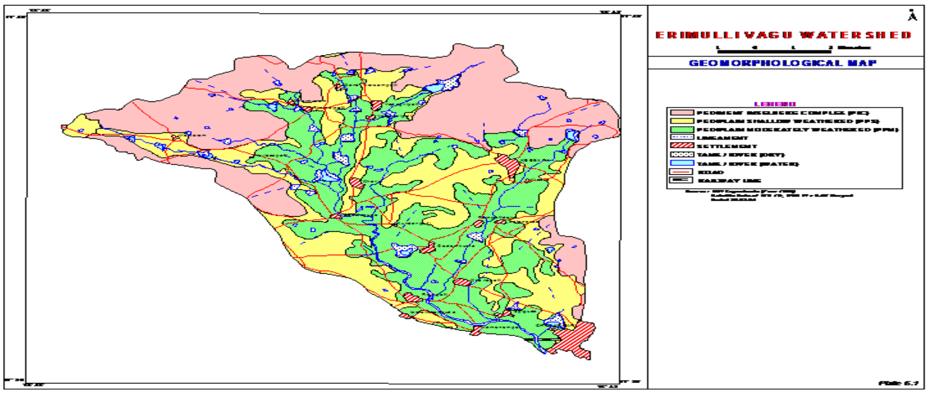

Figure 5 Geomorphology Thematic Map

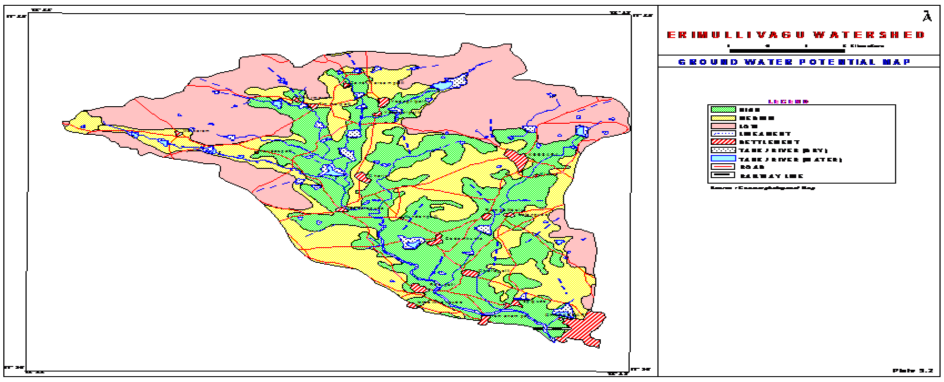

Figure 6 Ground Water potential thematic map

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