ANALYSIS OF GROUNDWATER POTENTIAL ZONES USING ELECTRICAL RESISTIVITY, RS & GIS TECHNIQUES IN A TYPICAL MINE AREA OF ODISHA

A

DISSERTATION

SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE

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CERTIFICATE

This is to certify that the Dissertation entitled "ANALYSIS OF GROUNDWATER POTENTIAL ZONES USING ELECTRICAL RESISTIVITY, RS & GIS TECHNIQUES IN A TYPICAL MINE AREA OF ODISHA" submitted by ***SURAJIT MURASINGH*** *to the* **National Institute of Technology, Rourkela***, in partial fulfillment of the requirements for the award of* ***Master of Technology*** *in* ***Civil Engineering*** *with specialization in* ***Water Resources Engineering*** *is a record of bonafide research work carried out by him under my supervision and guidance during the academic session 2013-14. To the best of my knowledge, the matter embodied in this thesis has not been submitted to any other University or Institute for the award of any degree or diploma.*

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Place: -

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Date-

Place-

Surajit Murasingh

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LIST OF ABBREVIATIONS

CGWB-Central Ground Water Board

DEM -Digital Elevation Model

FCC- False Color Composite

GIS- Geographic Information System

GSI- Geological Survey of India

IRS-P6- Indian Remote Sensing satellites

IMD- India Meteorological Department

JSPL- Jindal steel and Power Ltd.

MRL- Maximum Residue Levels

MSL- Mean Sea Level

NRSC- National Remote Sensing Centre

NIT rkl- National Institute of Technology Rourkela

SMS- Soil Moisture Sensor

SRTM- Shuttle Radar Topography Mission

LISS-III- Linear Imaging Self Scanner sensor

VES- Vertical Electrical Sounding

ABSTRACT

Despite sufficient rainfall, large part of India suffers from water scarcity. Ground water occurs in weathered or semi-weathered/fractured layers in hard-rock areas whose thickness varies, in general, from 5m to 20m. Satellite pictures are widely being used for groundwater exploration because of its ability to identify various ground features, which may serve as an indicator of groundwater's presence, Study and analysis of remote sensing data is a fast and economical way of finding and exploring. Present study, for assessment of groundwater availability in Tensa valley (Sunderghar District, Odisha) shows various groundwater potential zones. India had been delineated using remote sensing and GIS techniques. The groundwater availability at the valley was roughly divided into different classes (i.e., Excellent, very good, good, moderate, and poor) based on its hydrogeomorphological condition. Toposheets by Survey of India and IRS-1C satellite imageries are used for preparing various thematic maps viz. geomorphology, slope, land-use, lineament density, drainage density, and soil map, were transformed to raster class data using feature to raster converter tool in ArcGIS. All the raster maps were allocated to a fixed percentage of influence and weighted their after weighted overlay tool or technique was used. For getting the groundwater potential zones, each weighted thematic layer was computed statistically. The results thus obtained were later verified with resistivity survey test data. The results obtained were integrated with the different thematic maps on GIS platform which yielded a good match with the obtained resistivity test result. Further, a low cost soil moisture meter has been designed and developed in the Department of Civil Engineering to monitor the surface moisture which also acts as the indicator of possible groundwater potential sites, different crops and plants/trees located in the region.

Key words-Groundwater; Remote sensing and GIS; Resistivity survey; Soil moisture sensor; mine area

CHAPTER 01

INTRODUCTION

1.1 General

Water one of the most important natural resource occurring both as surface water and groundwater. It is vital for all life on the earth. Developments of our society are dependent on the availability and use of adequate water. This precious resource is sometimes scarce, sometimes abundant but unevenly distributed, both in space and time. Groundwater represents the second-most abundantly available freshwater resources and constitutes about 30% of fresh water resources of the globe *(subramanya,2008)*. More than 1.5 billion people in the world are known to depend on the groundwater for their drinking water requirements. The groundwater is derived from precipitation and recharge from surface water. It is the water that has infiltrated into the earth directly from precipitation, recharge from streams and other natural water bodies and artificial recharge due to action of man.

Groundwater has been a popular resource of water in many tropical countries. Groundwater is easy to extract, and it remains well protected from the hazards of pollution that the surface water has to put up with. However, situations wherein we have encountered overexploitation of groundwater resources are not uncommon. Insufficient knowledge regarding the basics of groundwater is the primary reason why we have not been able to use groundwater resources to their full extent. Thus, there is a growing emphasis on groundwater management.

The groundwater constitutes one part of the earth's water circulatory system well-known as hydrologic cycle. Figure-1.1 shows some of many facets involved in the hydrologic cycle these various facts involved in this cycle are evaporation, interception, transpiration, surface runoff, infiltration and percolation*(subramanya,2008)*.Figure 1.1 shows a schematic diagram of hydrologic cycle.

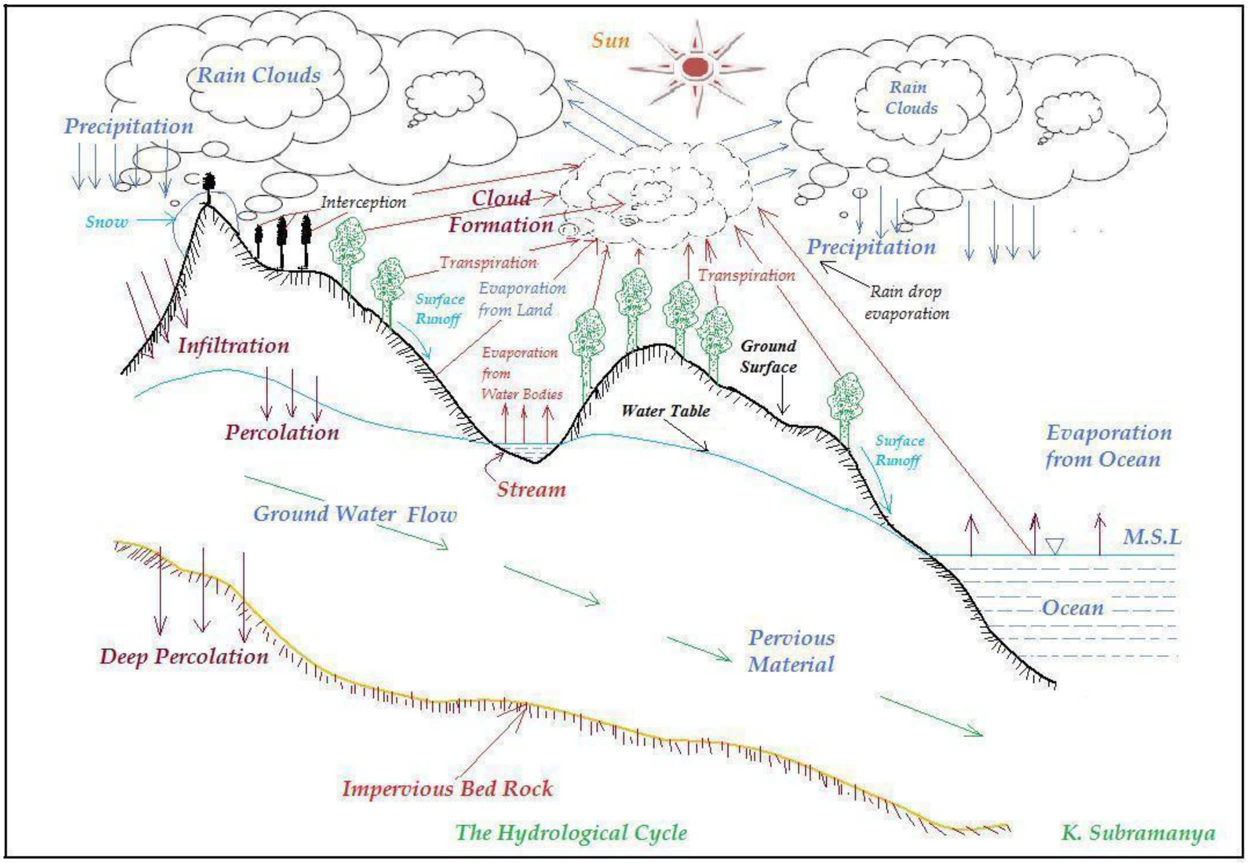


Figure 1.1: The Hydrologic cycle (Source: Subramanya, 2008)

It can be seen from the above figure that, though the concept of the cycle seems simple, the whole phenomena are enormously complicated. It is not just a large single cycle but it is composed of many interrelated cycles.

1.2 Distribution of Groundwater

The formation below the earth's surface is divided into two zones by an irregular surface called the ***water table*** *(D.K. Todd,1980)****.***At all points on the water table the pressure is atmospheric. The zone betwixt the ground surface and the water table is called the ***unsaturated zone* or the *vadose zone.*** In this zone soil particles contain either air or water or both. Hence it is known as ***zone of aeration*** *(D.K.Todd,1980)****.*** Water in this zone is held to the soil particles by capillary forces. Thus while this water is able to move within the vadose zone, it cannot move out of the zone into wells or other places that are exposed to atmospheric pressure.In the zone below the water table all the soil pores are completely filled with water and hence it is called the zone of ***saturation or the phreatic zone.*** The phreatic zone may extend to considerable depth, but as the depth increases the weight of overburden tends to close the pore space little water is found at depths greater than 3km.

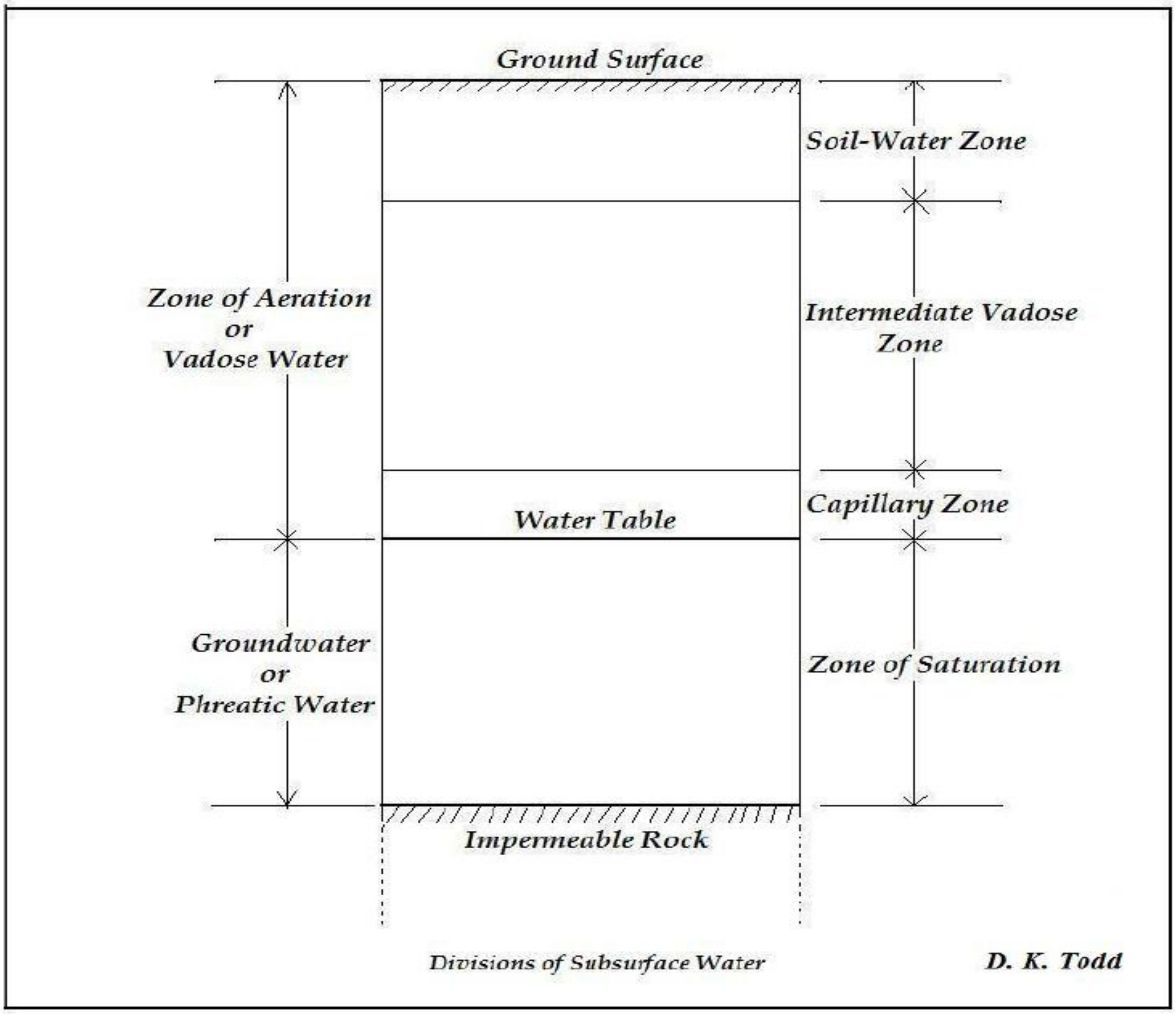


Figure 1.2: Vertical distribution of Groundwater (Source: D.K.Todd, 1980)

1.3 Historical context of Groundwater& its importance

Groundwater use took off to previously endless levels after 1950 in various parts of the world by the presentation of tube well and mechanical pumping designing in right on time twentieth century and their creating acclaim was seen after 1950. In Spain, groundwater use raised from 2 cubic kilometers for every annum to 6 in excess of 1960–2000 (Martinez‐cortina and Hernandez-Mora 2003). Indian subcontinent groundwater use raised from around 10–20 cubic kilometers for every prior year 1950 to 240–260 by 2000 (Shah and others 2003). In the United States groundwater's offer in watering framework water rose from 23% in the year 1950 to 42% in 2000 (Winter and others 1998). Chinese history records accidental cases of rancher lifting water from shallow wells by barrels for watering vegetables. Anyway Northern China had very nearly no flooding framework until 1950, and its tube well watering framework vanished simply after 1970.

Regardless of this exponential advancement in groundwater use in horticulture, the world is starting now exploiting simply a small amount of the earth's groundwater. At short of what 1,000 cubic kilometers for consistently overall groundwater use is a quarter of total overall water withdrawals yet just 1.5% of the world's yearly renewable freshwater supplies, 8.2% of yearly renewable groundwater, and 0.0001% of overall groundwater stores (assessed to be 7–23 million cubic kilometers) (Howard 2004). Its contribution to human welfare was enormous. Supplied of groundwater to private water necessities in distinctive human settlements, urban and normal, far and wide has been seen for the most part too. As demonstrated by various investigators, more than a far reaching section of the world's masses depends on upon groundwater for its drinking water supply (Coughanowr 1994). The imperativeness of groundwater in our day by day life is as such.

- Provides guideline regarding design and construction of ground water structure.
- Water availability in the ground creates a sense of ownership amongst land holders.
- Availability shows there is no shortage of water for supplying the demand of irrigation.
- Generates a vast scope for development of different activities----agriculture, industries etc.

1.4 RS and GIS applications in groundwater hydrology

Remote sensing operations in groundwater hydrology was a concerned, flying photos, and clear and close infrared satellite pictures had been utilized for groundwater examination likely since 1960s with essentially constrained achievement (Engman and Gurney, 1991). The deplorable deficiency of unearthly determination did not permit much powerful use in intrasite groundwater prospecting. Nevertheless with the headway of high determination multi-supernatural satellite sensors, the utilization of satellite picture (numbering microwave picture) for groundwater prospecting through and through extended in late 1980s (Waters et al., 1990; Engman and Gurney, 1991; Meijernik, 2000;

Jackson, 2002). The utilization of remote sensing picture had been wound up with an amazingly monetarily extra approach in groundwater prospecting and preparatory studies, due to high cost of depleting. For the most part, the examination of aeronautical photos or satellite picture is suggested before ground studies and dynamic work, in light of the way that it may dismissal low water-bearing strata and may in like way nonchalance the regions where field examinations (Revzonet al., 1983). It ought to be, then again, noted that the division of remote sensing does not take out the in situ information gathering, which is still essential to assert the rightness of remote sensing information and their outline. Unmistakably, remote sensing collaborators minimize the measure of field information accumulation.

A review of GIS procurements in hydrology and water organization has been shown by a couple of authorities all through ahead of schedule nineties and mid-nineties, for instance, Zhang et al. (1990), Devantier and Feldman (1993), Ross and Tara (1993), Schultz (1993), Deckers and Testroet (1996), and Tsihrintziset al. (1996). These studies indicate that GIS orders in hydrology and water organization are fundamentally in a showing directed association. Longley et al. (1998), on the other hand, while indicating the change of geocomputation, discuss diverse geoscientific procurements of GIS and furthermore the piece of geocomputation in the progression and order of GI developments. Regardless of the way that the usage of GIS in groundwater exhibiting studies goes by and by to 1987, its use for surface-water showing has been more prevalent than for groundwater exhibiting because the open regulated GIS extensions are essentially of the zone surface; few standardized extents of hydrogeologic properties are available (Watkins et al., 1996). Watkins et al. (1996) present a fabulous layout of GIS procurements in groundwater-stream showing and discuss its supportiveness and future headings. On the other hand, Pinder (2002) gives controlled procedure for groundwater stream and transport exhibiting using GIS advancement. The stream status of GIS and RS demands in groundwater hydrology is shown in succeeding fragments.

1.5 Applications of Electrical Resistivity in groundwater hydrology

For finding and locating out the presence of water-bearing formations, provision of electrical resistivity method is generally used (Zohdy et al. 1974; Fitterman and Stewart 1986; Taylor et al. 1992; Majumdar and Pal 2005; Ayolab 2005). Vertical change in resistivity was secured by performing vertical electrical soundings (VES) in given region at 5 areas utilizing Schlumberger electrode setup and AB/2 up to 100 m. The Schlumberger arrangement was as such, the potential and current terminals are placed collinearly where potential terminal was spaced a little distance than the current electrode. Mid-point of potential electrode (MN) and current electrodes (AB) coincide. The formula for calculating the apparent resistivity (ρa) is given as:

$$\rho_a = \frac{(AB/2)^2 - (MN/2)^2}{MN} \bullet \frac{\pi \Delta V}{I}$$

where,

AB Current electrode spacing (in metres)

MN Potential electrode spacing (in metres)

I Current (in amps)

V Voltage (in volts)

1.6 Objectives of the study

As mentioned above, *Analysis of Groundwater Potential Zones using Electrical Resistivity and RS & GIS Techniques in a Typical Mine Area of Odisha*. The specific aims of the present study are:

1. To estimate the groundwater potential and scarcity in Tensa valley and a sub basin of Brahmani river basin (samij sub-basin) of Odisha, India.
2. Application of Remote Sensing & GIS to Delineate surface features for estimating Groundwater Potential Zone.
3. Field survey to access the groundwater potential zone in a typical mine area using Resistivity Method.
4. Integration of different above techniques to developed groundwater potential map.
5. Design and Development of soil moisture meter.

1.7 Thesis outline

Chapter 01 Introducing the work related to Analysis of Groundwater, Distribution of groundwater, Historical context and its important, Application of RS & GIS, Electrical Resistivity survey and objectives of the present work.

Chapter 02 Mainly focuses on the previous research works related to the use of RS & GIS technique, application of resistivity method and importance of soil moisture for delineation of groundwater potential zone around the globe by many researchers and geologists.

Chapter 03 Describes about the geographical location of the study area, its characteristics, available of satellite data, groundwater data technique used.

Chapter 04 Method adopted for remote sensing and GIS analysis, for resistivity survey, for development of soil moisture sensor and for developing groundwater potential map.

Chapter 05 The results obtained from different objective were analyzed and the results are properly discussed below in this chapter.

Chapter 06 Provides the summary, important conclusions derived from present study.

CHAPTER 02

REVIEW OF LITERATURE

2.1Groundwater

Groundwater is the water that is found underneath the Earth's surface at profundities where all the pore (open) spaces in the soil, sediments, or rock are completely stacked with water. Groundwater of any structure whether from a shallow well or a significant well, devises and is refilled (energized) by precipitation. Groundwater is a piece of the hydrologic cycle, beginning when a piece of the precipitation that falls on the Earth's surface sinks (infiltrates) through the soil and enters (seeps) diving to wind up groundwater. Groundwater will at long last come back to the surface, discharging to streams, springs, lakes, or the oceans, to complete the hydrologic cycle.

2.2 Application of Remote sensing & GIS for Groundwater delineation

Many researchers have come out with procedure sand techniques of generating the groundwater potential zone maps by identifying remote sensing based on spatial layers of groundwater controlling parameters using GIS.

Minor *et al*., (1994) have attempted to present a unique methodology on groundwater for exploration using the technique of remote sensing and GIS, particularly in developing countries. The scientist has developed interpretation strategies that integrate various data types to characterize groundwater resources for locating a well point. Field observations and several remote sensing platforms are essential to create GIS based hydrogeological model on any study area.

Krishnamurthy *et al*., (1995) exhibited the ability of remote sensing systems and GIS in outline of groundwater potential zones. Topical layers, for example, lithology, landforms, lineaments and surface water bodies were utilized. The remotely sensed information, such as soils, drainage density and slope layers were made ready and true information sources were incorporated. Appointing suitable weights for every sub-units of an individual layer and the weights are summed up by incorporation.

The higher estimations of a total weight show the great groundwater potential zones and lower level estimations of aggregate weights demonstrate poor groundwater potential zones.

Krishnamurthy et al., (1996) made a GIS based model for distinguishing groundwater potential zones of Marudaiyar bowl, Tamil Nadu, India by joining distinctive topical layers, for instance, lithology, landforms, lineaments and surface water body on 1:50,000 scale were used as a piece of their work, what's more waste thickness and slant guide was utilized from toposheets. Furthermore a soil guide of 1:50,000 scale was made from soil toposheets and range used cooperation by regrouping the centered around their hydrological angles. All the topical layers were composed and analyzed using GIS model to achieve groundwater potential guide. Further, the results accumulated from field were acknowledged by the usage of field data. Finally, the author declare that the approach graph was profited and may be viably used as a piece of other equivalent catchments with suitable modifications.

Kamaraja*et al*., (1996) slightly modified GIS potential of a region. Data layers of specific themes such as lithology, geomorphology, structure and recharge conditions were integrated through the process of overlaying. The overlay analysis resulted in demarcation of groundwater units where each unit has the characteristic combination of groundwater controlling parameter Index (GWPI) values. Each GWPI value of groundwater unit indicated the groundwater potential of the corresponding geographical unit of study area. For grouping GWPI values, a class interval of 0.20 was considered.

Jayakumar*et al*., (1996) Used the dynamic range of data analysis for groundwater investigation in hard rock areas in the Kallar, Velar Sub-basin of Tamilnadu. The study brought out the geomorphic evaluation of the area controlled by denudation.

SujathaBiswar*et al*., (1999) Used of satellite data to identify various geomorphic features of the upper Baitarani river basin of Orissa. Further, the authors have classified the land features into denudation and fluvial origin and evaluated the groundwater potential of various landforms of the study area.

Shanta, kumar*et al.*, (1996) remote sensing and GIS technique for delineating potential areas for groundwater recharge for the entire state of Tamil Nadu. Thematic maps of geomorphology, geology, soil, slope, land use, drainage density, lineament density, runoff isolines, and depth of water table zones were taken into consideration.

Digital image processing technique was used in groundwater prospect. They studied the typical hard rock terrain in parts of Raichur district, Karnataka and found that certain technique like filtering and principal component analysis were useful in delineating the groundwater potential zone (Krishna Murthy *et al*., 2000).

Sarkar *et al*., (2000) A Groundwater potential map was generated for micro watershed by using thematic maps of drainage, lineament, lithology, slope and land use. They employed a multicriterion approach that allowed linear combination of weights of each thematic map (W) with the individual capability value (C.V) which were converted to capabilities values using Baysian statistics. These capabilities values (C.V) were multiplied with respective probability weight of each potential map. The groundwater occurrence was then classified into six categories of potentiality, namely excellent, very good, good, moderate, poor and very poor.

Gurugnanam*et al*., (2000)An attempted for identify the meteorological behavior and water level in 3D visualization mode and assessed the groundwater potential zone by integrating, geology, recharges and discharge map with geomorphology. The results were derived by using the GIS platform.

Krisingh, Ameresh and Ravi, prakash., (2006) for groundwater examination in hard shake zones, a coordinated methodology of remote sensing, geoelectrical and GIS was utilized. In their study, the groundwater possibility of the region was being assessed through coordination of diverse layers including hydrogeomorphology, lineament, incline, aquifer thickness and mud thickness. A nature's area, criteria for GIS examination have being portrayed for groundwater and suitable weightage has been designated to each information layer.the groundwater potential aide was generated and model was affirmed with field data to focus the precision of the model made.

Hsin-Fu Yeh*et al*., (2008)Assessing the groundwater recharge potential zone in Chih-Pen-Creek basin in eastern Taiwan using lhology, land use/land cover, lineaments, drainage and slope. The weights of the factors contributing to groundwater recharge was derived using aerial photos, geology maps, a land use database and field verification. The resultant map of the groundwater potential area was located towards the downstream region in the basin because of the high infiltration rates caused by the gravely sand and agricultural land use in these regions.

Raghuwanshi*et al.,* (2008)various thematic maps was prepared such as geological, geomorphological and lineament maps. The intergratedhydrogeomorphology map was prepared to assess the groundwater resources using remote sensing technique in and around the choral river basin, Indore and Khargone districts, Madhya Pradesh and revealed that the groundwater potential was moderate to poor in buried pediplains, plateaus, denudational and residual hills, lineaments/faults and narrow gorges . The groundwater prospects are good in alluvial plains, valley fills and meandering channels.

Javed, Akram.,et al., (2009) Remotely sensed data was used as a synoptic audit and tedious degree for topical mapping of customary stakes. In the present study hydrogeomorphological mapping has been finished in Kakund watershed, Eastern Rajasthan for recognizing groundwater potential zones. IRS-1d LISS III Geocoded FCC data in conjunction with Survey of India toposheet (1:50000 scale) and field inputs were used for topical mapping. Geomorphic units recognized through visual interpretation of FCC include: alluvial plain, level, valley fills, intermontane valleys, burried pediment, slants, and immediate edges. Lineaments were mapped since they go about as channel for groundwater energize. In perspective of hydrogeomorphological, area and lineament mapping for Kakund watershed has qualitatively been sorted into four groundwater potential zones, viz. extraordinary to incredible, moderate to extraordinary, poor to regulate and particularly poor to poor.

Jha, M.k et al., (2010) proposed a system for the estimation of groundwater potential using remote sensing, geographic information structure, geoelectrical, and multi-criteria decision technique. In this approach the available hydrologic and hydrogeologic data was detached into two get-togethers, exogenous (hydrologic) and endogenous (subsurface). A watchful examination in Salboni Block, West Bengal (India), uses six topical layers of exogenous parameters and four topical layers of endogenous parameters. Suitable weights were consigned to topical layers and their tricks were institutionalized using illustrative request methodology and eigenvector methods. By then the layers were consolidated using Arcgis programming to make two groundwater potential maps. As a rule, the composed framework was useful for the assessment of groundwater possessions at a vessel or sub-dish scale.

Biswas, Arkoprovoet al., (2012) Present study endeavors to select and portray different groundwater potential zones for the evaluation of groundwater accessibility in the seaside a piece of Ganjam area, Orissa utilizing remote sensing and GIS system. Satellite IRS-IC LISS III, Landsat TM computerized and SRTM information have been utilized within the present study to get ready different topical maps, viz., geomorphological, land, slant, waste thickness, lineament thickness map. On the premise of relative commitment of each of these maps towards groundwater potential, the weight of every topical guide has been chosen. Further, inside every topical guide positioning has been made for each of the peculiarities. All the topical maps have been enlisted with each one in turn through ground control focuses and incorporated regulated utilizing the standardized conglomeration technique as a part of GIS for processing groundwater potential record. On the premise of this last weight and positioning, the ground water potential zones have been outlined. Subsequently from the present study it is watched that an incorporated methodology including remote sensing and GIS method might be effectively utilized as a part of distinguishing potential groundwater zones in the study zone. Five classifications of groundwater potential zones, viz., astounding, great, great, moderate and poor have been separated. Significant parts of the study region has "great" and "Moderate" prospect while a couple of scattered regions have poor prospect. The astounding potential ranges are for the most part thought along the shore line.

Pester et al., (2013) concentrated on the depiction for groundwater change with the assistance of a remote-sensing . Irs–liss-III information alongside other information sets, e.g., existing toposheets and field perception information, have been used to concentrate data on the hydrogeomorphic peculiarities which comprises of covered pediment shallow valley fills, structural knolls, covered pediment moderate, slant guide and lineament thickness form . The focus of this study was to distribute the groundwater potential zones in Chhatna square, Bankura District, West Bengal. Three characters (hydrogeomorphology, slant, and lineaments) that impact groundwater occasions were concentrated on and consolidated. All the data layers have been joined utilizing GIS examination and the groundwater potential zones have been depicted. The weighted file overlay strategy has been emulated to outline groundwater potential zones. From the results it was inferred that there is great pledge between the normal groundwater potential guide and the present groundwater borehole databases. The territory is considered by hard shake landscape still because of the vicinity of planation surface along valley fills; it turned into the potential zone. The region has been sorted into four different zones: amazing, great, reasonable and poor.

Senthil Kumar, G.ret al., (2014) remote sensing and geological data framework (GIS) has turned into one of the heading devices in the field of groundwater examination, which helps in surveying, checking, and rationing groundwater assets. A detailed analysis was led to figure out the groundwater potential zones in Lekkur sub bowl of Mangalur Block, Cuddalore region, Tamil Nadu, South India.

The topical maps, for example, geography, geomorphology, soil hydrological gathering, area use/ area spread and waste guide were ready for the study range. All the topical maps were changed over into lattice (raster design) and superimposed by weighted overlay technique (rank and weightage insightful topical maps). From the investigation the groundwater potential zones with brilliant, great, great, moderate and poor prospects.

2.3 Electrical Resistivity used in Groundwater Hydrology

Using geophysical methods to assess and monitor geotechnical properties would be extremely useful as they are non-invasive, cheaper to perform than drilling many sampling wells and faster in operation. One of the commonly used geophysical methods in engineering investigations is the electrical resistivity method (Telford *et al.,* 1990; Reynolds, 1997).

Oseji*et al.,*(2000) Schlumberger VES to help locate the depth of a sandy coastal aquifer in Myanmar at 10-13m deep and 30-40m thick, thus determining effective places to drill observation wells. VES is also very useful in determining risk assessment of aquifers.

Fetter *et al.,* (2001) an alternative to fracture trace-based water bearing zone delineation is the application of geophysical methods. Following in the footsteps of petroleum and mining industries, hydrogeologists are increasingly integrating geophysical techniques in subsurface site characterization methods.

Zhu *et al.,*(2001)the most popular methods used in hydrogeological applications are ER and EM because of the close relationship between electrical conductivity and the physical properties of aquifers, i.e. conductance and resistance (Goldman et al., 1994). As previously mentioned, knowledge of the local geology, field observations and records from existing wells are required to successfully site a productive borehole.

(Meric*et al.*, 2005) also used combined geophysical methods to investigate large gravitational mass movement and their results suggest that monitoring the evolution of rock mass movement with time-lapse geophysical surveys could be beneficial.

The use of vertical electrical sounding (VES) method in prospecting for groundwater and the computation of hydraulic characteristics such as hydraulic conductivity and transmissivity, from interpreted geophysical data has proved to be very effective and efficient. Salem, (2001); Soupios*et al* and Singh, (2005); Ekwe*et al*, (2006); have successfully used the vertical electrical sounding method.

Others including Emenike, (2000); Onwuemesi and Egboka, (2006); Nfor*et al,* (2007) and Okoro*et al* (2010) have achieved success using same method.

Resistivity measurements have also been used to provide subsurface properties in slope stability studies where there is a contrast in porosity and saturation between the disturbed material and parent rock (Mauritsch*et al.,* 2000; Lapenna*et al.,* 2004). Perrone*et al.* (2004) applied geoelectrical prospecting techniques to identify the sliding surface and estimated the thickness of the mobilized material in Varco dIzzo landslide.

Vouilliamous*et al* (2007) informed that Vertical Electrical Sounding (VES) refers to the method of using a geophysical array at a single location in order to determine the changes in geology that occur with increase in depth. VES can be performed using various arrays and has been successful in geophysical studies regarding groundwater.

Srinivasanet al., (2013)an exertion was made to examine groundwater for watering framework reason at the time of rainstorm bafflement which would serve as a key part in both short and long haul perspective in and around the Wellington vault of Vellar bowl by surveying the subsurface geology and groundwater potential zones. An effort had been made to perceive the subsurface lithology and aquifer zones by geoelectrical resistivity handle in a bit of Tittagudi, Nallur and Vriddhachalam square of Cuddalore District. This technique is useful to layout the subsurface stations, weathered zone and split illustration, et cetera. Electrical soundings have been headed at every 5 Km interims in system outline by grasping Schlumberger framework in 30 locations.which have been qualitatively and quantitatively deciphered using programming. Pseudo portions have been prepared by Ipi2 WIN ver.3.1 and isoresistivity maps were surrounded by using programming Mapinfo 8.5 Considering the topographical, geomorphology and hydrogeological circumstances the VES interpretation was completed.

2.4 Importance of Soil Moisture in relation with Groundwater Hydrology

Throughout the most recent decades, numerous studies have examined the conceivable outcomes of earth perception for hydrological purposes and spaceborne remote sensing is progressively utilized for mapping and observing hydrological states and uxes, for example, precipitation (e.g. Kummerowet al., 2000), dirt dampness (Njokuet al., 2003; Wagner et al., 1999b), snow spread (Dankers and de Jong, 2004; Immerzeelet al., 2009), area surface temperature (Wan and Li, 1997) and dissipation (Bastiaanssenet al., 1998a,b; Su, 2002; Mu et al., 2007; Jung et al., 2010).

Up to now, just the Gravity Recovery and Climate Experiment (GRACE, Tapleyet al., 2004), a space gravity mission propelled and worked by the National Aeronautics and Space Administration (NASA) since March 2002, has been perceived as a groundwater appraisal device, speci_cally for discovering groundwater stockpiling motion (Rodellet al., 2007; Swenson et al., 2008; Strassberget al., 2009; Rodellet al., 2009).

Sutanudjajaet al., (2004) had utilized the ERS spaceborne microwave information for soil dampness perceptions to foresee groundwater heads in space and time.

An examinations of remotely-sensed soil dampness signs with ground-measured soil dampness information (e.g. Broccaet al., 2010), precipitation information (e.g. Wagner et al., 2003) and release information (e.g. Scipalet al., 2005).

Becker, (2006) Groundwater conduct could be induced from remotely-sensed surface declarations, for example, rise, area surface temperature, vegetation and soil dampness.

Pollaccoet al. (2007) had utilized the amount of pressure driven obligations that are key for mimicking groundwater energize in unsaturated soil. This kind of test tells that correct ground water energize could be found by upgrading the pressure driven parameters against a period arrangement of soil dampness profiles. Yet these water driven parameters ought not to be remarkable. This analysis exhibits that diverse soils can additionally give comparative ground water energize site. Consequently different amalgamations of water driven parameters can give comparative energize as of reference soil. This indicated that pressure driven parameters are joined because of (1) range equifinality and (2) recompense equifinality.

CHAPTER 03

THE STUDY AREA, FIELD SURVEY AND DATA COLLECTION

3.1 The study area

The study area is in Tensa valley Sundargarh district, Orissa (Figure 3.1). It has a hilly topography with its elevation varying from 590 above mean sea level to 840 above mean sea level. There are number of valleys with dry drainage channels within the area. Entire region is been covered by undulating hilly tract intersected by gorges and passes. Besides many seasonal nalas, there are four perennial nalas in the region. Basically it's a rugged mountainous region bisected by number of geomorphic valleys; the central part of the area has in-situ laminated and massive ore bodies covered with laterite. Tensa had been proclaimed as the best mine by the Director General of Mines Safety, Govt. of India. JSPL's iron metal mines, at Tensa valley in area Sundargarh, Odisha, it is 100 km from Rourkela, satisfy the organization's prerequisite of iron mineral for handling wipe iron. Prepared as a component of JSPL's retrograde incorporation arrangements to make the organization confident, iron mineral from Tensa mines guarantees consistency in the nature of crude material utilized within wipe iron ovens. Operational since 1990, these mines are famously known as TRB (Tantra, Raikela, Bandhal) Mines. The mining lease range structures a piece of Survey of India Toposheet No. 73 G/1 and lies between latitude 21º53'00'' to 21º53'48'' and longitude 85º10'07'' to 85º11'55" .

As this portion of the district is a remote area, medium of communication to the place is road only. Location of the study area is shown below in Figure 3.1.Figure 3.2 shows the boundary of the study area.

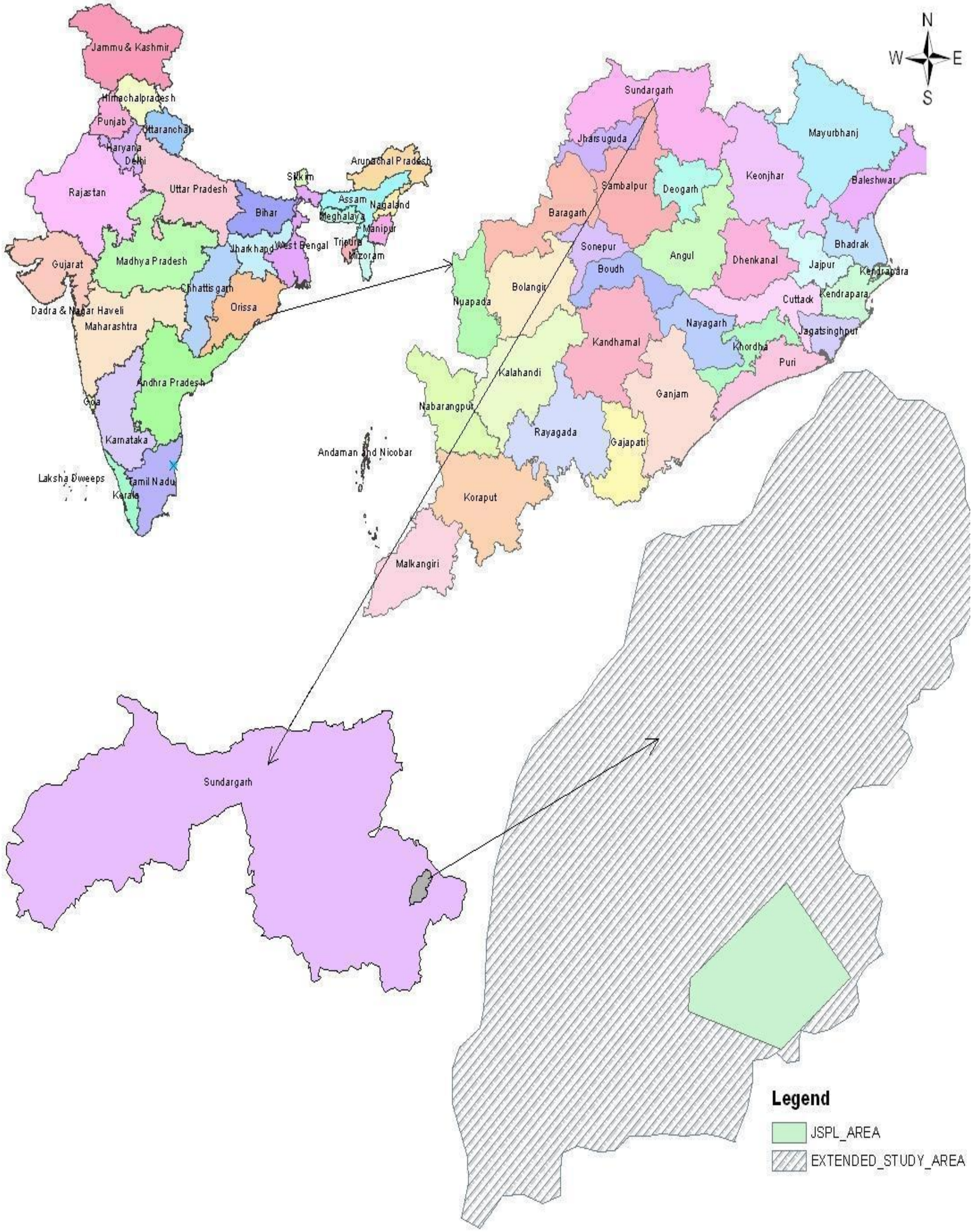


Figure 3.1: Location map of the study area

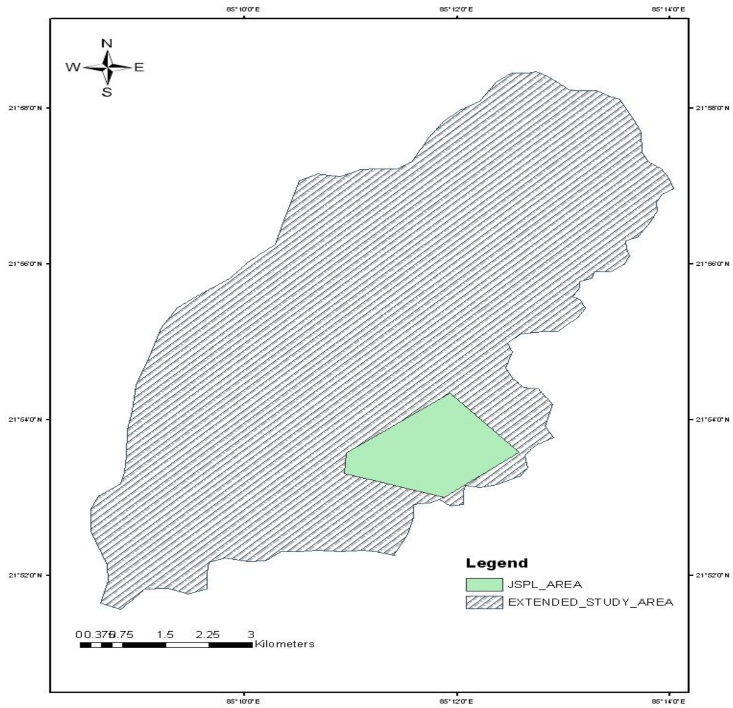


Figure 3.2: Extended study area, a sub basin of Brhamani river basin

Though the study area was only for the JSPL area but remote sensing and GIS analysis was performed on a sub basin of Brahmani river basin (samij sub-basin) the extended study area and the JSPL area shown in the Figure 3.2.

Using the IRS P6 LISS-III data a FCC (False Colour Composite) was developed with the band combination techniques for visually interpreted; based on the image interpretation keys and geotechnical elements as such tone, shape, size, texture, association, drainage, pattern etc. Interpretation of a FCC led to identification and delineation of different hydrogeomorphological units. Field checks subsequently were conducted in the study area for veracity of remote sensing data and also for incorporating the field knowledge in the map.

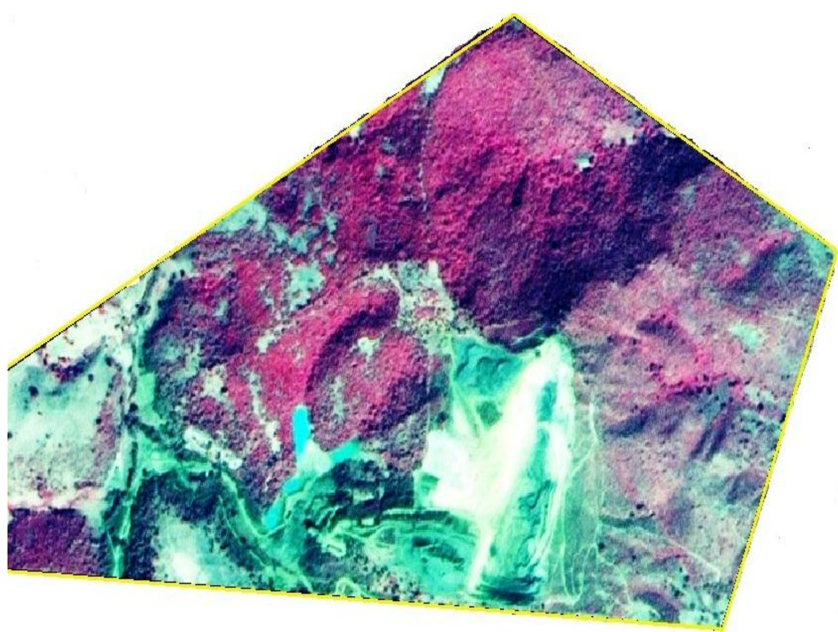


Figure 3.3: FCC Image of JSPL Area, 2013 NRSC

3.1.1 Physical Characteristics

Physical Characteristics of any study area described the natural environment of the place. They include the following parameters:

3.1.2 Physical Features:

The physical features of any geographic area mainly consider with the landforms and water bodies; it has a hilly topography with its elevation varying from 590 above mean sea level to 840 above mean sea level. Entire area is covered by undulating hilly tract intersected by gorges and passes. There are many seasonal nalas, about four perennial nalas in the region along with some artificial structure for rainwater harvesting act as the only source of water bodies in that region.

3.1.3 Soil

Soil of entire area is less fertile. The area is fully occupied by red sandy soil, gravelly and lateritic soil. It contains a large quantity of iron because of that;it generally deficient in nitrogen and phosphorous. Soil in that area was general loose in texture and well drained. Large quantity of iron concentrations is present in the soil.

3.1.4 Minerals

Since, the study area is been surrounded by numbers of mines;the minerals that areavailable i.e. iron-ore, manganese, dolomite, mica,limestone, fire-clay, bauxite, lead copper, and zinc.

3.1.5 Land use/Land cover

Land cover of study area is largely forested. Around 80% of the areacovered with dense forest. Moderate development is been primarily seen in the stream valleys. Barren lands are present in patches. Now days; the forest cover is been gradually decreasing due to rapid extension of mine areas around the basin.

3.1.6 Agriculture

With adverse climate, having hilly topography, unreliable precipitation and light soil texture, the cropping pattern of the district mainly depend on rainfall, as it is the main source of irrigation along with medium irrigation, minor irrigation and lift irrigation. People mainly grow paddy as the major crop in their fields in *Kharif* season. Blackgram, maize, and greengram are also grown by farmers of that region.

3.1.7 Temperature

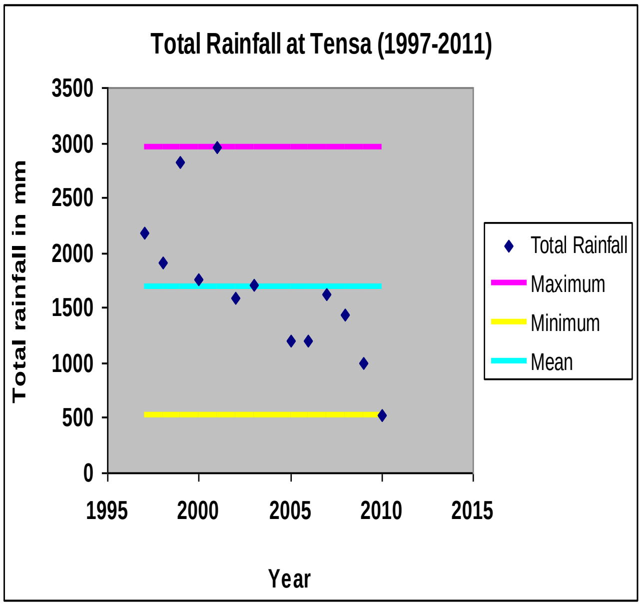
The study area fall along the sub-tropical climatic region. The climate of the area is been aggressively hot during summer with high humidity. The maximum temperature begins to rise rapidly during the month of May. During the summer maximum temperature is recorded around 40°C. The weather becomes more pleasant with the approach of the monsoon in June and remains as such up to the end of October. The temperature during the winteri.e. for the month of December is around7 °C- 10 °C.

3.1.8 Relative humidity

Monthly average relative humidity (RH) recorded at Keonjhar IMD station (1993-2002) as it is the only nearest station located near the study area. According to the data obtained from the station it was found that high monthly relative humidity occurs between the month of June to October was that; average values at 8.30 hrs and 17.30 hrs are 67% and 50% respectively.

3.1.9 Rainfall

The study area experiences sub-tropical climate with abundant rainfall during monsoon months. The seasons of the study area mainly divided into four seasons. The hot season lasts from March to May; period from June to September is the south-west monsoon season. October and November constitute the post monsoon season and the cold season is from December to February. The nearest IMD station is at Keonjhor. Mean Monthly rainfall data for the year from 1997-2011 provided by JSPL were also analyzed. It was interesting to know that the total annual rainfall occurred during this period at TRB Iron Ore Mine, Tensa was 2954.7 mm (year 2001), which is much higher than the total rainfall occurred in Sundargarh district for the last 100 year (Figure 14).The total annual rainfall was also observed to be very high during the year 1999 with a value of 2826.7 mm. Further, the maximum mean monthly rainfall occurred during the month of July was observed to be 1428.8 mm, which is much higher than the 100 year mean monthly rainfall.



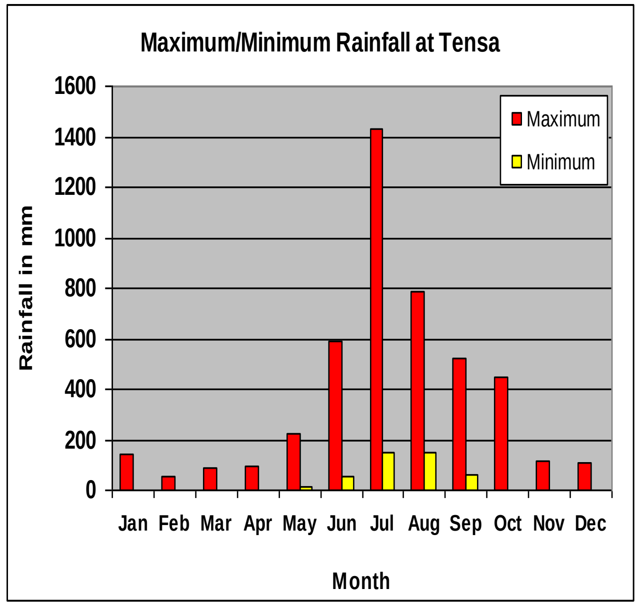


Figure 3.4: Total Annual, Maximum, and Minimum Monthly rainfall

3.1.10 Drainage

As the study area has a hilly topography. Elevation varies from 840 MRL (north eastern part) to 590 MRL (southwest part). There are number of valleys with dry drainage channels within the area. Entire area is covered by undulating hilly tract intersected by gorges and passes. Besides many seasonal nalas, there are about four perennial nalas in the region. Basically it's a rugged mountainous region being bisected by number of geomorphic valleys. The central region of the area has insitu laminated and massive ore bodieswith laterite. Samijnalaa tributary of Kurahi River which is a tributary of Brahmani River.

3.1.11 Industry

Sundergarh district capture an important position in the mineral map of the state. Iron-ore and manganese-ore dominate the region of the study area. Based upon these minerals many small and medium industries are established around the study area.

3.2 Field Survey

Field surveys were made during the years 2013 and 2014 at 6(six) locations of the sub-basin to collect ground water information using Electrical resistivity tests. Vertical electrical soundings using Schlumberger array were carried out with maximum to half current electrode separation (AB/2) more than 100 m which is highly used in groundwater exploration study. Apparent resistivity at sounding stations is plotted against the corresponding half electrode spacing to look for weaker or stronger water potential zones.

The essential rock sorts happening in this study region (GSI 1979) include augen gneiss and migmatitic gneiss of Easier Sambalpur stone and medium-grained biotite, stone and gneiss of Upper Sambalpur stone of Archaean age; quartzite of the Iron Metal Gathering of More level Proterozoic, dolerite dyke and quartz vein/reef of Center Proterozoic, and fine mud shale, slate and phyllite of the Chandarpur Gathering of Upper Proterozoic. As demonstrated by the dispersed GSI (1979) aide used inside the present study, the sedimentary rock (fine soil shale) is showed agreeing with low quality alterable rocks (slate and phyllite). Hard shake needs vital porosity; water penetrates through discretionary porosity organized by breaking and weathering of rocks. Both Easier and Upper Sambalpur stones are broken and weathered. A couple of sets of lineaments have been perceived in these rocks. In any case, lower Sambalpur stone is more weathered and broke and in this way has ideal groundwater prospects over Upper Sambalpur Stone. Joints and cleavage are accessible in quartzite while fine earth shale, slate and the phyllite social affair of rocks have a couple of faults and sheets as reported in the geological quadrangle portray. Fine earth causes blockage of open pore space for improvement of water. In light of splitting and accusing in Sambalpur rocks, it has been given a higher situating than quartzite and fine earth shale, slate and the phyllite get-together of rocks. Quartzite has been given a higher situating than fine earth shale, slate and phyllite due to the region of cleavage and joints. The region of dolerite dyke and quartz vein/reef is a proof of a groundwater obstruction

The land use of the study region is mostly hilly forested area with little agriculture and a few built-ups/residential areas.

3.3 DATA Collection

Different types of data was been collected for the present study purpose; such as satellite data, topographic maps, groundwater data, metrological data.

3.3.1 Used of Satellite Data

Different types of satellite data was been used for Remote sensing analysis purpose, most of the thematic maps were derived from the IRS-LISS III satellite data (year 2012). The IRS-LISS III data were procured from NRSC, India and other datasets were downloaded freely from their respective websites for free.

Cartosat-1(DEM) data was downloaded from the NRSC site (open data download) for developing the Satellite image of the study area and groundwater map have been downloaded from Central Groundwater Board, Bhubaneswar site. Survey Toposheet was also used. Geographic Information System and Image Processing (ARC VIEW, ARC GIS, and ERDAS IMAGINE software) have been used for analysis and mapping of the individual layers. **Resourcesat LISS III** datawas process in the ERDAS IMAGINE software and a satellite image of the study area was developed using the FCC (false colour composite) technique; for generating the FCC interpretation tool was used in ERDAS IMAGINE software as shown in above Figure 3.3.

3.3.2 Topographical Data Analysis

A topographical map was obtained from the owner M/s JINDAL STEEL & POWER LTD.

Concern office in order to obtain various maps for cross verification with the satellite data which was used. In this study, ARCGIS 10.2 version software has been used to delineate different thematic following maps: (1) Drainage density map, (2)Lineament density map, (3) Landuse/land cover, (4) Digital elevation map, (5) slope map etc. ARCGIS 10.2 version was used for GIS analysis.

3.3.3 Groundwater Assessment Data

The data require for assessment of groundwater in Tensa and a sub basin of Brahmani river basin (samij sub-basin) was collected from the different website.

For the preparation of a review or a report on groundwater potential and scarcity about the sundargarh district, Odisha, data such as annual report, groundwater level scenario in India, groundwater year book, Hydrogeological Features, geology, climate and rainfall, physiography etc. was been downloaded from (http://cgwb.gov.in/) and (http://cgwb.gov.in/SER/default.htm) , a detail studies was been carried out to understand the groundwater scenario for the above objective and the outcome result has been shown in the next chapter i.e. chapter 05 Result and Discussion.

Table 3.1 Ground water scenario of Orissa

Area (Sq.km)	1,55,707
Physiography	Five physiographic units • Coastal Plains • Northern Uplands • Erosional plains of Mahanadi valley • South-Western Hilly Region • Subdued Plateaus
Drainage	Mainly eight major river basins are presence in the State, whereas the Indravati, Kolab, Machakund sub-basins forms part of Godavari river basin. Most of the major rivers flow in easterly and southeasterly.
Rainfall (mm)	1502
Total Districts / Blocks	30 Districts

3.3.3(a) Ground Water Resources:

The common revive of ground water happens through permeation from area after rain events. The quantum of dynamic ground water, which might be yearly concentrated, is by and large figured as ground water potential. The ground water assets evaluations are constantly completed at an interim of five years succeeding on the standards and technique recommended by the Ground Water Estimation Committee (GEC) of Government of India. According to the most recent appraisal (2008-09), the State has net dynamic ground water resources of 16.69 lakh ha.m (BCM). Out of which, investigation to the degree of 4.36 lakh ha.m (BCM) has been made for different employments. Basin wise ground water assets & its usage are given in the table underneath.

Table 3.2 Groundwater resource and its utilization basin wise

Sl. No.	Basins	Net ground water resources (HM)	Annual GW Utilisation (HM) as of 31.03.2009				Stage of GW Development(%) (col.7/col.3)
			Irrigation Use	Domestic Use	Industrial use	Total	
1	2	3	4	5	6	7	8
A.	River Basin						
1	Mahanadi	685477	123278	35730	3809	162817	23.75%
2	Brahmani	198033	44296	8543	2376	55215	27.88%
3	Subarnarekha	59855	17412	2055	443	19910	33.26%
4	Baitarani	167215	52467	5366	2889	60722	36.31%
5	Budhabalanga & Jambhira	122591	39763	4491	1602	45856	37.41%
6	Rushikulya	117910	24873	6064	689	31626	26.82%
7	Indravati	55912	3969	2966	392	7327	13.10%
8	Kolab	75343	3285	2351	869	6505	8.63%
9	Bahuda	11023	2487	551	51	3089	28.02%
10	Vamsadhara	72402	10002	2025	545	12572	17.36%
11	Nagabali	26167	1710	1235	529	3474	13.28%
B	Area draining directly						
12	Kansabansa	49614	19980	1531	591	22102	44.55%
13	Chilika	27372	3711	1204	72	4987	18.22%
	State Total	**16,68,914**	**3,47,233**	**74,112**	**14,857**	**4,36,202**	**26.14%**

3.3.3(b) Hydrogeology

The State which is underlain by various rock sorts extending in age from Archaean to Recent. The State was hydrogeologically sub partitioned into united, semi-combined & unconsolidated establishments. The combined arrangements incorporate hard crystallines and minimized sedimentary rocks although semi-merged establishments incorporate weathered and friable Gondwana sedimentary and inexactly established Baripada bunks. The unconsolidated arrangements incorporate laterites and late alluvium. The yield of tubewells tapping stone gneisse runs between 10-35 m3/hr though other combined establishments, it extends between 5-18 m3/hr. The yield of tubewells in semi combined establishments run between 20-115 m3/hr.

Table 3.3 Dynamic ground water resources (2009) of Orissa

Annual Replenishable Ground water Resource	17.78 BCM
Net Annual Ground Water Availability	16.69 BCM
Annual Ground Water Draft	4.36 BCM
Stage of Ground Water Development	26 %

Orissa has 16,68,914 hectare metre (HM) or 16.69 BCM of net dynamic groundwater resources accessible for development, said by the latest investigations of Directorate of Groundwater Survey and Investigation (DGSI).

The survey report, says, "the State has gross dynamic ground water resources of 17, 77,507 (HM) or 17.77 billion cubic metres, out of which 1,08,593 HM or 1.08 BCM is considered to be natural losses. Thus annually 16, 68,914 HM or 16.69 BCM of net dynamic ground resources is available for development." The report also says, Coastal districts are found to be utilising groundwater more than interior districts of the State. "The highest level of groundwater utilisation is observed in Bhadrak district (55.49 per cent) and the lowest in Malkangiri (8.76 per cent). Considering blocks, the highest and lowest level of groundwater utilisation are observed in Baliapal (69.96 per cent) of Balasore district and Podia (4.57 per cent) Malkanagiri district".

It was also cited in the report that "the average level of groundwater utilisation in our State is only 26 per cent, and there is a lot of scope for further utilisation." "Although nearly 80 per cent of the States' geographical area is covered under hard rock terrain, it is endowed with a good potential of water resources. But, the available water resources are not equitably distributed all over the State. Water scarcity and pollution are some of the key issues that need to be addressed on priority,"

"A suitable legislation is required for effective management of groundwater resources of the State. The ongoing climate change processes are going to impact the present hydrological cycle which may induce further uncertainties in temporal and spatial availability of water".

CHAPTER 04

METHODOLOGY

In this chapter, it describes about the different methodology adopted for present study; regarding the preparation of a report on groundwater potential and scarcity, application of remote sensing and GIS techniques for remote sensing analysis, performing the resistivity survey in the field, for deigns and development of soil moisture sensor. The details methodologies are described below.

4.1 Development of different thematic maps using Arc GIS tools

Cartosat-1 Digital elevation model (DEM) data were collected (Source: http://bhuvan3.nrsc.gov.in/). Area of interest was extracted from the DEM data and was imported to Arc GIS. Overlaying was done with the previously drawn boundary map which was done using the toposheet. Then the required digital elevation model for the study area was developed.

4.1.1 Preparation of thematic maps

The IRS P6 LISS III dataset which is geocoded False Color Composite, having the band consolidation of 1,2,3 was acquired from NRSA, Hyderabad India. Than the IRS FCC was outwardly translated focused around picture understanding keys and, for example, tone, composition, size, shape, design, waste, cooperation and so forth (Lillesand and Kiefer, 2002). FCC was deciphered for the recognizable proof and depiction of distinctive hydrogeomorphological units. Waste guide of the study territory was concentrated from the cartosat-I DEM and thusly redesigned from the toposheet gave by – M/s JINDAL STEEL & POWER LTD. toposheet on was of 1:2000 scale. The seepage guide was digitized physically as well as a line scope demonstrating the whole stream system. Calculation based network estimations of DEM system joined on Arc/Info GIS programming was utilized for making stream system of the study zone. For making stream system; stream course, filling, sink, stream amassing, stream requesting was utilized (Strahler 1952, Jenson and Domingue 1988, Tarboton et al. 1991).

Other thematic layers were prepared; for present study, mainly six different themes was evaluated: (i) geomorphology (G), (ii) landuse (LU), (iii) lineament density (LD), (iv) soil (S), (v) drainage density

(D), and (vii) slope (E) on the raster GIS platform. Raster GIS model was embraced since it was enhanced spatial determination for pictures and for expansive region scope. Crude pictures were digitally handled utilizing look-up table stretch, histogram leveling, key part investigation and 363 high-pass directional separating systems for making geomorphology and lineament thickness maps. Soil maps was digitized and changed with support of satellite symbolism and put away as topical maps.cartosat-1dem information from NRSA, Hyderabad India was utilized within the present study to concentrate slant guide.

Stream heading guide was created from DEM; the DEM of the study range was used as an info. It has given a reasonable picture about the stream heading in the study range. Considering stream heading guide as an information, stream collection guide was produced utilizing Arc GIS instruments.

Area utilization/area spread information was gathered. Chose part of the study territory was transported in to Arc GIS and the area utilization/area spread guide was produced. The diverse topical maps was utilized as a part of depicting groundwater prospective zones which were given weights and positioning focused around their impact in groundwater prospects as indicated in (Table 4.1).

Table 4.1: Weighted and % influence of different thematic layers

Sl. No.	Theme	% influence	Class	Weighted
1	Slope	30	376-484.150	9
			484.150-549.506	8
			549.506-589.000	**7**
			589.000-628.493	**6**
			628.493-693.849	**5**
			693.849-802.000	**3**
2.	Lineament Density	25	0.0000-0.5423	4
			0.5423-1.0840	5
			1.0840-1.6270	6
			1.6270–2.1694	7
			2.1694-2.7117	8
			2.7117-3.2541	9
3.	Drainage Density	20	0.0-1.0	4
			1.1-2.0	5
			2.1-3.0	6
			3.1-4.0	7
			4.1-5.0	8
			5.1-6.0	9
4.	Land use/Land cover	15	Water bodies	10
			Evergreen Forest	9
			Deciduous Forest	8
			Grassland	7
			Kharif only	6
			Scrubland	5
			Double/Triple	4
			Current fallow	3
			Other waste land	2
			Build up	1
5.	Soil	5	Red Earths	8
			Red Sandy soil	9
6.	Geomorphology	5	Anthropogenic Terrain	5
			Highly Dissected hills and valleys	6
			Moderately Dissected Hills and Valleys	7
			Pediment- Pediplain Complex	8

4.2 Field survey

Electrical resistivity surveys in order to find the best possible points for drilling for extraction of ground water. In theory, the ground resistance may be derived from the general formula:

$$\text{Resistance} = \textit{Resistivity} \times \frac{Length}{Area}$$

Electrical investigation strategies may be subdivided into two primary gatherings. One group is concerned with estimation of resistivity, or conductivity, of rocks; the other gathering is concerned with estimation of their capacitance. The galvanic, instigation, magneto-telluric, and telluric techniques fit in with the first group, and the incited polarization strategies have a place with the second gathering. All resistivity techniques might be petitioned mulling over varieties of resistivity with depth (profundity sounding strategies) or for examining horizontal changes in resistivity (horizontal profiling routines).

4.2.1 Method adopted

Vertical Electrical Sounding Method is a geophysical method for investigation of a geological medium. The method is based on determining of the electrical resistivity or conductivity of the medium. The estimation is done based on the evaluation of voltage of electrical field induced by the distant grounded electrodes (current electrodes).

The vertical electrical resistivity sounding methods (VES) are profundity sounding galvanic techniques. The electrical resistivity of rock is a property which relies on upon lithology and liquid substance. The resistivity of coarse-grained, decently combined sandstone soaked with new water is higher than that of unconsolidated residue of the same porosity, immersed with the same water. Likewise, the resistivity's of indistinguishable permeable rock specimens fluctuate impressively as indicated by the saltiness of the immersing water. Higher the saltiness of the water, the bring down the resistivity of the rock. Accordingly, it is very workable for two separate sorts of rock, for example, shale and sandstone, to be of basically the same resistivity when the sandstone is immersed with saline water and the shale with new water. Hence, the number and thicknesses of the geoelectric units as decided from VES estimations at a region may not so much be the same as the geographical ones. In this appreciation, geoelectric units characterize parastratigraphic units (Krumbein and Sloss, 1963, p. 333) whose limits may be grating with the stratigraphic limits.

The VES systems were presented by Schlumberger in 1934. From that onward, awide varity of VES system were created (Keller and Frischknecht, 1966, pp. 90-196), yet the Schlumberger exhibit stayed as the best show for depth sounding. However, application of the VES techniques was recently popular, limited to shallow examination, primarily in light of the fact that electronic measuring gadgets of sufficient affectability were not accessible aside from in massive structures, and halfway on the grounds that deeper entrance would have implied a more extensive assortment of resistivity layers than could potentially be consolidated in any set of standard resistivity set of standard resistivity curves. These standard curves gave the main method for understanding by the curve matching systems. The late developments in gadgets and the approach of fast workstations made it conceivable to enter to substantial depth while utilizing convenient equipment, and to translate the results without the confinements forced by the standard resistivity curves collections. Nonetheless, the understanding of VES information, and additionally all other resistivity information, is ambiguous. This will be focused on further in this report, yet it is critical to remember that an interesting translation might be made just when great control is accessible through wells which were penetrated by method for advanced penetrating practices and logged by balanced logging gadgets. Advanced penetrating practices guarantee insignificant changes in the properties, of the strata infiltrated by the well, and balanced logging gives the genuine resistivity of the strata in outright units.

Aim of this study was to determine feasibility by using one of VES methods-i.e. the Schlumberger array-for identifying various groundwater potential zones in Tensa Valley, Sunderghar District, Odisha, India.

4.3Design & Development of Soil Moisture Sensor

Soil Moisture sensors (SMSs) measure soil moisture at the root zone and regulate the existing conventional irrigation timer, resulting in considerable water savings when installed and used properly. A customized soil water content threshold is set, allowing for dryer or wetter soil condition. Soil Moisture sensors (SMSs) function similarly to Electrical resistivity meter but by measuring soil moisture at the root zone they are more effective at minimizing irrigation when plants do not need additional water.

The configuration and advancement of sensors was to be a straightforward, simple to introduce strategy to screen and demonstrate the level of soil dampness that is constantly controlled with a specific end goal to accomplish greatest plant development and all the while enhance the accessible of water present in the dirt, so that groundwater potential zone might be known effectively. A basic micro-controller-based circuit with programming interfacing unit, test driver unit, power supply unit and showcase unit and so on was utilized coupled with one another units which let us know the dampness level in soil. The utilization of effortlessly accessible segments decreases the assembling and upkeep costs. This makes the proposed framework to be an efficient, fitting and a low upkeep answer for provisions, particularly in provincial territories and for little scale agriculturists and household utilization.

The sensor which was building is a resistive sensor. The resistive sort of dampness sensor is the harshest. It uses the two tests to pass present through the dirt, and thereafter we read that imperviousness to get the dampness level. More water makes the dirt conduct control more easily (less safety), while dry soil conducts power more defectively (more safety).

Soil Moisture sensors should be placed at least 5ft. / 1.524m from any structure, from impervious surfaces, from depressions/swales, from the property line (to avoid overspray from neighboring irrigation system) and from septic tanks/ drain fields, and at least 3 ft. / 0.9144m from plant beds. They should also be placed to avoid high moisture areas, and so should be at least 5 ft. from downspouts, overhangs, hose bibs, air conditioning condensate lines, tree canopy drip lines, and shade on the north side of a home. Sensors are installed in the root zone, in undisturbed soil when possible.

One issue with resistive sensors is that the safety of a material progressions with temperature. So when the sun beats on the dirt and the dirt warms up, the safety changes. This will transform a false "dry" read. Therefore, a dirt temperature sensor might be utilize so that information to twist the dirt dampness to uproot the false perusing.

The soil Moisture sensors overrides the controller’s scheduled irrigation events when they are not needed but it does not control the duration of those events. To achieve maximum water use efficiency, the irrigation run time must be set appropriately on the irrigation controller according to application rate, season, region and plant needs.

If the system is applying excessive amounts of irrigation, an irrigation contractor trained in the installation and operation of soil moisture sensors should be called in for an inspection. If the system is running properly, an annual recalibration is recommended along with an inspection. More frequent recalibration may be needed due to changing plant needs (site changes or termination of establishment period), seasonal weather variation, or if the sensors were placed improperly.

When a landscape maintenance company or homeowner makes fertilization or pesticide applications, they may temporarily turn off the Soil Moisture Sensor controller to allow a watering-in application.

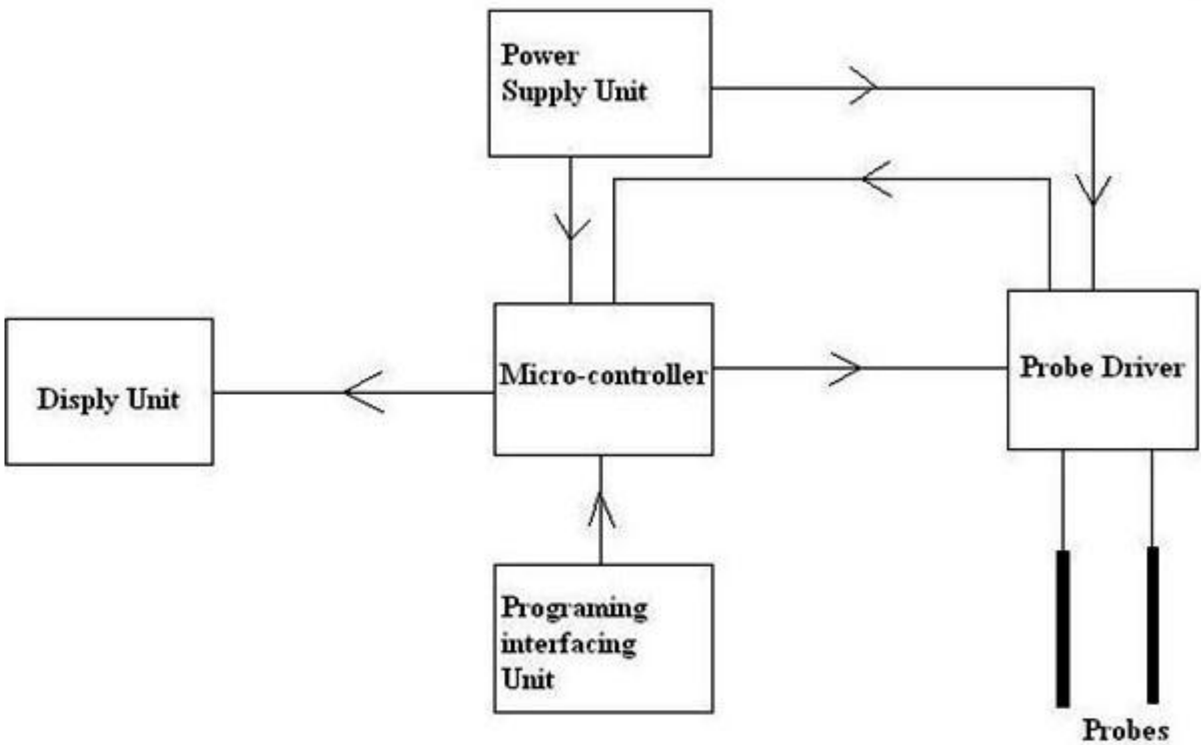


Figure: 4.1 Block Diagram of the SMSs System

CHAPTER 05

RESULTS & DISCUSSION

In this chapter; the results obtained from different objective were analyzed and the results are properly discuss below.

5.1Remote Sensing & GIS analysis for Groundwater Potential Zone

The data required for remote sensing and GIS was downloaded from NRSC, Hyderabad various thematic maps were delineated using Arc GIS software. The different thematic maps are given described and shown below.

5.1.1 Geomorphology

The meaning of Geomorphology has an important meaning in the chambers dictionary i.e. "scientific study of the nature and history of landforms on surface of Earth and other planets, and the processes of their creation." The different geomorphology units were depicted from satellite information and are portrayed underneath and introduced in Figure 5.1. They assume an extremely critical part in groundwater prospects (Horton 1945, Thornbury 1985) and subsequently the highest weight is given (Table 4.1). Different classes were distinguished in the study area and are portrayed beneath such as.

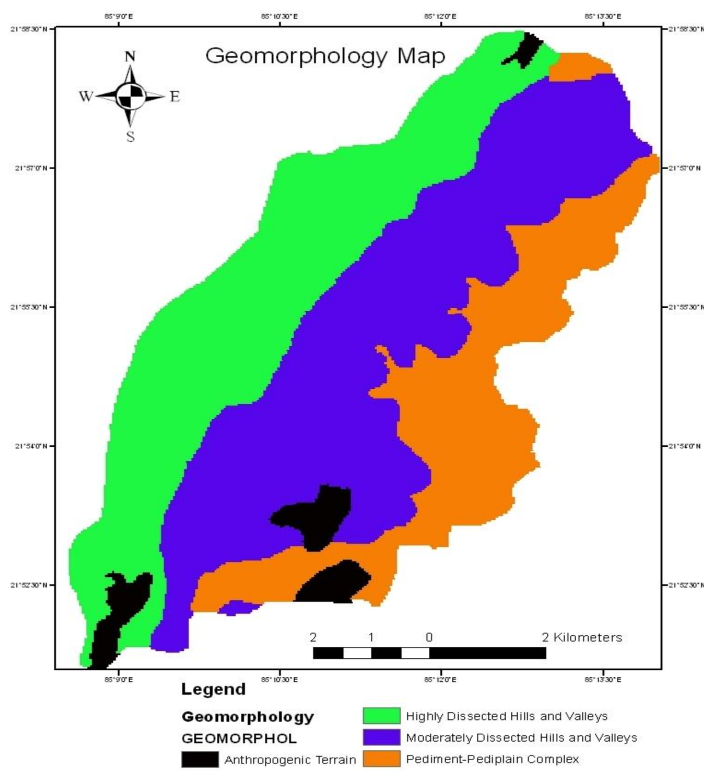


Figure 5.1: Geomorphology Map

.i) Anthropogenic Terrain ii) Highly Dissected hills and valleys iii) Moderately Dissected hillys and valleys iv) Pediment-pediplain complex.

Anthropogenic Terrain has been given the lowest weighted as it has been created or caused by human activity. Pediment-pediplain has been given the highest weighted since; it isthe surface which consists of chiefly bare rock but may have a covering veneer of alluvium or gravel this acts as a highest groundwater recharge source in the study area. Highly dissected hills and valleys were given the lowest weighted since it's having mainly Runoff as compared with the moderately dissected hills and valleys which is acting as Recharge-Cum-Runoff.

5.1.2 Landuse / landcover

Landuse/landcover map (Figure 5.2) was prepared from NRSC Bhuvan satellite dataset of 2011-2012 maximum likelihood algorithm technique was used for generating it. The following classes are distinguished: (i) water bodies, (ii) Build up, (iii) Kharif only, (iv) Double/Triple, (v) Scrubland, (vi) EverGreen Forest (vii) Deciduous Forest (viii) Grassland (ix) Current Fallow (x) Other waste Land.

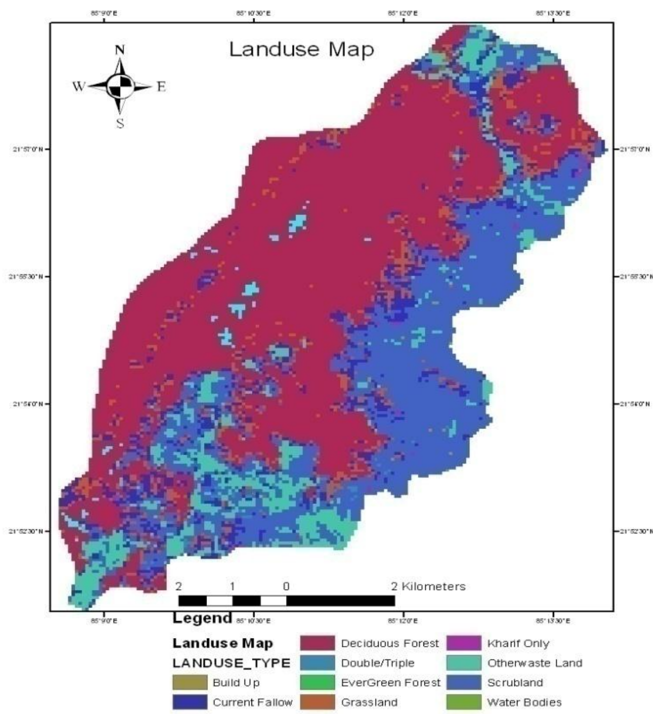


Figure 5.2: Land use/land cover Map

Different landuse/landcover classes was weighted based on their water requirement. The water bodies were given the highest weight over other landuse features since its incessant recharge to ground, ensued by Evergreen forest only, which pull maximum amounts of water from the deep root zone for sustaining, resulting the present of water below the ground surface. Evergreen forest was weighted higher than deciduous forest and grassland was given less weighted after Kharif since is a crop which required huge amount of water and thus it act as a good groundwater recharge. Scrubland is a land that is covered with small bushes and tree where as current fallow land is a land which was periodically left idle i.e. land that is not planted to a crop; that is why it was given less weight than scrubland. The lowest priority was given to waste Land as it lacks a vegetation cover. The various weighted of landuse/ landcover classes are presented (Table 4.1).

5.1.3Lineament Map

A surface Lineament map was prepared from the **Cartosat-1**DEM data from NRSC. Lineaments are the sharp features indicated by sixtones colour in (Figure.5.2) In the present study, 363 high-pass directional convolution kernels filter under spatial enhancement techniques were applied to delineate the lineaments from satellite imagery of IRS P6 LISS III of 21 March 2013. PC analysis was also been used for

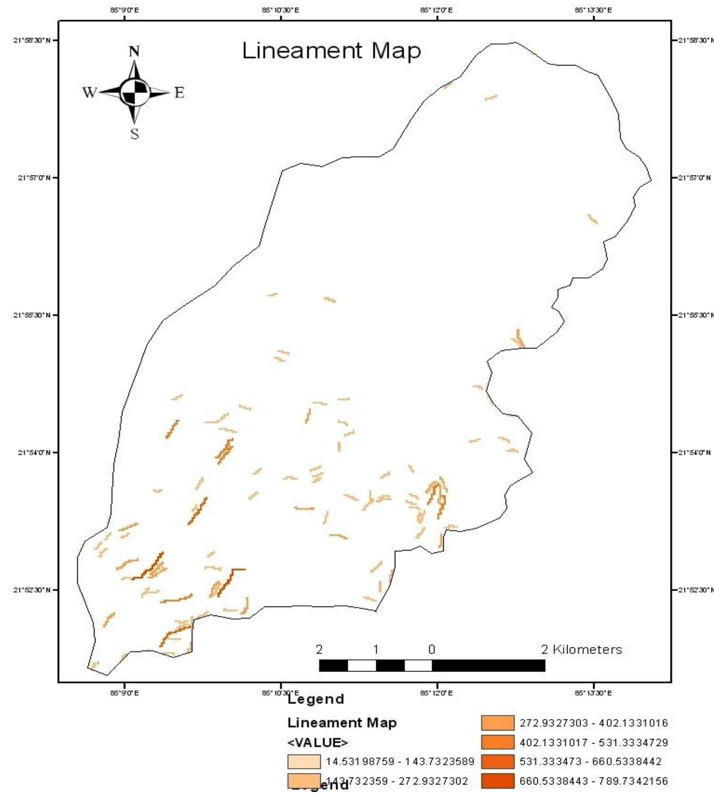


Figure 5.3 Lineament Map

delineating the smaller lineament features. Lineament characteristics were mainly found along the SW–SE and the NE–SE directions, and a very few are along the E–W and the N–S directions, as shown in (Figure 5.3). Lineaments play a very important role in recharging groundwater in the hard terrains rock (Koch and Mather 1997). Groundwater potential is very much higher near lineament zones.

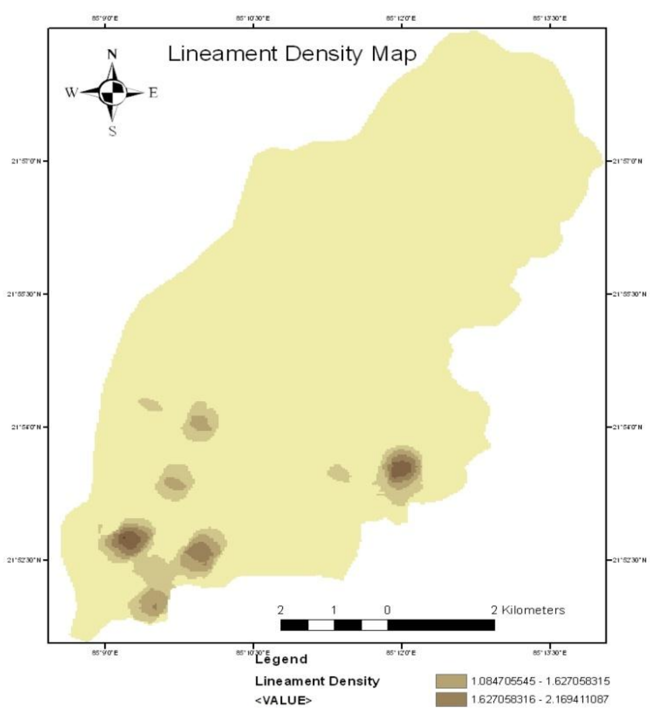


Figure 5.4: Lineament Density Map

5.1.4 Lineament Density Map

The above lineament map of analysis area was used for generating the lineament density, using the line density tool as shown in the (Figure 5.4). Polygons with higher values of lineament density will achieve greater recharge and hence a better prospects for groundwater. Lineament density was divided into various intervals: 0-0.5423, 0.5423–1.0840, 1.0840–1.6270, 2.1694–2.7117 and 2.7117–3.2542 (Table 4.1). The most significant value of ranking was designated to highest lineament density interval.

5.1.5 Soil

S.P Raichaudhuri & others, satellite imageries, air photographs, I.C.A.R, I.A.R.I, National soil survey, state agricultural depts.., Agricultural Universities, G.S.I, survey of India maps, Field (SOI 1981) Mainly two types of soil; groups as Red Earths, red sandy soil, which was ranked based on their groundwater expectations. The Sandy soils are very highly permeable, light textured and well drained, and rate of infiltration is excellent. Red Earths soils are a little moderately well drained and possess of fine loams. The moisture content of the soil is very nice because of its fine loamy texture. The Green forest soil is rich in humus. It is found in the forest land of the study area and their weights for different soil are presented in (Table 4.1).

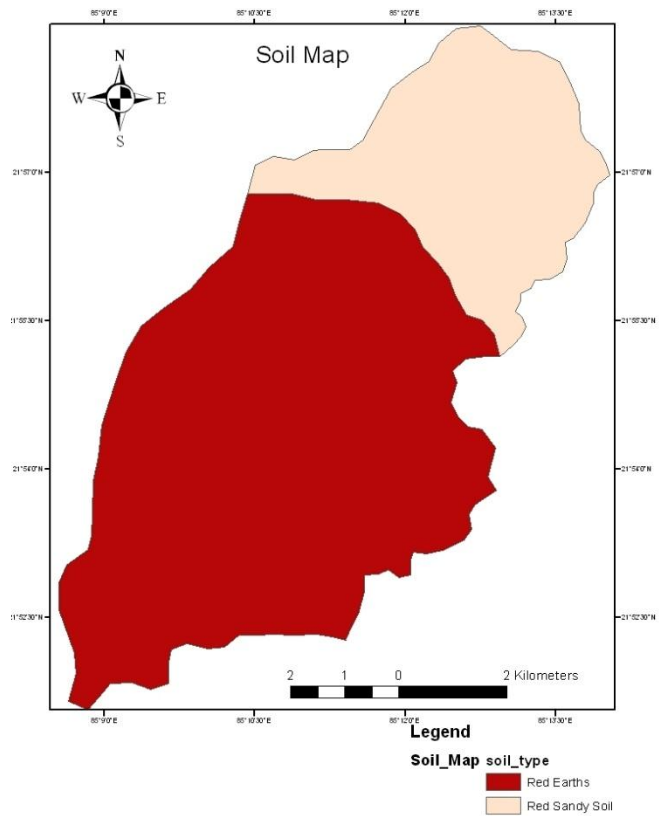


Figure 5.5: Soil Map

5.1.6 Drainage Map

Drainage of the study area is one of the practical approaches to know the lithological and structural control of land form evolution. Agricultural activities depends on natural rivers, wells, rain fed structure, minor irrigation, seasonal rivers etc. Entire area is covered by undulating hilly tract intersected by gorges and passes. Besides many seasonal nalas, there are about four perennial nalas in the region. Presently, the important source of supply of water in this study area is basically Samij Nala.

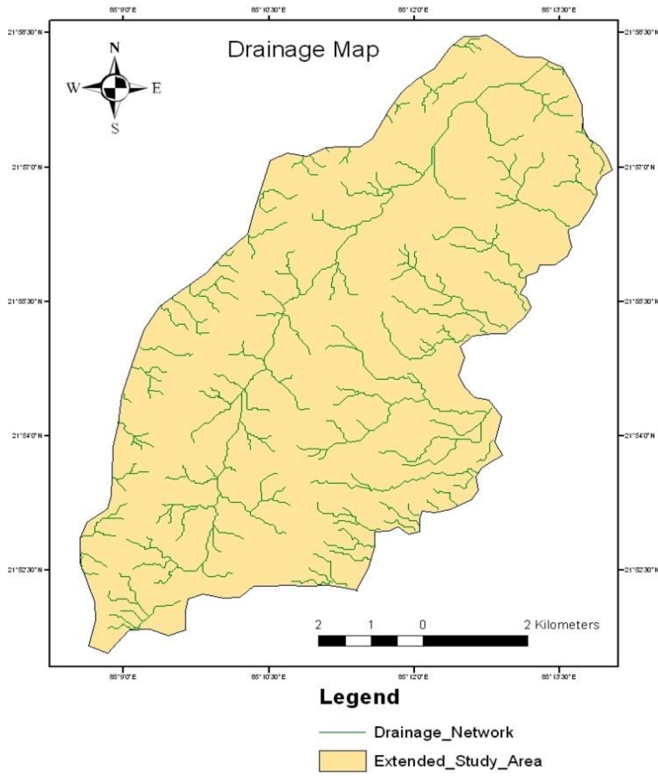


Figure 5.6: Drainage Map

5.1.7 Drainage density

The study area was delineated from **Cartosat-1** DEM data from NRSA, Hyderabad India was used in the present study which is freely available. Drainage density of the study area was calculated (Miller 1953) as the 'total length of streams in the sub basin area' and expressed as km/km^2. The drainage density was found to be 0.024 m^{-1} (Figure 5.7). Drainage density value was grouped into six groups: 0.0-1.0, 1.1–2.0, 2.1-3.0, 3.1-4.0, 4.1-5.0, and 5.1-6.0. A low drainage density region causes higher infiltration and it yields in better groundwater potential zones as correlated to a high drainage density region. The higher weight was given to the low drainage density regions

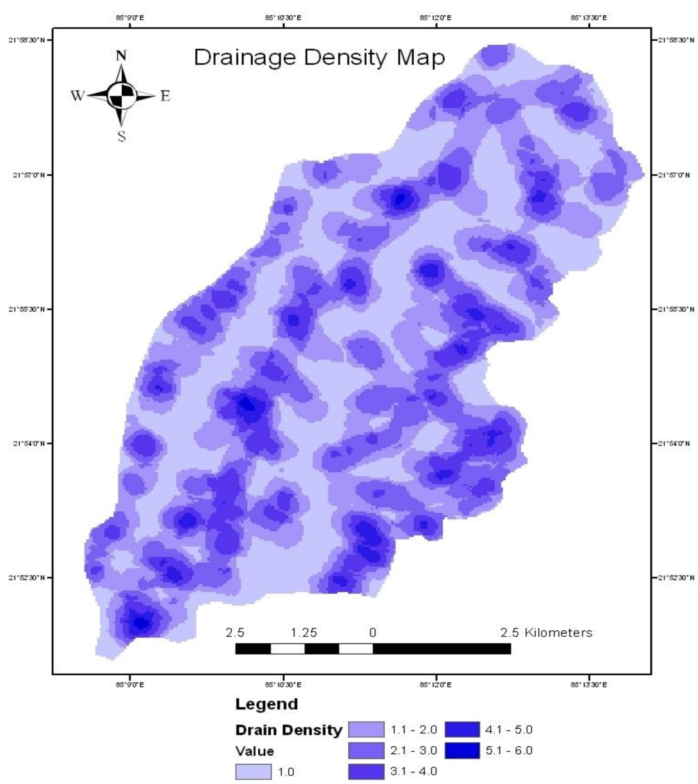


Figure 5.7: Drainage density map

and the lower weight to the high drainage density areas, shown in (Table 4.1).

5.1.8 Slope

Slope map was generated from **Cartosat-1**DEM data from NRSA, Hyderabad India was used in the present study which is freely available. Greater portion of the area has very flat terrain except the upper part, which is a hilly terrain with a steep slope varying from 50% to 60%. Slope range was differentiated into six groups. Finally, six classes of slopes (376.000-484.150, 484.150-549.506, 549.506- 589.000, 589.000-628.493, 628.493-693.849 and 693.849-802.000) were differentiated and shown in (Figure 5.6). Higher slope will produce more runoff with lesser infiltration, and it will have a poor groundwater prospects contrasted with low slope region. The higher weight has been assigned to gentle slope and lesser weight to higher slope, as shown in (Table 4.1).

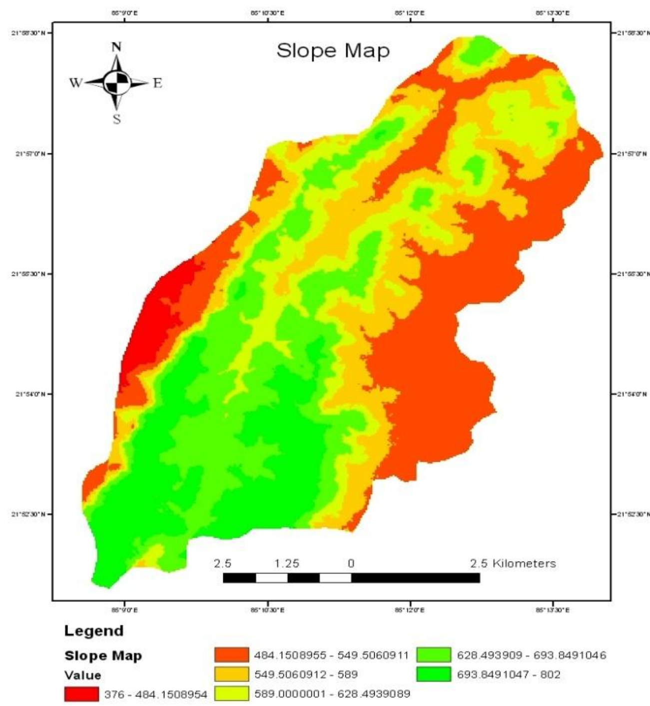


Figure 5.8: Slope Map

5.2 Integration of Thematic Layers for Modeling using GIS: Weighted Index Overlay Model:

Depending upon the groundwater potentiality, each class of the main six thematic layers (geomorphology, slope, drainage density, lineament density, soil, land use) are roughly placed into one of the following groups viz., i. Excellent, ii. Very good, iii. Good, iv. Moderate, v. Poor. Suitable weighted on a scale of '0 -8' has been given to each class of a particular thematic layer based on their contribution towards ground water potentiality. The % influence of each thematic map is been given based upon its contribution toward ground water. The weighted and % of influence assigned for varous classes on all thematic layers are shown in the (Table 1). All the thematic maps have been integrated. A final groundwater potential map (Figure 11) is prepared with application of above technique.

Table 5.1 Integrated Weight Range for Various Groundwater Potential Zones

Groundwater Category	Lower and Upper Weight Table
Excellent	7.1 – 8.0
Very Good	6.1 – 7.0
Good	5.1 – 6.0
Moderate	4.1 – 5.0
Poor	0.0 – 4.0

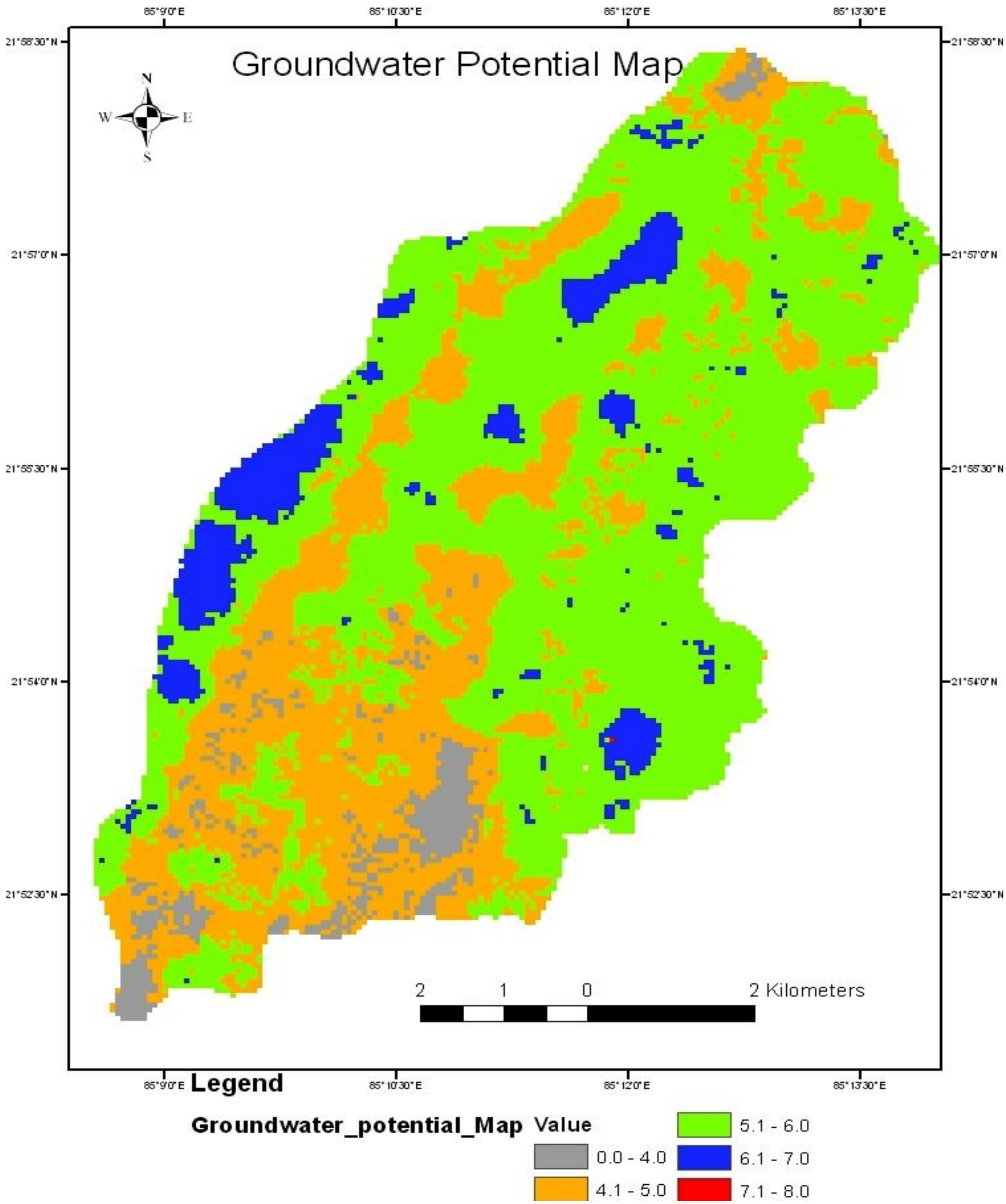


Figure5.9: Groundwater Potential map of the study area

5.3 Electrical Resistivity Tests

Field surveys were made during the years 2013 and 2014 at 5(five) locations of the sub-basin to collect ground water information using Electrical resistivity tests. Vertical electrical soundings using Schlumberger array were carried out with maximum to half current electrode separation (AB/2) more than 100 m which is highly used in groundwater exploration study. Apparent resistivity at sounding stations is plotted against the corresponding half electrode spacing to look for weaker or stronger water potential zones. The result which was obtained had been analyzed and plotted in MS Excel and IPI2win software which is mainly used by the geo-physic researchers. Detail of the resistivity site and the outcome results such as obtained error, types of curve used, probable aquifer thickness, and classes of aquifer are given below in Table 5.2.

Table 5.2: Vertical Electrical Resistivity (VES) data are summarized

Location		**Obtained Error**	**Types of Curved used for matching with the Field Data**	**Probable Aquifer Thickness (m)**	**Aquifer Type**
Latitude	**Longitude**				
21^{0}53’20.114”	85^{0}11’14.706”	2.74 %	Three Layer Curve	5	Un-Confine Aquifer
21^{0} 53’00.137”	85^{0}11’56.297”	16.08 %	Two Layer Curve	4.32	Un-confine Aquifer
21^{0} 53’32.484”	85^{0} 11’02.347”	18.71 %	Thee Layer Curve	5.7	Confine Aquifer
21^{0} 53’27.11”	85^{0}11’13.74”	315 %	Two Layer Curve	No water was found	
21^{0} 53’29.13”	85^{0} 11’02 .96”	6.32 %	Four Layer Curve	5.2	Confined Aquifer

After performing the remote sensing analysis, the result which was obtained was subsequently cross-checked with the resistivity survey data. Since, resistivity is a costly and time consuming therefore it was carried out only within the JSPL area not throughout the entire samij sub-basin in Tensa valley. Five vertical electrical soundings using Schlumberger array were carried out with maximum to half current electrode separation (AB/2) more than 100 m which is highly used in groundwater exploration study. The result which was obtained had been plotted in MS excel and a curved matching analysis was performed with some standard curved in the IPI2win software. The output of the curved matching analysis was also shown. Therefore, study area has a good prospect for groundwater resource. All the graphs and IPI2 win software output of different location are given and shown below. Resistivity is a measure of how much the soil resists the flow of electricity. Since, the ground of Earth surface is inhomogeneous therefore, the measured quantity is known as the apparent resistivity. In coarse, granular soils, the groundwater surface is noted generally by a sudden variation in water saturation and thus by a variation of resistivity. Moreover, the resistivity of ground water changes from 10 to100 ohm-m. depending on the concentration of dissolved salts.

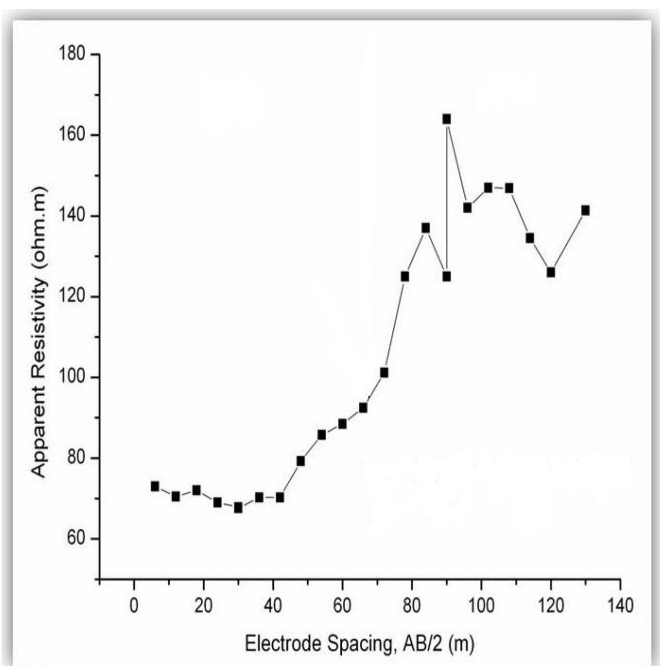


Figure 5.10(a): Near kabitanala (source:MS Excel)

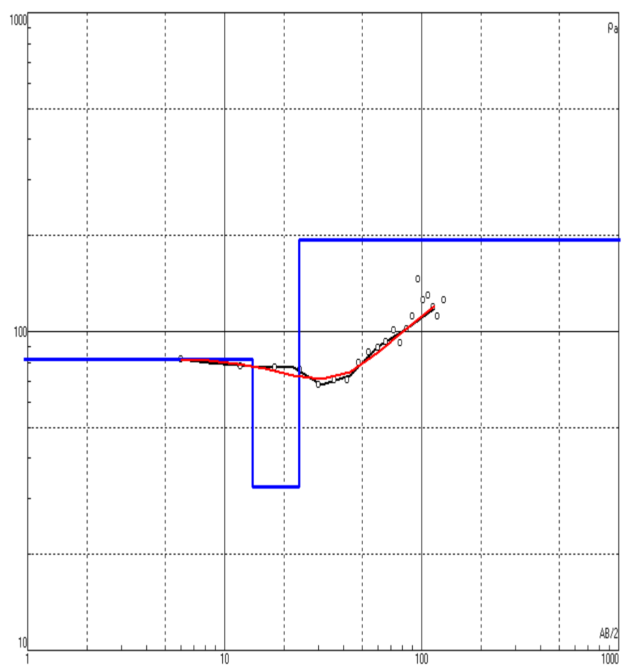


Figure 5.10(b): Near kabitanala (source: IPI2win software)

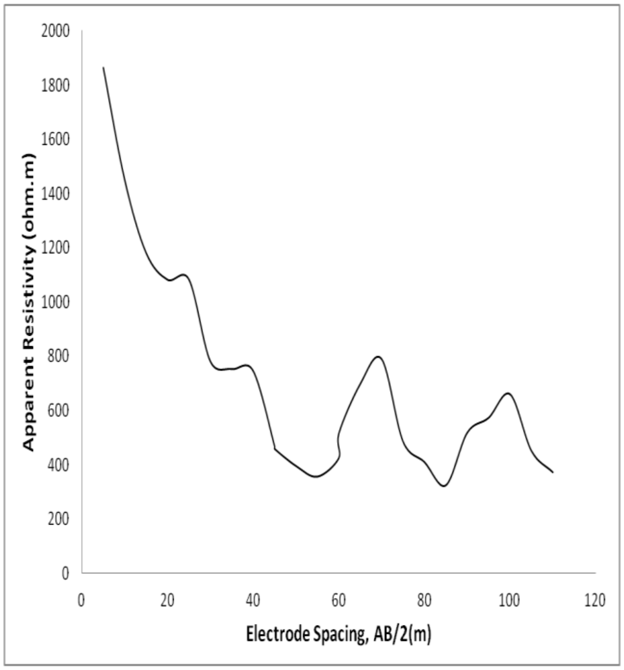


Figure 5.11(a): J2 Pillar (source: MS Excel)

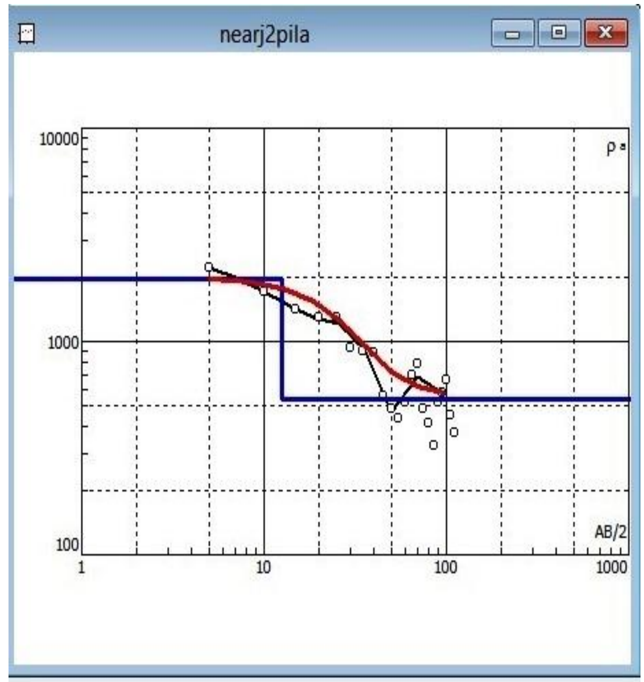


Figure 5.11(b): Near J2 Pillar (source: IPI2win software)

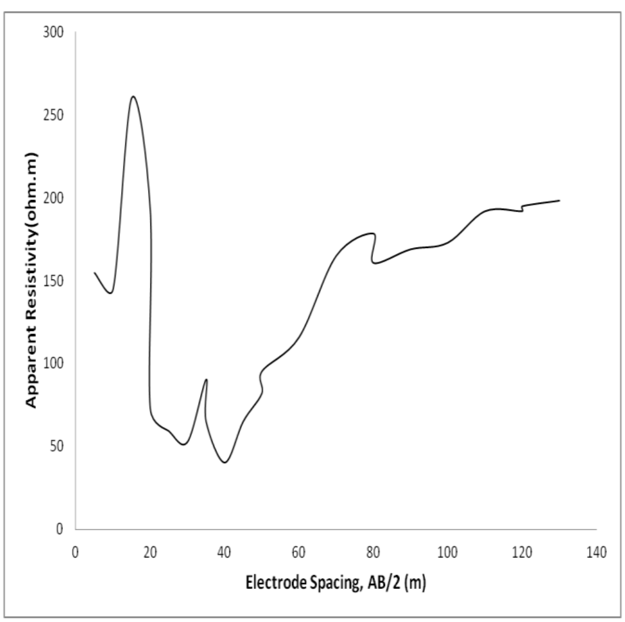


Figure 5.12(a): Near Cow shed (source: MS Excel)

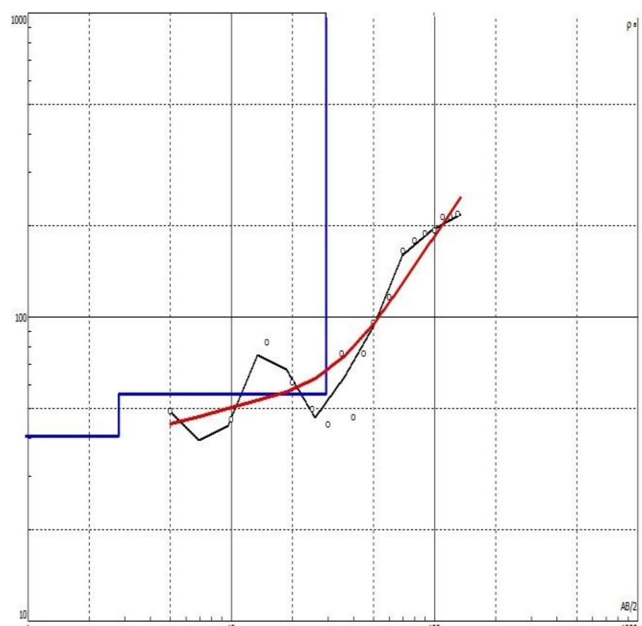


Figure 5.12(b): Near Cow shed (source: IPI2win software)

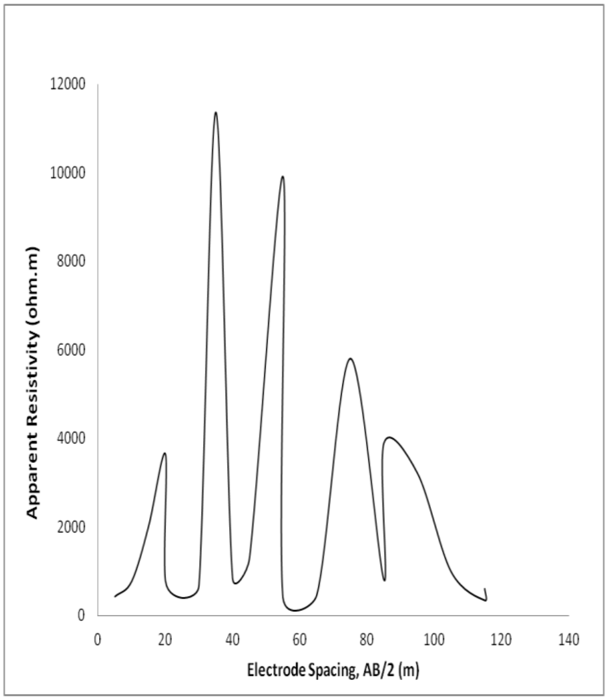


Figure 5.13(a): Near Pump house (source: MS Excel)

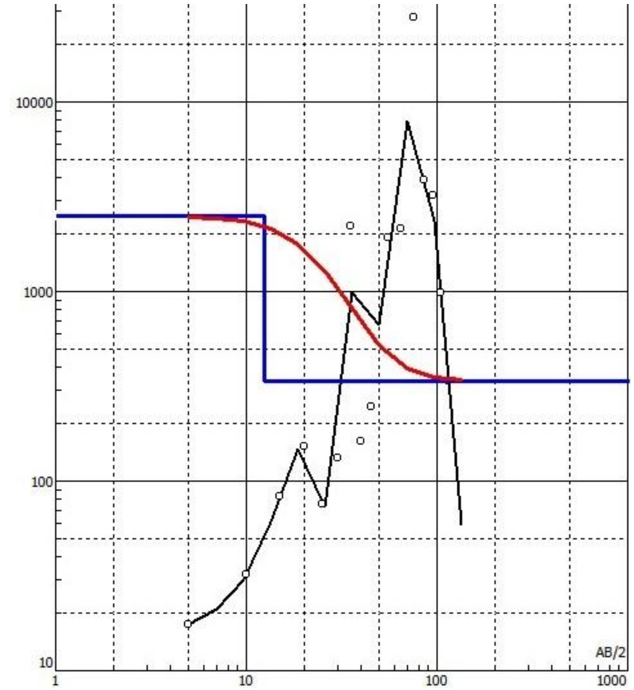


Figure 5.13(b): Near Pump House (source: IPI2win software)

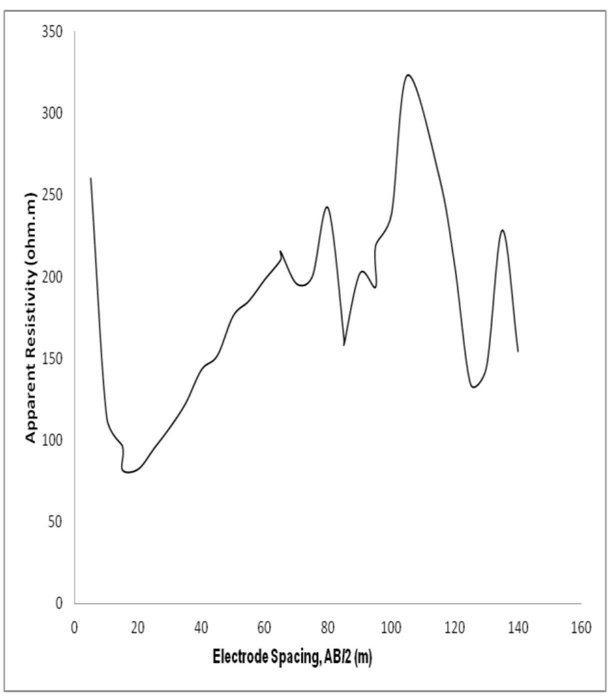


Figure 5.14(b): Near swimming pool (source:MS Excel)

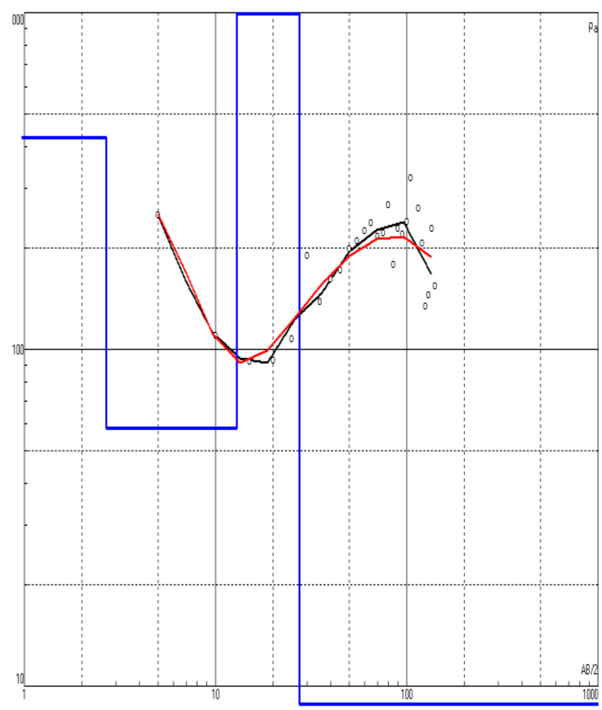


Figure 5.14(b): Near swimming pool (source: IPI2win software)

The resistivity result was compared along with the remote sensing analysis and shown in the (Figure5.15). After comparing both the outcome result i.e. result of remote sensing and resistivity it can be concluded the study area of JSPL lie between "Moderate to Good."

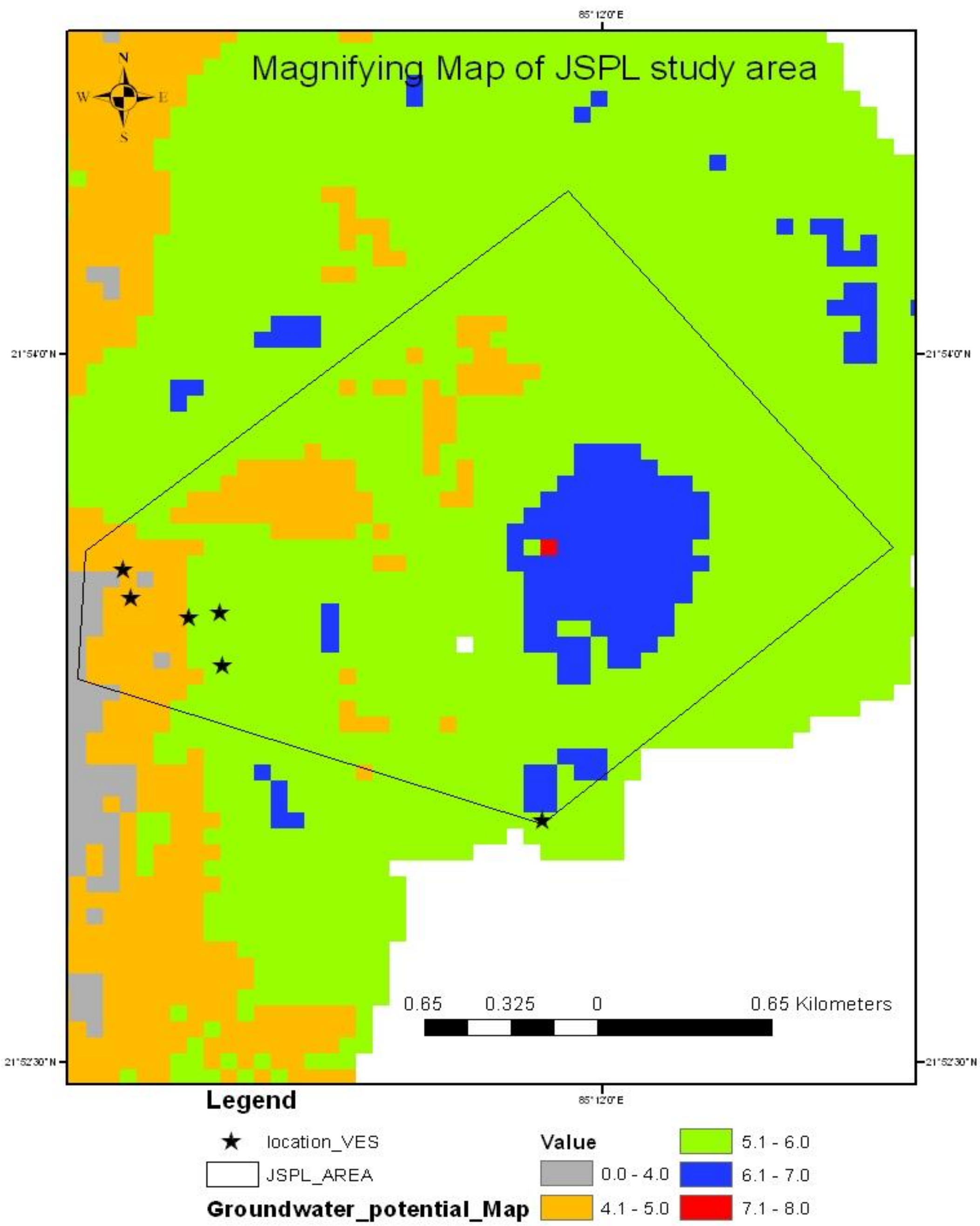


Figure 5.15: Comparison map of both the result

5.4 Design & Development of the soil moisture sensor

A prototype of soil moisture sensor was design and developed by assembling the locally available parts as shown in the (Figure 5.16) below along with the development of the cover body. Many researcher have found that soil moisture acts as an indicator for drought, float, and even for ground water. Soil moisture acts as a medium for interlinking between the satellite remote sensing data and resistivity data.

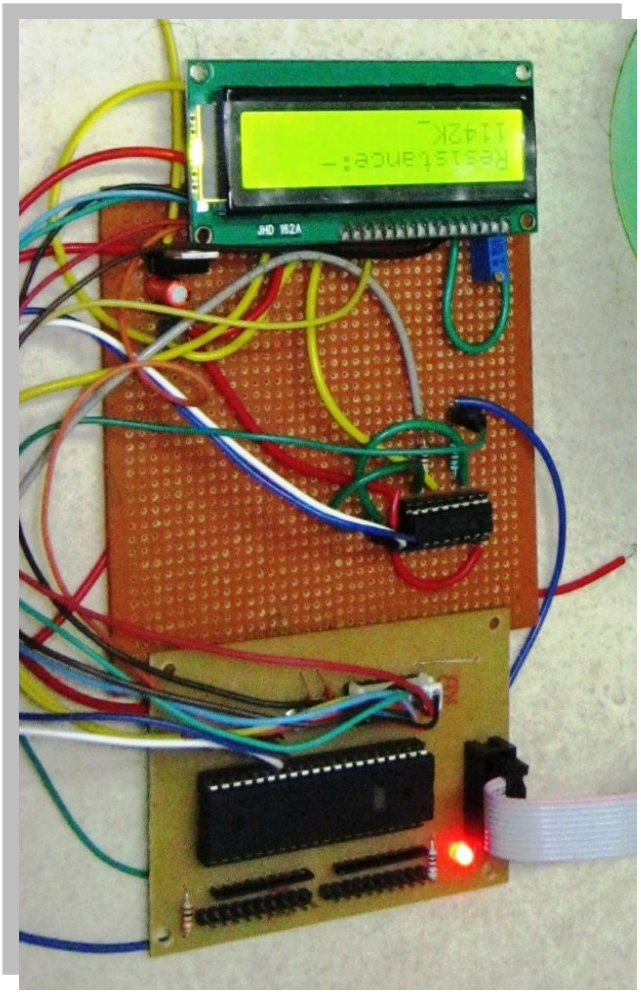


Figure 5.16: Complete set after fabrication

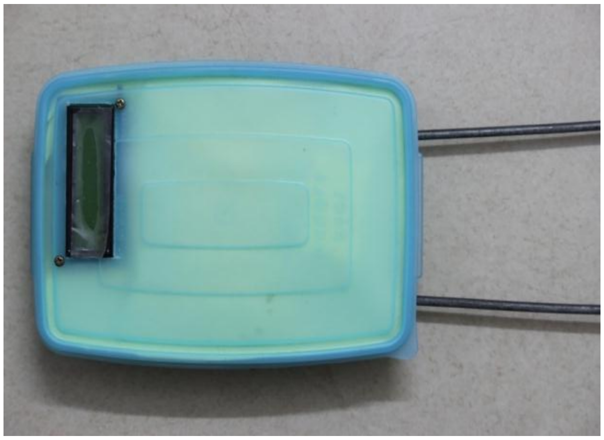


Figure 5.17: Front view

Figure 5.18: Back view

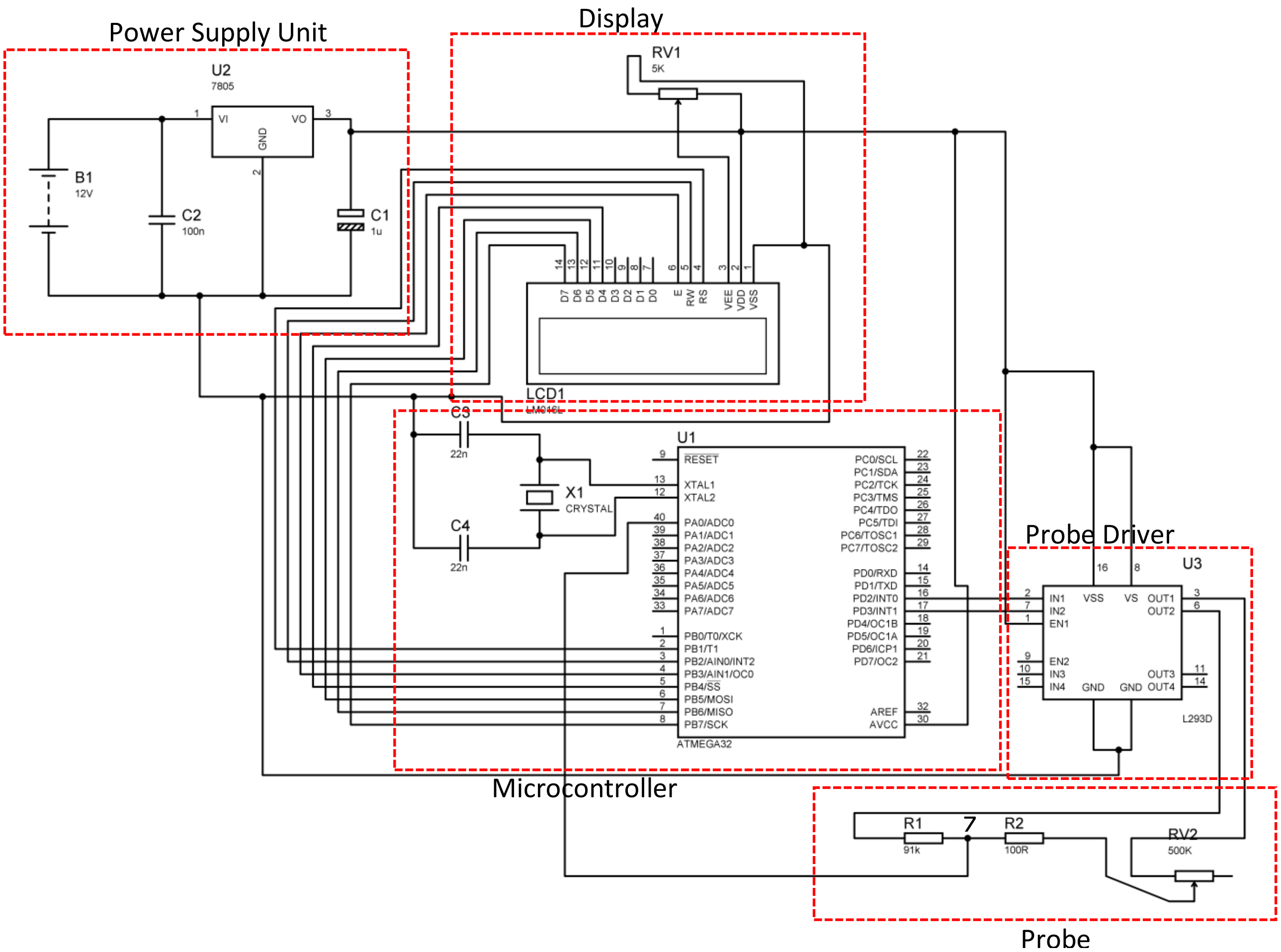


Figure 5.19: Circuit Diagram

The proposed soil moisture sensor has five major units named

1. Power supply unit
2. MCU
3. Display unit
4. Probe driver unit
5. Probe

5.4.1 Power supply unit

Voltage controller U2 (7805), two capacitors C1 and C2 and Battery B1 altogether known as power supply unit. Here MCU and display unit need a voltage of 5V, U2 is here for this reason. It maintains a constant voltage difference throughout the system. C1 and C2 are by pass capacitor, if there is any transient in power supply these capacitors will bypass that to ground.

5.4.2 MCU

The whole circuit is made around the MCU. It is the brain of the system. For our purpose Atmega32 is chosen as it has internal ADC, 2 Timers, 4 IO ports and most important 32 KB programmable flash memory. To provide clock source to the system crystal X1 is connected. Capacitors C3 and C4 are connected as per the documentation of Atmega. PORTB is specifically left for LCD1 (JHD162A), i.e. pin 2 to 8 of Atmega. Sensor input is connected to the ADC0 pin i.e. pin 40. Pin PD2 and PD3 are for sensor driver i.e. pin 15 and 16.

5.4.3 Display unit

Character LCD JHD162A is the best choice for display unit as it can display characters and numbers graphically. It is also low cost and, configuring and programming is not so difficult. VSS and VDD are for power supply, so VSS is connected to GND and VDD is to 5V. VEE is for Contrast setting and Connected through a preset RV1. E, RW and RS are control pins and connected to PB1, PB2 and PB3 respectively. D0 to D7 are data pins for LCD. But here LCD is configured in software to work in 4 bit mode so only 4 pins needed for data. So D4 to D7, data pins, connected to PB4 to PB7.

5.4.4 Probe driver

Sensor driver is made around the IC L293D. It is H-bridge motor controller, but it is used here it can full fill our requirements. Atmega provides very less amount of current, in range of micro ampere, which can’t drive the sensor. So we need a converter which maintains the voltage level at 5V but increase the current. This job is done by L293D. VSS and GND are power supply for L293D, so these are connected as shown in the circuit. VS is the voltage level for output for our course it is 5V, so it is connected to VSS. L293D has two motor drivers, for enabling each there are two enable pins, EN1, EN2. Here driver 1 is used so EN1 is connected to 5V (logical One or True). In1 and In2 are input for L293D and Outputs for Atmega so these are connected to PD2 and PD3 of Atmega.

It was essential to develop a soil moisture sensor in institute, since soil moisture acts as an indicator for much climatic damage. It was an attempt to develop soil moisture sensor with locally available electronics good by assembling. Since the cost in the existing market is very high and it is very difficult to get in the Indian market. The comparison between the existing soil moisture sensor and NIT Rourkela soil moisture sensor as shown in the Table 5.6.

Table 5.3: Comparison between existing and the developed soil moisture sensor

Existing Soil Moisture Sensor	NIT Rourkela, Soil Moisture Sensor
It is Costly i.e. 305.37 US$ OR Rs18000	It is cheap i.e. a material costs totalled approximately US$ 21.72 OR Rs1355.
Complex to understand	Very simple
Required a trained person to operate	Easy to carry, since light in weight
Difficult to get in Indian Market	Fully, use of indigenous technology

5.4.5 Observed reading obtained by the developed sensor

The developed sensor was taken to the field and the observed moisture of the surface soil was noted down and the soil sample was collected and the moisture level was found out using the oven drying method. Ohm is SI the unit of Resistance and here kilo represents the factor of 1000. ohm is the resistance of the object if transmitting one ampere current through it generates a voltage difference of one volt across it.

Table 5.4 Soil Sample-1

Date	**Time**	**Location**	**Condition of Soil**	**Reading Obtain** (NIT rkl, SMS)	**Moisture Content** (calculated by oven dry method)
08 MAY 14	10:38 AM	Naga dam	Fully wet	6 kΩ	21.26 %

Figure 5.20: Collection of soil sample-1, Naga Dam

Table 5.5 Soil Sample-2

Date	**Time**	**Location**	**Condition of Soil**	**Reading Obtain** (NIT rkl, SMS)	**Moisture Content** (calculated by oven dry method)
08 MAY 14	10:55 AM	G.D Birla Lawn	Morning Irrigation was done	13 kΩ	12.29 %

Figure 5.21: Collection of soil sample-2, G.D Birla garden lawn

Table 5.6 Soil sample-3

Date	Time	Location	Condition of Soil	Reading Obtain (NIT rkl, SMS)	Moisture Content (calculated by oven dry method)
08 MAY 14	11:15 AM	In front of Library Lawn	Partially wet	16 kΩ	16.55 %

Figure 5.22: Collection of soil sample-3, In front of the Library (Rose) garden lawn

Table 5.7 Soil Sample-4

Date	Time	Location	Condition of Soil	Reading Obtain (NIT rkl, SMS)	Moisture Content (calculated by oven dry method)
08 MAY 14	11:15 AM	In front of Library Lawn	Fully wet	5 kΩ	30.58 %

Figure 5.23: Collection of soil sample-4, In front of the Library (Rose) garden lawn

CHAPTER 06

CONCLUSION

The present study can be summarized in the following way:

In this present study, from the first objective it can be concluded that the coastal regions of Odisha state are found to be utilizing groundwater more than interior districts of the State. The successful use of the remote sensing data on GIS platform has helped in obtaining detailed scenario of groundwater situation in the study area which is fully surrounded by mines. The required thematic maps for the groundwater prospecting zones of the study area were directly generated by remote sensing data using the software ERDAS Imagine and ARCGIS. Various algorithms which were essential for the hydrological application was used in Arc/Info GIS which were useful in creating study area boundary, stream network, lineament and drainage density maps. The integration of all the thematic maps result six groundwater potential zones – poor, moderate, good, very good and excellent –and the weighted range for various groundwater potential zones were categorized such as- Excellent zone 7.10 – 8.00, Very Good 6.1 – 7.0, Good 5.1 – 6.0, Moderate 4.1 – 5.0, Poor 0.0 – 4.0. The poor zone was indicating the least favorable area for groundwater prospect; whereas excellent zone indicates the most favorable area for groundwater prospect. The results which were secured from the integration of various thematic maps were compared with VES data for ground truth verification which shows that the study area fall in the range of moderate to good; which accounts 75.00% of the study area. Rather a prototype of soil moisture sensor was developed for finding out the surface moisture which can act as an intermediate or an indicator for linking between the remote sensing and GIS technique with the resistivity technique.

SCOPE OF THE STUDY IN FUTURE

- Study area of my present work is situated at a location which is mainly surrounded by many mine areas. If each mine is been considered as a small study area, then their size will be less than the present study area. Proper groundwater management must be done for meeting their ever growing demand for water.

- Results obtained from the present study work are very good. Therefore, more study should be done such as groundwater recharge, groundwater pollution in order to protect the groundwater potential zone.

- Groundwater flow and transport modelling can be done for the study area.

- Groundwater Quality for the study area can be performed.

- More resistivity survey should be conducted in order to save the both factor i.e. cost and time in locating the groundwater potential zone, so that boring could be done at the exact location.

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Instrument used for resistivity survey

Figure: Vertical electrical sounding, Department of mining engineering, NIT Rourkela