

GROUND WATER PROSPECTING IN THE DROUGHT PRONE AREAS - GEOPHYSICAL AND GEOSPATIAL APPROACH

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Engineering Degree in
Civil Engineering
By

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DEPARTMENT OF CIVIL ENGINEERING
SCHOOL OF BUILDING AND ENVIRONMENT

SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)

Accredited with Grade "A" by NAAC
JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119

APRIL - 2021



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DEPARTMENT OF CIVIL ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **MELBIN ROBIN** (Reg.No. 37200040) and **RAMKUMAR K** (Reg.No. 37200058) who carried out the project entitled **"GROUND WATER PROSPECTING IN THE DROUGHT PRONE AREAS - GEOPHYSICAL AND GEOSPATIAL APPROACH"** under our supervision from December 2020 to April 2021.

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DECLARATION

We MELBIN ROBIN (Reg.No. 37200040) and RAMKUMAR K (Reg.No. 37200058) here by declare that the Project Report entitled "GROUND WATER PROSPECTING IN THE DROUGHT PRONE AREAS - GEOPHYSICAL AND GEOSPATIAL APPROACH" done by me under the guidance of Dr. S. Packialakshmi M.E.,Ph.D., submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Civil Engineering.

1.



2.



DATE : 07/04/2021

PLACE: Chennai

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ABSTRACT

The sustainable development and management of groundwater resources requires precise quantitative assessment supported scientific principle and modern techniques to identify the zones of very good, good, moderate and poor groundwater potential. The Alangudi Taluk, Tamil Nadu (India) is situated towards the eastern part of Pudukkottai. In the eastern part of the district is a flat terrain consisting of alluvial plains. It is experiencing commercial development of groundwater in addition with escalating domestic and industrial demands. The present study is aimed to develop the mapping of groundwater potential zones and groundwater quality for the selected study area by using the remote sensing and geospatial techniques. Data like water level, water quality, rainfall, climatology and geophysical resistivity from various sources and satellite imageries have been used for this study to observe the changes on the sources of water resource systems. For delineation of groundwater potential zones, thematic maps of different governing themes of groundwater potential zones such as geology, geomorphology, Land use/Land cover, Lineament, soil texture have been created to their relative importance. The generated village wise groundwater potential map has shown a vast spatial variability of ground water potential and the area that belongs to the “very good” potential category is quite less in the entire study area (7 %) which alarms the development of existing groundwater resources. The study concluded that a considerable falling trend of groundwater level during pre-monsoon showed the alarming threat for further development. Thus, the presented study identified the prospect of groundwater development and provides guidelines to water resource managers and village officials to recommend conservation and protection strategies against the identified poor groundwater potential zones.

CHAPTER NO.	TABLE OF CONTENTS TITLE	PAGE NO.
	ABSTRACT	
	LIST OF TABLES	
	LIST OF FIGURES	
	LIST OF ABBREVIATIONS	
1	INTRODUCTION	2
	1.1 GENERAL	2
2	REVIEW OF LITERATURE	3
	2.1 GENERAL	3
	2.2 REVIEW OF LITERATURE	3
3	AIM AND SCOPE	10
	3.1 AIM	10
	3.2 OBJECTIVE	10
4	MATERIALS AND METHODS	11
	4.1 METHODOLOGY	11
	4.2 GEO PHYSICAL METHODS	12
	4.2.1 VES SURVEY	12
	4.3 GEO SPATIAL METHODS	15
	4.3.1 DATA COLLECTION	15
	4.3.1.1 GROUND WATER LEVEL	15
	4.3.1.2 RAINFALL DATA	17
	4.3.1.3 GROUND WATER QUALITY	18
	4.3.1.4 BOREHOLE LITHOLOGY	19
	4.4 GIS MAPPING	19
	4.4.1 GENERAL	19
	4.4.2 GEOLOGY MAP	19
	4.4.3 GEOMORPHOLOGY MAP	20
	4.4.4 LINEAMENT MAP	20
	4.4.5 SOIL MAP	20
	4.4.6 LAND USE & LAND COVER MAP	20
	4.4.7 SLOPE MAP	21

	4.4.8 GROUNDWATER POTENTIAL MAP	21
	4.5 SOIL TESTING	22
5	RESULT AND DISCUSSION	23
	5.1 GEOPHYSICAL METHOD	23
	5.1.1 VES SURVEY	23
	5.2 GEOSPATIAL METHODS	24
	5.2.1 GROUNDWATER LEVEL	24
	5.2.2 RAINFALL DATA	27
	5.2.3 GROUNDWATER QUALITY	28
	5.2.3.1 pH	28
	5.2.3.2 TOTAL HARDNESS	28
	5.2.3.3 SODIUM ADSORPTION RATIO	28
	5.2.3.4 SOLUBLE SODIUM PERCENTAGE	29
	5.2.3.5 RESIDUAL SODIUM CARBONATE (RSC)	29
	5.3 GIS MAPPING	29
	5.3.1 GEOLOGY MAP	29
	5.3.2 GEOMORPHOLOGY MAP	30
	5.3.3 LINEAMENT MAP	31
	5.3.4 SOIL MAP	32
	5.3.5 LAND USE & LAND COVER MAP	33
	5.3.6 SLOPE MAP	34
	5.3.7 GROUNDWATER POTENTIAL MAP	35
	5.4 SOIL TESTING RESULTS	37
6	SUMMARY AND CONCLUSION	37
	6.1 GENERAL	37
	6.1.1 VES SURVEY	37
	6.1.2 DATA ANALYSIS	37
	6.1.3 GIS MAPPING	37
	6.2 CONCLUSION	38
	REFERENCES	38

LIST OF TABLES

TABLE NO.	TITLE	PAGE NO.
4.1	Electrical Resistivity details of the study area	14
4.2(a)	Groundwater level details at point 1	15
4.2(b)	Groundwater level details at point 2	16
4.2(c)	Groundwater level details at point 3	16
4.3	Rainfall Data of the study area	17
4.4	Groundwater Quality of the study area	18
4.5	Borehole Lithology of the study area	19
5.1(a)	MF and NMF details at first point of the study area	24
5.1(b)	MF and NMF details at second point of the study area	25
5.1(c)	MF and NMF details at third point of the study area	25
5.2	Calculated minimum and maximum grid cell values for assessing favourable potential zonation	36
5.3	Soil Test Results	37

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE NO.
4.1	General Methodology	11
4.2	GIS Mapping Methodology	12
4.3	VES Instrument	14
4.4	Soil Testing	22
5.1(a)	Resistivity Details at Point 1	23
5.1(b)	Resistivity Details at Point 2	23
5.1(c)	Resistivity Details at Point 3	24
5.2(a)	Groundwater Level at First Point	26
5.2(b)	Groundwater Level at Second Point	26
5.2(c)	Groundwater Level at Third Point	27
5.3	Rainfall Data of Study Area	27
5.4	Geology Map of the Study Area	30
5.5	Geomorphology Map of the Study Area	31
5.6	Lineament Map of the Study Area	32
5.7	Soil Map of the Study Area	33
5.8	Land use & Land cover of the Study Area	34
5.9	Slope Map of the Study Area	35
5.10	Groundwater potential Map of the Study Area	37

LIST OF SYMBOLS AND ABBREVIATIONS

GIS	-	Geographic Information Systems
VES	-	Vertical Electric resistivity Survey
LULC	-	Land use & Land cover
DEM	-	Digital Elevation Model
MF	-	Monsoon Fluctuation
NMF	-	Non Monsoon Fluctuation
SAR	-	Sodium Adsorption Ratio
TH	-	Total Hardness
SSP	-	Soluble Sodium Percentage
RSC	-	Residual Sodium Carbonate
EC	-	Electric Conductivity
CaCO ₃	-	Calcium Carbonate

CHAPTER 1

INTRODUCTION

1.1 GENERAL

Drought in India has resulted in tens of millions of deaths over the 18th, 19th, and 20th centuries. More agricultural villages in Pudukkottai dist, Tamilnadu has no rivers They depends on bore wells for their irrigation purpose. Now a days the bore wells are dead due to drought. Groundwater plays an important role all over the world for the survival of both flora and fauna. India is one of the largest users of groundwater, particularly for drinking and agriculture purposes Agriculture is one of the most important sectors of Indian economy. In rural areas, the major sources of groundwater for drinking and irrigation purpose are hand pump and tub well. Groundwater is the water present beneath Earth's surface in soil pore spaces and in the fractures of rock formations A unit of rock or an unconsolidated deposit is called an aquifer when it can yield a usable quantity of water. The depth at which soil pore spaces or fractures and voids in rock become completely saturated with water is called the water table. Groundwater is recharged from the surface; it may discharge from the surface naturally at springs and seeps, and can form oases or wetlands. Groundwater is also often withdrawn for agricultural, municipal, and industrial use by constructing and operating extraction wells.

CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL

Groundwater is the water found underground in the cracks and spaces in soil, sand and rock. It is stored in and moves slowly through geologic formations of soil, sand and rocks called aquifers. Groundwater supplies drinking water for the rural population. Groundwater helps grow our food. 64% of groundwater is used for irrigation to grow crops. Groundwater is an important component in many industrial processes. Groundwater is a source of recharge for lakes, rivers, and wetlands.

2.2 REVIEW OF LITERATURE

Srinivasa Rao & Jugran (2003) are studied on Delineation of groundwater potential zones and zones of groundwater quality suitable for domestic purposes using remote sensing and GIS using Survey of India (SOI) topographic was used to prepare base, contour, drainage and slope percent maps. Remotely sensed image data from IRS ID were visually interpreted for tone, texture, size, shape, relief, drainage pattern, vegetation association, and other factors. Field studies were conducted and corrections were made accordingly to maps of geology, lineaments, and hydromorphogeology. Well inventory, well yield, water table level, and groundwater samples were collected during field study. The groundwater samples were analysed for various ions and interpreted using standard methods. For groundwater potential, these weights ranged from 1 to 7. For groundwater quality and suitability of use, the weights ranged from 1 to 4. For groundwater potential, these weights ranged from 1 to 7. For groundwater quality and suitability of use, the weights ranged from 1 to 4.

Packialakshmi, Nagamani & Ambujam (2020) studied the Assessment of groundwater potential using geospatial techniques for urbanized Mambakkam mini-watershed, Kancheepuram district, India. . Data like water level, water quality, rainfall, climatology and geophysical resistivity from various sources and satellite imageries have been used for this study to observe the changes on the sources of water resource system. The Inverse Distance Weighted (IDW) method was used for generating the thematic layers of rainfall, depth to bed rock, weathered rock, jointed

rock and water levels. The generated village wise groundwater potential map has shown a vast spatial variability of ground water potential and the area that belongs to the “very good” potential category is quite less in the entire study area (12 %) which alarms the development of existing groundwater resource. The study concluded that considerable falling trend of groundwater level during pre-monsoon showing the alarming threat for further development. Thus the presented study identified the risk of groundwater development and provides guidelines to water resource managers and village officials to recommend conservation and protection strategies against the uncontrolled commercial development especially on the identified poor groundwater potential zones.

Anbazhagan & Jothibasu (2016) has studied Geoinformatics in groundwater potential mapping and sustainable development: a case study from southern India. The geomorphology and lineaments interpreted from IRS P6 LISS III satellite data were integrated with resistivity data for the generation of a sustainable groundwater potential map. Ranking and weight were assigned for all thematic layers based on their importance in controlling the occurrence of groundwater. The spatial integration was carried out using ArcGIS 9.3 software. The integrated map shows three different potential zones as highly favourable, moderately favourable and least favourable groundwater potential zones. The results obtained through the GIS spatial integration are validated with water level data.

Chaitanya Pande, Kanak Moharir, Sudhir Kumar Singh & Abhay Varade (2019) investigated the An integrated approach to delineate the groundwater potential zones in Devdari watershed area of Akola district, Maharashtra, Central India. The thematic layers of land use/land cover, groundwater depth, slope, drainage, flow direction, flow accumulation and geomorphology were prepared using IRS-LISS-III satellite data coupled with Shuttle Radar Topography Mission data on 23.50 and 30 m spatial resolution, respectively. The raster layers of these themes were estimated by employing ArcGIS software 10.3 and multi-influencing factor method and subsequently assigned with the relative weights as per their groundwater potential characteristics. For acknowledgement of the groundwater potential map, all the thematic layers and their respective weightage values were

subjected to weighted overlay analysis (WOA) method. The evolved map demonstrates six groundwater potential zones in the study area

Mahamat Ouchar Al-Djazouli, Karim Elmorabiti, Abdelmejid Rahimi, Omayma Amellah & Omer Abdelrahim Mohammed Fadil (2020) focused on combining GIS, RS, and analytical hierarchy process; in addition to the factors controlling the movement and retention of groundwater. Six factors (rainfall, slope, land use/land cover, drainage density, lineament density, and lithology) were used to integrate the spatial analysis of areas likely to hold groundwater. The results indicate that potential groundwater areas are unevenly distributed throughout the study area.

Renie Thomas , Vijayasekaran Duraisamy (2017) studied on investigating Hydrogeological delineation of groundwater vulnerability to droughts in semi-arid areas of western Ahmednagar district. . The current study involves a field hydrogeological mapping that was integrated with remote sensing and GIS to delineate areas. This technique was based on using different thematic layers viz. lithology, slope, landuse and land cover, lineament, drainage, soil type, depth to groundwater and annual rainfall. Additionally, pumping tests were carried out to classify the study area into different hydrogeological typologies to help delineate communities that are most vulnerable to subsurface heterogeneity. This paper attempts to underline the groundwater scarcity zones based on different influencing thematic layers and provide a robust methodology to prioritize areas vulnerable to groundwater unavailability, by categorizing the study area into different vulnerable class types – extreme, high, moderate and low.

Sultan Araffa, Mahmoud Mohamadin, Hassan Saleh Sabet & Mustafa Takey (2019) are investigated Geophysical interpretation for groundwater exploration around Hurghada area, Egypt. Here the RTP magnetic data were used to interpret of magnetic data, which was used to illustrate the depth of the basement rocks and subsurface structures. The geoelectrical survey is represented through measuring 24 VESes which were collected by using Schlumberger configuration of AB/2 ranged (from 1.5 to 300 m). The results of quantitative interpretation refer to the subsurface sequence consists of four geoelectrical units.

Meindinyo, Utuedeye and Adedokun (2017) studied on Vertical Electrical Sounding (Ves) For The Determination Of Under Ground Resistivity In Part Of Nigeria Wilberforce Island, Amassoma, Bayelsa State. Total of five Vertical Electrical Sounding (VES) were obtained using the Schlumberger electrode array configuration with maximum current electrode spacing of 400-500m. The data obtained was interpreted using computer assisted interpretation software (IPI2win) which showed that the area is composed of topsoil, clay, sand, clayey sand, sandy clay, medium coarse sand and fine coarse sand. Various geosounding curves were obtained at the various stations. The resistivity plot shows that stations in VES1, VES2, VES3, VES4 and VES5 have QQH, KH, QHA, KH and AA type of curves. Four geoelectric layers were identified in all VES station except that of VES1 and VES3 where five geoelectric layers were actually identified.

Soundarya, Logavarshan and Bhumika Dey (2018) have studied Evaluation of ground water quality in chennai city and its suitability for drinking use. The water samples were collected from seven site which is near to problematic areas. The test conducted for pH test, temperature, total solids, hardness, chlorine test and BOD. The average temperature, concentration of pH, turbidity, Total hardness, TDS, Chlorine and BOD are found to be 27.38 °C, 7.1, 2.5 NTU, 150 mg/l, 60 mg/l, 180 mg/l, and 0.2mg/l respectively. The results obtained were found to be within the permissible limit other than BOD which is subjected to treatment.

Monomoy Goswami studied about investigate Trend analysis of ground-water levels and rainfall to assess sustainability of groundwater in Kamrup Metropolitan District of Assam in Northeast India. In this study, seasonal and annual trends of ground water level and rainfall in the Kamrup region were analysed from monthly water-level data of 39 stations and concurrent rainfall data from January 2007 till June 2019 by using nonparametric Mann-Kendall test and Sen's Slope estimator. The trends indicate cause of concern, and provide scientific basis for strategizing ground water development and management for sustainable water-use in the region.

Subramanian, Prabhakaran, Kumar, Ganesan, Selvaraj and Babu (2012) are studied Groundwater quality investigation in Keeramangalam area, Alangudi taluk, Pudukkottai district. Twenty-one groundwater samples were collected from bore

wells and open wells during post monsoon (April 2008). The ground water samples have been analysed by various quality parameters such as pH, electrical conductivity (EC), Total dissolved solids (TDS). The water chemistry of various ions viz. Ca^{2+} , Mg^{2+} , Na^{+} , K^{+} , HCO_3^{-} , Cl^{-} , SO_4^{2-} , and PO_4^{3-} are carried out. The results were evaluated in detail and compared with (WHO, 1984). The chemical composition of the ground water is controlled by rock water interaction with sandstone, clay and Archaean to Proterozoic deposits. The chemical quality was evaluated for drinking use following the guidelines of WHO. Groundwater is potable except in some isolated pockets. It is inferred from Piper trilinear diagram suggest that the groundwater quality is characterized by mainly belongs to alkaline earth exceeding alkalies. As per USSSL classification of water quality mostly it falls under C3S1 category.

Subramani, Prabakaran and Karunanidhi (2015) are studied Groundwater prospecting in a part of Tamirabarani River basin, South India using Remote Sensing and GIS. FCC image of IRS 1D LISS III data and Survey of India toposheets have been used to prepare various thematic maps viz., topography, drainage, geology, geomorphology, lineament, slope, land use map of the study area. The regional slope of the terrain is towards northeast. Groundwater in the area is phreatic conditions in weathered horizons and in alluvial formations. A groundwater potential zonation map has been generated by assigning proper weightages and ranks to various parameters. Flood plains and lineament intersections are possessing high groundwater potential. Pediments, however, possess moderate to poor groundwater potential. The potential map has been verified by ground checks.

Kshitindra Singh, Geeta Tewari, and Suresh Kumar (2020) are studied Evaluation of Groundwater Quality for Suitability of Irrigation Purposes. A Case Study in the Udham Singh Nagar, Uttarakhand. A total of 50 groundwater samples have been collected and analysed for pH, EC, TH, HCO_3^{-} , CO_3^{2-} , Cl^{-} , SO_4^{2-} , NO_3^{-} , Ca^{2+} , Mg^{2+} , Na^{+} and K^{+} . To assess the groundwater quality for irrigation purpose, parameters like sodium adsorption ratio (SAR), soluble sodium percentage (SSP), residual sodium carbonate (RSC), magnesium hazards (MHs), permeability index (PI), and chloroalkaline index (CAI) values have been calculated. In USSSL diagram,

most of the groundwater samples fall in the C2S1 category and were safe for irrigation purpose. Only seven groundwater samples fall in the C3S1 category, indicating medium to high salinity which is safe for irrigation purpose for all types of soils but with limited care of exchangeable sodium. On the basis of RSC, all groundwater samples were observed to be suitable for irrigation purpose. Piper diagram indicated that 50% of the groundwater samples belonged to the Mg^{2+} - Ca^{2+} - HCO_3^- type and 48% was classified as the Ca^{2+} - Mg^{2+} - Cl^- type. Durov diagram suggested possibilities of ion mixing and simple dissolution of ions from polluted soil.

Molua Collins, Igherighe Edwin and Eseka Kenneth (2013) are studied about Analysis of electrical resistivity data for the determination of aquifer depth at Sapele RD in Benin city. The resistivity method of surveying was carried out for the study of underground aquifer at Sapele road in Benin-City, Edo State, Nigeria. Data were acquired using the ABEM Terrameter 300B using the Schlumberger array. Two locations were considered, and for each location, the vertical electrical sounding was used to obtain readings for resistance and the apparent resistivities. The results obtained showed that water bearing formation for the two survey areas

Sandeep Meshram and Sunil Khadse (2015) are studied about Application of Vertical Electrical Soundings (VES) for Delineating Sub Surface Lithology for Foundations. The present paper presents the results of the use of Vertical Electrical Sounding coupled with Hydrogeological studies of the Cauvery-Vaigai-Gundar (CVG) link canal area. On the basis of generalized Vertical Electrical Soundings (VES) log it is seen that the aquifers in tertiary rocks are deep – seated, the depth varying from 80 to 300 m from the ground level. It was observed that the open wells are tapping unconfined aquifer system is highly weathered rock, moderately weathered/ fractured hard rock and highly fractured hard rock. The bore wells are tapping the confined aquifer system 40 m Below Ground Level (BGL) in highly fractured hard rock. The aquifers in the bore wells were reported to be in between 40 to 120 m BGL. Most of the bore wells are dry at present due to depletion of aquifer owing to very little precipitation and over exploitation. From resistivity survey it is inferred that where ever highly fractured hard rock are expected along the link, abundant quantity of ground water may be present there in that fractured zones. The result of resistivity values of different rock types of the area show resistivity of less

than 20 ohm-m in the weathered soil, while highly fractured rocks show its range between 100 to 250 ohm-m, moderately fractured rocks shows range between 250 and 500 ohm-m and the massive crystalline rocks exhibit the range of more than 500 ohm-m. The water table shows periodical variations. During the excavation of the canal, the study of water table condition will give an idea about the chances of striking ground water to cut and cross drainage portions as ground water poses a serious hazard during the excavation works.

CHAPTER 3

AIM AND SCOPE

3.1 AIM

Severe drought conditions have affected ever increasing demand of water in Alangudi Taluk of Pudukkottai district. Decreasing rainfall trends together with increasing demand for groundwater irrigation of this agriculture-based area utters urgent need for sustainable groundwater resource development. Thus, prospecting of groundwater potential zones is essential for effective management of water resources in the study area.

3.2 OBJECTIVE

By conducting the detailed literature survey, the following objectives were formulated to conduct the experimental investigation for further studies

- To study the drought scenario in the selected study village
- To assess the status groundwater level fluctuations and their quality in the study area
- To map the groundwater potential zones by using weighted index overlay in GIS
- To conduct soil test and recommend specific cropping patterns and irrigation methods

CHAPTER 4

MATERIALS AND METHODS

4.1 METHODOLOGY

The methodology adopted in this study is discussed below in Figure 4.1 and it was adopted to achieve the objective of this study. Fig 4.2 indicated that method of GIS mapping.

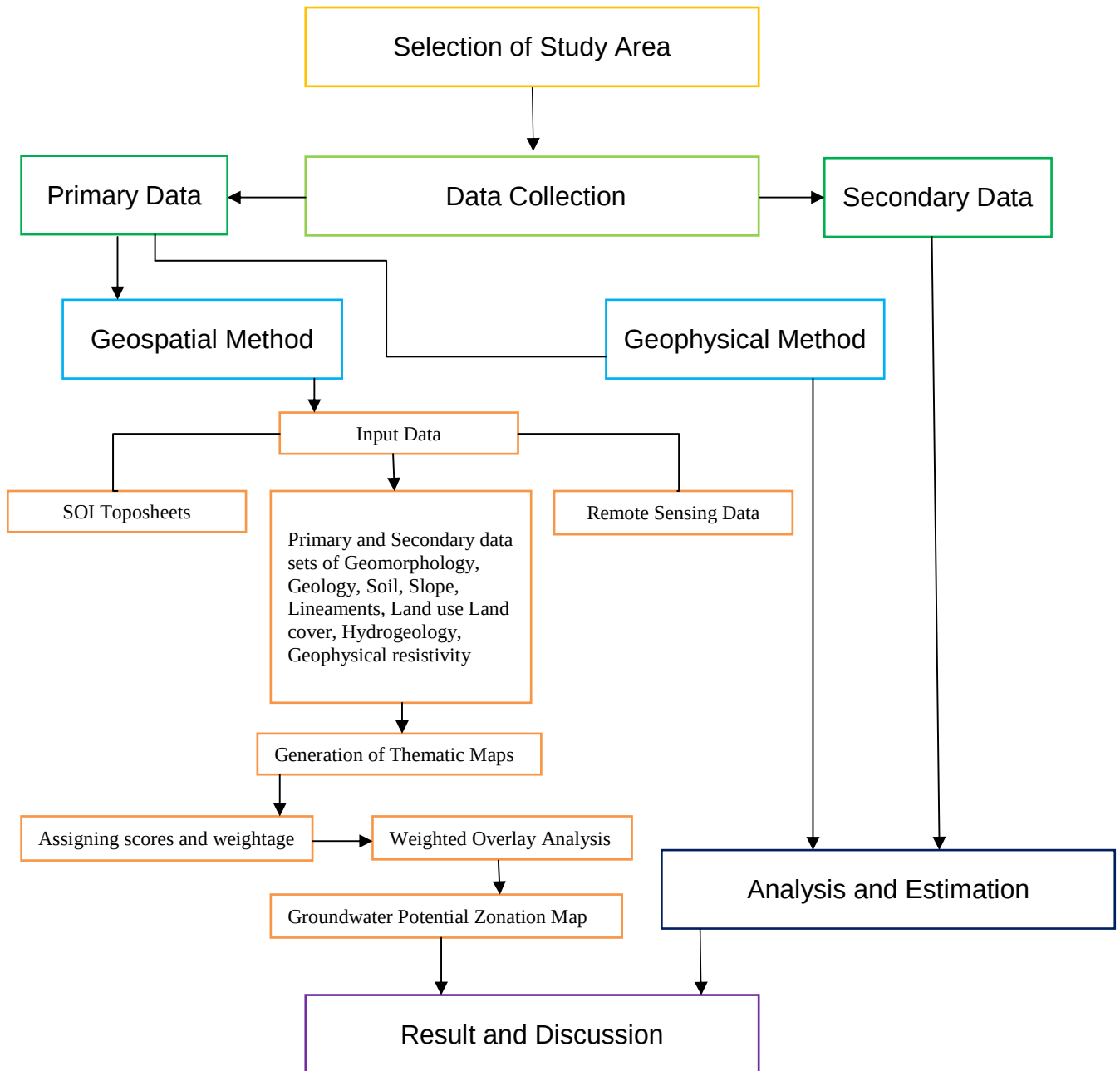


Fig 4.1 General Methodology

4.2 GEOPHYSICAL METHODS

4.2.1 General

Geophysical survey is necessary to ascertain subsurface geological and hydrogeological conditions and helps to delineate regional hydrogeological features, even pinpoint locations for drilling of boreholes. Geophysical data provides information on local geological environment such as type and extent of surface material, extent and degree of weathered mantle, the nature and extent of underlying bedrock, the structural elements etc. that influence ground water occurrence and movement. The important geophysical method involved in ground water exploration is Geo - Physical prospecting. Geophysical methods are used to identify seawater intrusion based on resistance values. Resistance values are indirectly proportional to the conductivity of groundwater. Usually, groundwater has higher resistance values. But in coastal areas, low resistance values are found, which indicates the presence of seawater. Here we tried to find out the nature of groundwater using the Vertical Electrical resistivity survey method.

4.2.2 VES Survey

Electrical Resistivity Survey is an attractive tool for delineating subsurface geology without soil disturbance. Reliable correlation between electrical resistivity values and other field geological parameters can help in successful interpretation of the engineering properties and behavior of soil in evaluation of difficult terrains e.g. for obtaining hard rock position, obtaining continuity of rock strata and for knowing the position of various sub – stratifications. This has led to develop and put in practice the geophysical method of subsurface investigation for a more precise, economical and fast assessment of large areas.

The use of geophysical instrumentation to study the method of electrical resistance is predicted in the flow of electric current and rock material below. to permit the passage of current through the bottom such a rock material should possess some sort of electric resistance, and be able by their nature to store charges. So some basic equations will necessarily relate these quantities. Once we apply a voltage V across the ends of a body of constant cross sectional area, the current I is proportional to the applied voltage (Ohm's law). So that

$$V = IR \text{ or } R = \frac{V}{I}$$

Where R is the proportionality constant called the resistance of the body.

We also know that for a given material, the distance is proportional to its length and inversely proportional to the cross sectional area of the body, so that

$$R = \frac{\rho L}{A} \text{ or } \rho = \frac{RA}{L} \text{ or } \rho = kR$$

Where ρ , is the resistivity of the material has unit Ohm-metre (Ωm) and k is Geo constant.

The vertical electrical sounding (VES) technique involves the utilization of electrical method, with depth control, during which electrode spacing is increased to get information from greater depths at a given surface location. It is used for detecting changes with depth within the resistivity of the world, beneath the given location. The principle of VES is predicated on the very fact that the broader the present electrode separation the deeper the present penetration.

$$\rho = \frac{\left(\frac{AB}{2}\right) - \left(\frac{MN}{2}\right)}{MN}$$

Where MN = distance between potential electrodes,

AB is the distance between current electrodes. Using these methods Electrical Resistivity details were founded. Table 4.1 indicated the details of Electrical Resistivity of the study area.

Table 4.1 Electrical Resistivity details of the study area

S. No	Point 1		Point 2		Point 3	
	Thickness (m)	Resistivity (Ohm-m)	Thickness (m)	Resistivity (Ohm-m)	Thickness (m)	Resistivity (Ohm-m)
1	0.8	37	0.5	42	1	876
2	4.7	9	6.6	7.3	5	282
3	17.5	19	27.4	20.3	29	33
4	62.4	8.6	73.6	9.6	97	41

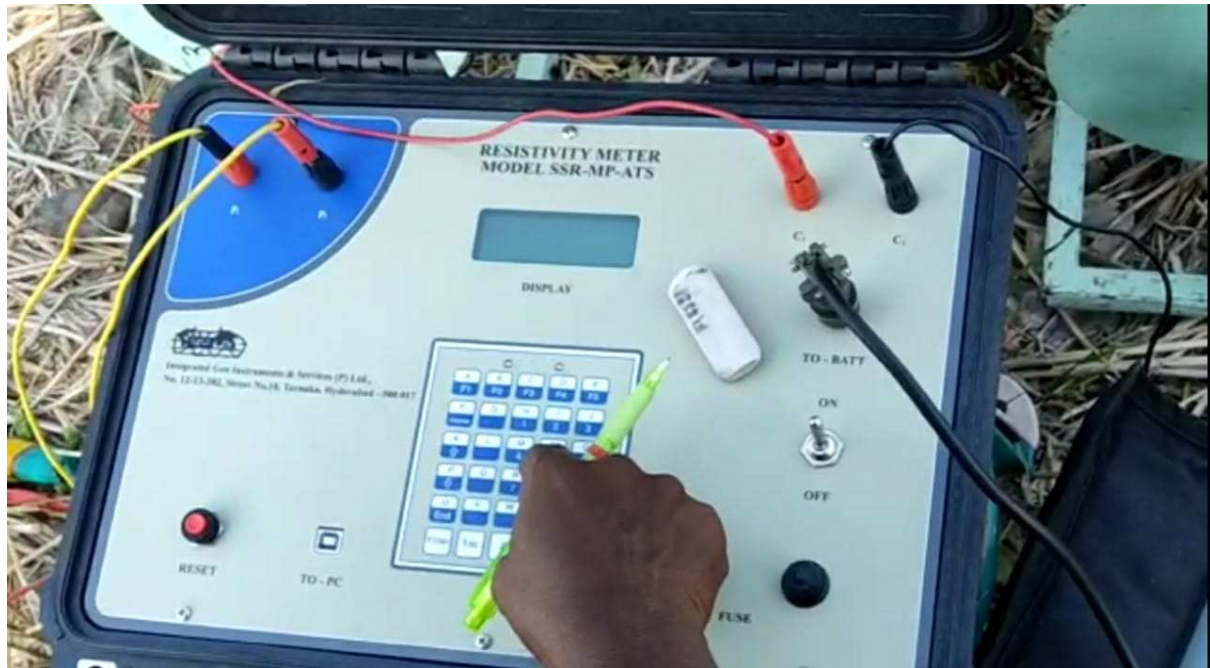


Fig 4.3 VES Instrument

4.3 GEOSPATIAL METHODS

4.3.1 Data Collection

Information such as groundwater level, groundwater quality, borehole lithology, soil data, rainfall data and land use data were obtained from secondary data at the State Ground and Surface Water Data Center. Further information was also obtained from the Central Groundwater Board. Some results were obtained by analyzing this information.

4.3.1.1 Groundwater Level

Although most agricultural activities are based on rivers and lakes, agriculture is dependent on groundwater in drought prone or waterlogged areas. It is very important to take into account the Ground water level when looking for ground water potential for agriculture. Where groundwater level is high, groundwater potential is high. Where groundwater levels are low, groundwater potential is also low. Places high. Where groundwater levels are low, groundwater potential is also low. Places with high groundwater levels are generally greener and better places for people to

live. They are also home to animals, birds and all other living things. Therefore the Groundwater level is taken as an important factor in this study and its levels are studied. These details are shown in Table 4.2(a),(b)&(c).

Table 4.2(a) Groundwater level details at point 1 of the particular study area

S.No	Year	Month	Water Level (m)
1	2012	January	2.79
2		May	6.31
3	2013	January	6.75
4		May	7.15
5	2014	January	5.22
6		May	5.82
7	2015	January	5.38
8		May	4.73
9	2016	January	3.22
10		May	4.14
11	2017	January	4.1
12		May	6.22
13	2018	January	6.05
14		May	5.71
15	2019	January	3.1
16		May	6.1
17	2020	January	6.7
18		May	7.62

Table 4.2(b) Groundwater level details at point 2 of the particular study area

S.No	Year	Month	Water Level (m)
1	2019	June	7.08
2		December	1.12
3	2020	January	4
4		May	5.25
5		June	4.05
6		December	6.6

Table 4.2(c) Groundwater level details at point 3 of the particular study area

S.No	Year	Month	Water level (m)
1	2019	June	6.27
2		December	2.4
3	2020	January	1.68
4		May	3.16
5		June	3.25
6		December	3.9

4.3.1.2 Rainfall Data

Precipitation, especially rain, features a dramatic effect on agriculture. All plants need a minimum of some water to survive, therefore rain (being the foremost effective means of watering) is vital to agriculture. While a daily rain pattern is typically vital to healthy plants, an excessive amount of or insufficient rainfall are often harmful, even devastating to crops. Drought kills crops and increase itching, high humidity weather causes harmful fungal growth. Plants need varying amounts of rainfall to survive. For instance, certain cacti require small amounts of water, while tropical plants may have up to many inches of rain per annum to survive. During the wet and dry seasons, soil nutrients decrease during the wet season and increase erosion. Animals have adaptation and survival strategies to the wet regime. The previous dry season led to food shortages during the wet season, because the crops have not yet matured. Developing countries have noted that their populations show seasonal weight fluctuations thanks to food shortages seen before the primary harvest, which occurs late within the wet season. Rain can be harvested by using rainwater tanks; Treated for potable use or indoors or for irrigation, excessive rain in the short term can cause flash flooding. Table 4.3 represents the Rainfall Data for a particular study area derived from State Ground and Surface Water Resources Data Centre.

Table 4.3 Rainfall data of the particular study area

Year	2006	2007	2008	2009	2010	2011	2012
RF(mm)	1037	709.5	1124.1	1007.7	1162.4	1121.6	728.7

Year	2013	2014	2015	2016	2017	2018	2019	2020
RF(mm)	591	945.6	1308.2	532.3	883.3	860.8	994.7	1002.3

4.3.1.3 Ground Water Quality

Water may be a solvent and dissolves minerals from the rocks with which it comes in touch. Spring water may contain dissolved minerals and gases. The foremost common dissolved mineral substances are sodium, calcium, magnesium, potassium, chloride, bicarbonate, and sulphate. In hydrochemistry, these materials are called common components. The assessment of water quality is one among the important tools for sustainable development and provides decisive information for water management. Knowing the availability of water for irrigation requires knowledge in both quantity and quality. Table 4.4 represents the Groundwater quality for a particular study area derived from State Ground and Surface Water Resources Data Centre.

Table 4.4 Groundwater Quality details of the study area

S. No	Chemical Components Present in Ground Water	Post Monsoon				Pre Monsoon			
		Point 1		Point 2		Point 1		Point 2	
		Jan 2018	Jan 2019	Jan 2018	Jan 2019	July 2018	July 2019	July 2018	July 2019
1	TDS	319	471	512	1593	451	709	9560	1819
2	Ca	28	30	18	20	28	28	136	84
3	Mg	32.805	42.525	14.58	77.76	18.22	29.16	257.58	42.525

4	Na	26	85	124	465	89	173	2997	554
5	K	27	0.1	20	15	36	23	66	9
6	CO ₃	2.3915	0.586	0	0	2.27	18	0	12
7	HCO ₃	127.51	124.39	152.5	530.7	152.64	189.1	213.5	250.1
8	pH	8.3	7.7	8.1	7.8	8.2	8.5	7.9	8.4
9	TH	205	250	105	370	145	190	1400	385
10	SAR	0.7902	2.3392	5.2662	10.52	3.22	5.46	38.85	12.28
11	RSC	-1.96	-2.9	0.38	1.2	-0.34	-0.1	-24	-3.24
12	SSP	46.57	53.99	81.55	83.08	73.00	77.42	88.61	81.65

4.3.1.4 Borehole Lithology

Borehole geophysics is that the science of recording and analyzing measurements of physical properties made in wells or test holes. Borehole geophysics is employed in groundwater and environmental investigations to get information on well construction, rock lithology and fractures, permeability and porosity and water quality. The geophysical sound system consists of probes, cable and maps, power and processing modules, and data recording units. Highly invasive geological systems could also be ideal watersheds. Water moves through an aquifer from the recharging areas to the discharge areas. Groundwater recharge occurs from infiltration into the soil or from runoff from rock bottom of surface water bodies like lakes and streams.

Table 4.5 Borehole lithology of the study area

Point	Depth	Lithology
1	3-4	Laterite
2	12-6	Sandstone

4.4 GIS MAPPING

4.4.1 General

Elements of soil, geography, geology, lines, water level and aquatic nature are essential for the aquifer and thematic maps were created for the study area. The generated thematic maps were analyzed to identify favorable potential zones in the Earth's environment.

4.4.2 Geology Map

Ground water holding capacity of rocks depends on compactness of the rocks. Compactness successively depends on the presence of pore spaces within the permeability and rocks (porosity). The map was obtained from Geological survey of India. The water -bearing properties vary from one rock type to a different rock type. These influences both the permeability of aquifer rocks and the distribution of fracture pattern.

4.4.3 Geomorphology

Geomorphological maps portray important geomorphic units, landforms and underlying and aid understanding of the processes, materials/ lithology, structures, and geological controls regarding groundwater occurrence, also on groundwater potentials. It will be considered as surface indicators for identification of subsurface conditions. A scientific study of those maps is useful for choosing groundwater potential zones and artificial recharge sites. This information provides a reliable base for effective planning, development, and management of groundwater resources of a region. The distribution and extent of those geomorphological features are highly variable in accordance with the lithological variation. This map is obtained by using the Geological survey of India.

4.4.4 Lineament

Lineaments represent zones of faulting and fracturing leading to increased permeability. They are hydro-geologically important since they act as pathways for groundwater movement. Lineament density of a region can directly reveal the groundwater potential since the presence of lineaments usually denotes permeable zone. Lineament map is obtained from the Geological survey of India.

4.4.5 Soil

Soils are derived from rocks because of weathering. Soil characteristics have a substantial role on the infiltration of water. This map is generated from the Geological survey of India website. The speed of infiltration largely depends on grain size of soil.

4.4.6 Land use Land cover

Land use refers to man's activities in land, various uses which are distributed on land, etc. Land cover denotes the water bodies, rocks, natural vegetation, etc that resulted because of land transformation. LULC affects evapotranspiration volume, timing, and recharge of groundwater system. It is observed that spatial variation within the amount of groundwater storage occurs because of changes in land use and vegetation cover, so proper understanding of LULC is important to estimate the water resources, and it has therefore been included during this study. This map is obtained from decadal land use and land cover classifications across India.

4.4.7 Slope

Slope is one of the major factors that directly control the recharge rate. Generally, slope and infiltration rate have an inverse relation. Flat surface areas with gentle slope are favourable for recharge as it holds the water for a long time, whereas relatively steep slope decreases the infiltration rate by increasing the runoff. The gradient of slope varies throughout the region due to the undulating terrain. This map is generated by using Digital Elevation Model (DEM) from Bhuvan website.

4.4.8 Groundwater Potential

The ground potential map has been prepared by integrating the thematic information on geomorphology, lineament, soil and land use land cover by giving appropriate weightages. The layers of geomorphology, lineament and land use land cover themes were interpreted from the satellite data and were digitized in the vector format. For the lineaments, buffer zones were created with a 10 m width, which is optimum for the influence and occurrence of groundwater. The scores for different classes of identified map layers were considered for calculating the weightages. In

the layer of , the classes of fluvial deposits are considered as low potential structures to groundwater due their physical properties of compact nature and being primarily hard when compared to Cuddalore formation. Likewise, all the thematic layers were given a relative weightage by considering the classes of relevant hydrogeological formations that represented its range of potential and storage of groundwater. The Nominal Group Technique was employed to allocate the weightages and scores for the related thematic layers and the sub-classes were selected accordingly. In that technique, ranking of targeted themes were performed as per the expert opinion and the outputs of similar studies. Each grid cell attained a value through an additive overlay technique which generated the raster formatted output layer. Greater value of the grid cell, is considered as the most preferred cell, which is located in the favourable groundwater potential zone. This has been assessed by considering possible maximum and minimum grid values calculated and are given in Table 5.2. The major groundwater storing and controlling features such as intersection of lineament, slope, geomorphology, land use, and are significant to groundwater occurrences and movement in the study area. The process of interpretation under GIS environ, helps in developing the groundwater potential zonation map. The potential zonation map clearly confirms the groundwater potential areas of the Alangudi Taluk.

4.5 SOIL TESTING

Soil properties were examined to recommend suitable crop varieties for farmers. For this purpose 15 soil samples were widely collected in that particular study area with the help of Agriculture Department officials. They were then submitted for analysis at the Government Soil Testing Center at Kudumiyamalai in Pudukkottai district. Their results are given in Table 4.6.



Fig 4.4 Soil Testing

CHAPTER 5

RESULTS AND DISCUSSION

5.1 GEOPHYSICAL METHOD

The use of the electrical resistivity method as a geophysical tool for exploration is based on the flow of electric current through the ground, and rock material. To allow the passage of current through the ground such a rock material should possess some form of electrical resistance, and be able by their nature to store charges.

5.1.1 VES Survey

The electrical resistivity method as a tool for geophysical exploration, is based on the fact that the underlying rock materials can impose resistance to the flow of current and as such ohm's law could be applied to them if the earth is homogenous, the resistivity measured is called true resistivity otherwise, the term apparent resistivity is used and this is a weighted average of the resistivities of the various formation.

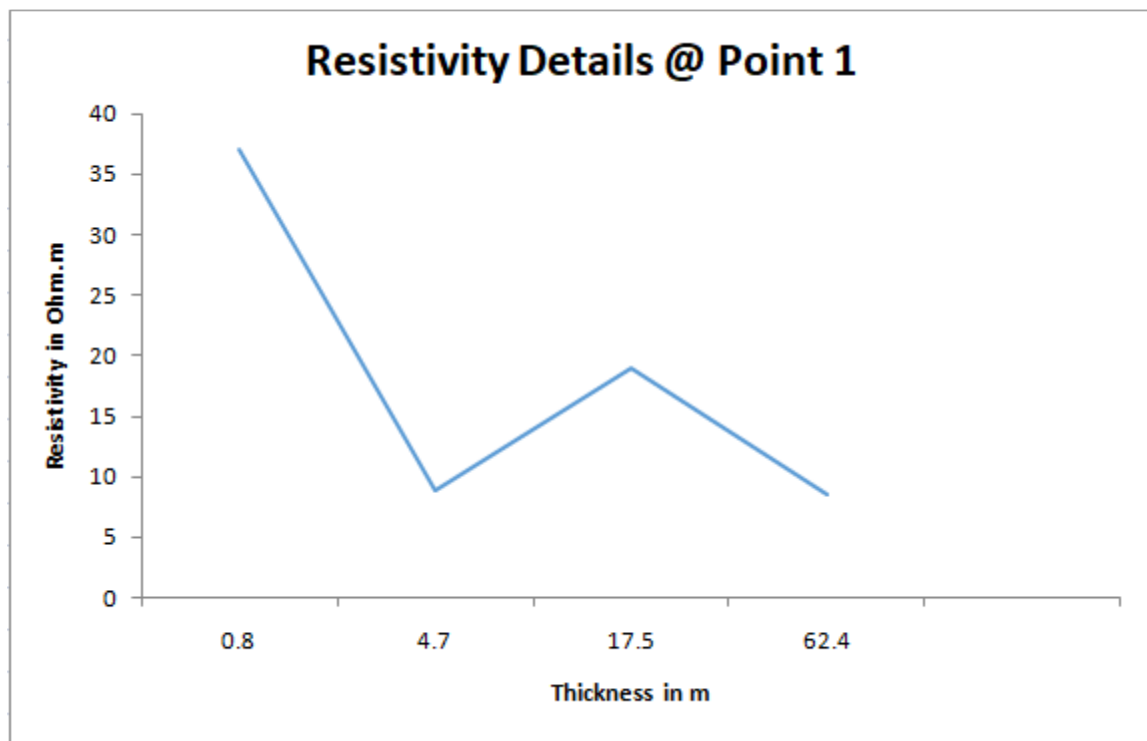


Fig 5.1(a) Resistivity details at point 1 of the study area

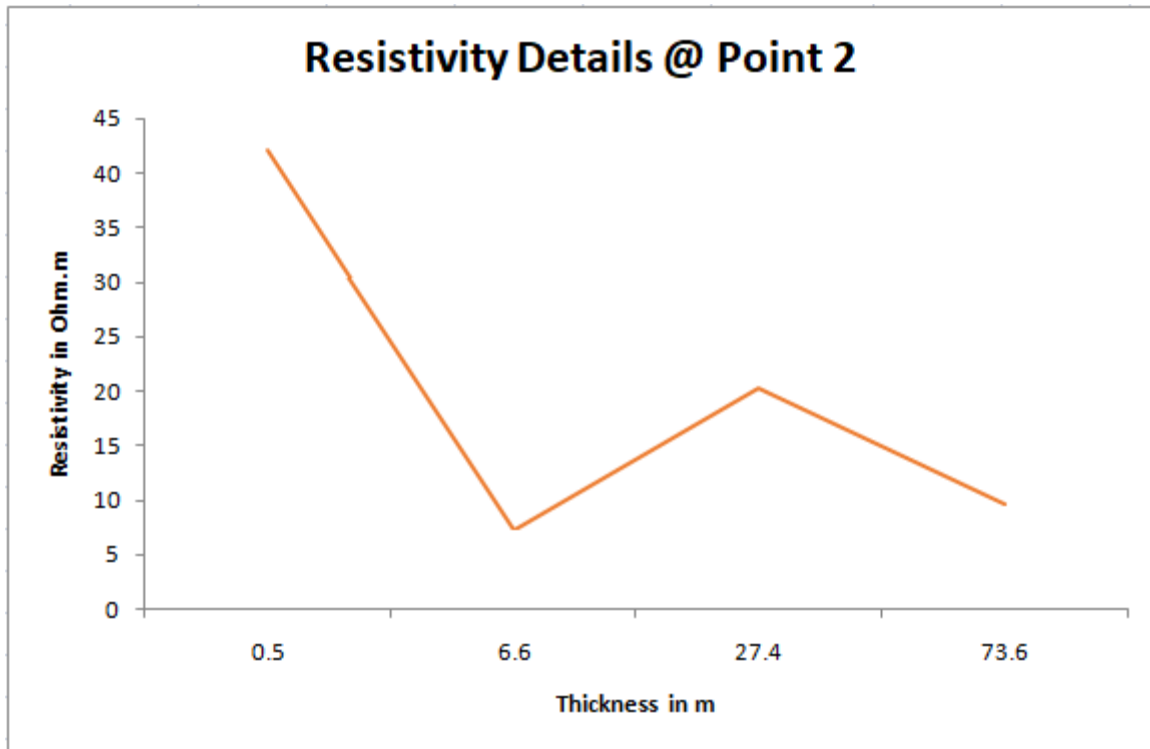


Fig 5.1(b) Resistivity details at point 2 of the study area

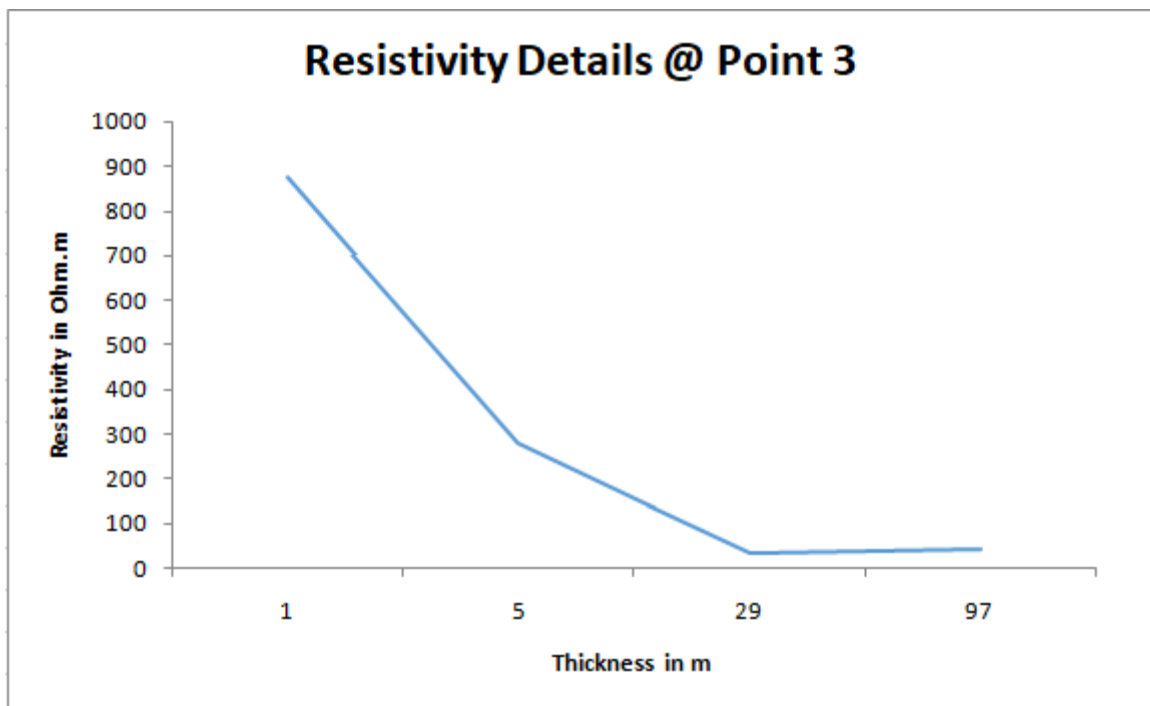


Fig 5.1(c) Resistivity details at point 3 of the study area

At the first point the resistivity level is high at first and then the wealth can be seen to decrease as you go down. The same is true of point 2 & 3(Fig 5.1(a),(b)&(c)) . Therefore at this particular study area the resistivity at the top is high and the resistivity is low at the bottom. From this it can be seen that the water at the top is

good and the salinity of the water increases as it goes down. The use of salt water for agriculture can lead to more problems. So in this particular study area, it is better to avoid taking water from greater depths and using it for agriculture.

5.2 GEOSPATIAL METHODS

5.2.1 Groundwater Level

Groundwater level data were collected from the State Ground and Surface Water Resources Data Center for the specified study area from 2012 to 2020 (Table 5.1). Looking at the map in Fig. 5.2, we can see that GWL is slightly different from 2012 to 2020.

Table 5.1(a) MF and NMF details at the first point of the study area

S.No	Water Level From Surface			MF	NMF
1	May 12	Jan 13	May 13	- 0.44	- 0.4
	6.31	6.75	7.15		
2	May 13	Jan 14	May 14	1.93	- 0.6
	7.15	5.22	5.82		
3	May 14	Jan 15	May 15	0.44	0.65
	5.82	5.38	4.73		
4	May 15	Jan 16	May 16	1.51	- 0.92
	4.73	3.22	4.14		
5	May 16	Jan 17	May 17	0.04	- 2.12
	4.14	4.1	6.22		
6	May 17	Jan 18	May 18	0.17	0.34
	6.22	6.05	5.71		
7	May 18	Jan 19	May 19	2.61	- 3
	5.71	3.1	6.1		
8	May 19	Jan 20	May 20	- 0.6	- 0.92
	6.1	6.7	7.62		

Table 5.1(b) Groundwater level at the second point of the study area

June 19	Jan 20	June 20	MF	NMF
7.08	4	4.05	3.08	- 0.05

Table 5.1(c) Groundwater level at the third point of the study area

June 19	Jan 20	June 20	MF	NMF
6.27	1.68	3.25	4.59	- 1.5

With the MF and NMF for those groundwater levels, the groundwater level in that particular study area is at an average level that decreases in a few years and increases in a few years (Figure 5.2). Thus it is better to use less ground water in that area.

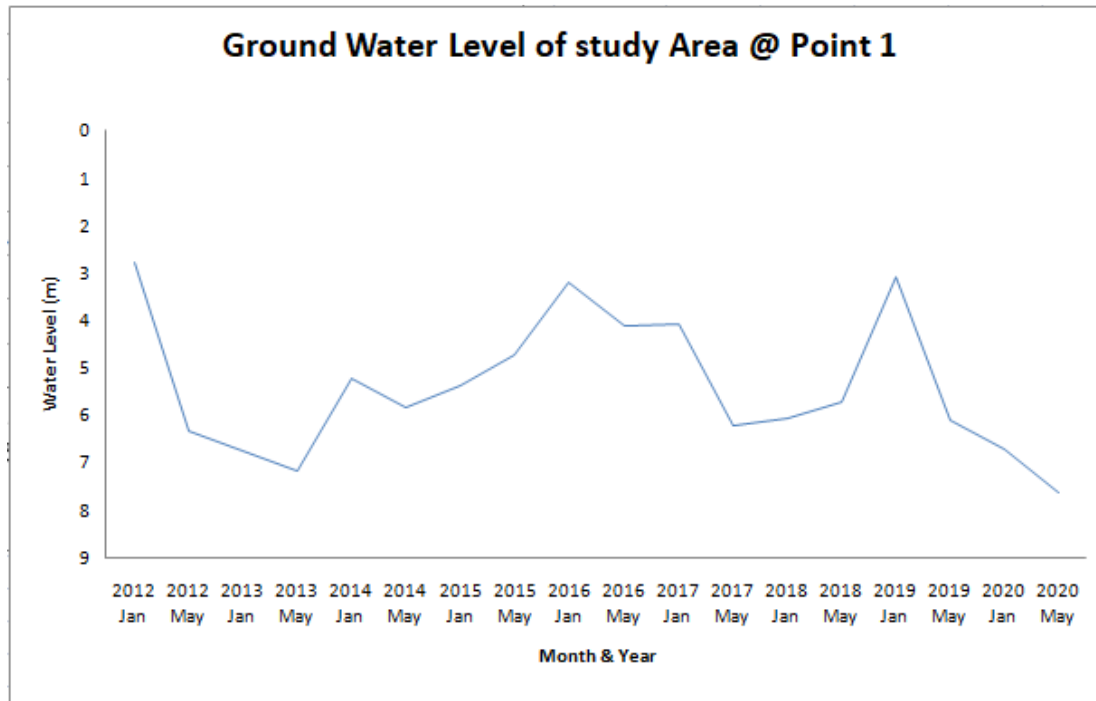


Fig 5.2(a) Groundwater level at the first point of the study area

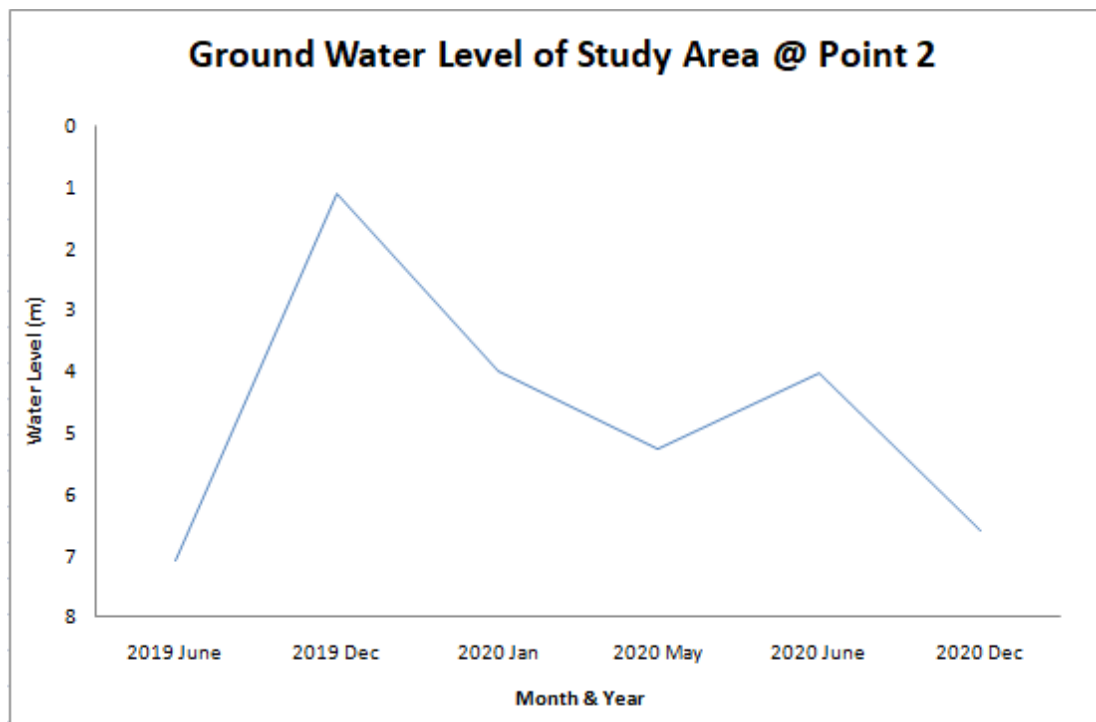


Fig 5.2(b) Groundwater level at the second point of the study area

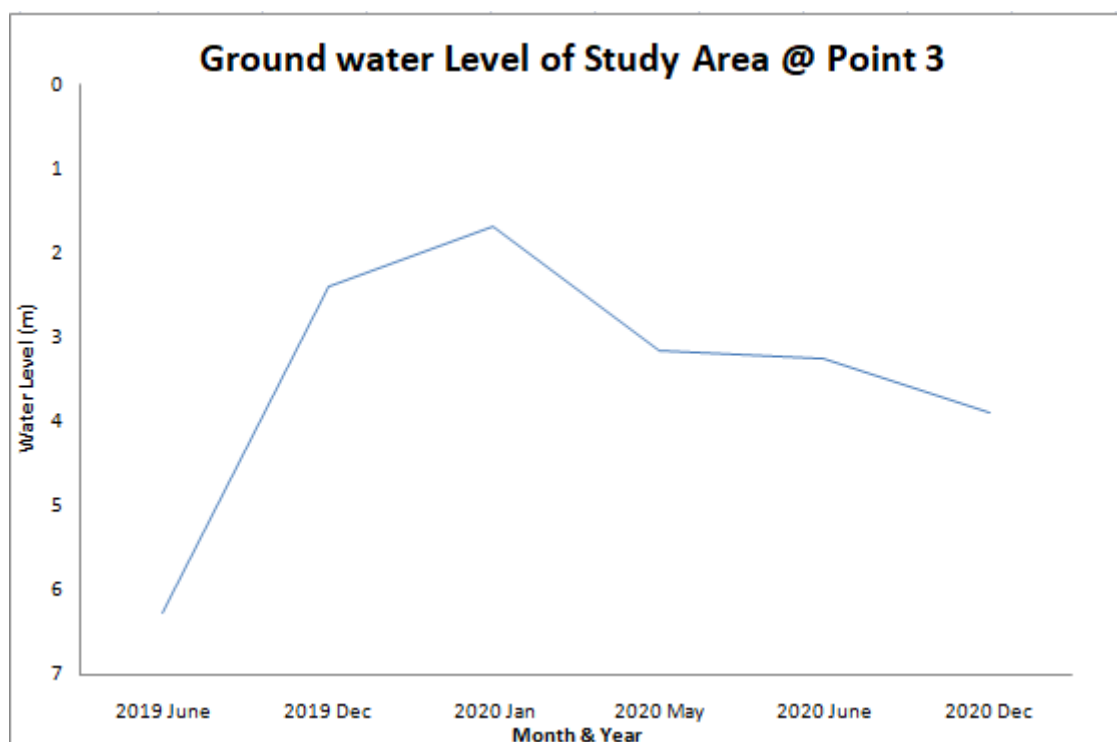


Fig 5.2(c) Groundwater level at the third point of the study area

5.2.2 Rainfall Data

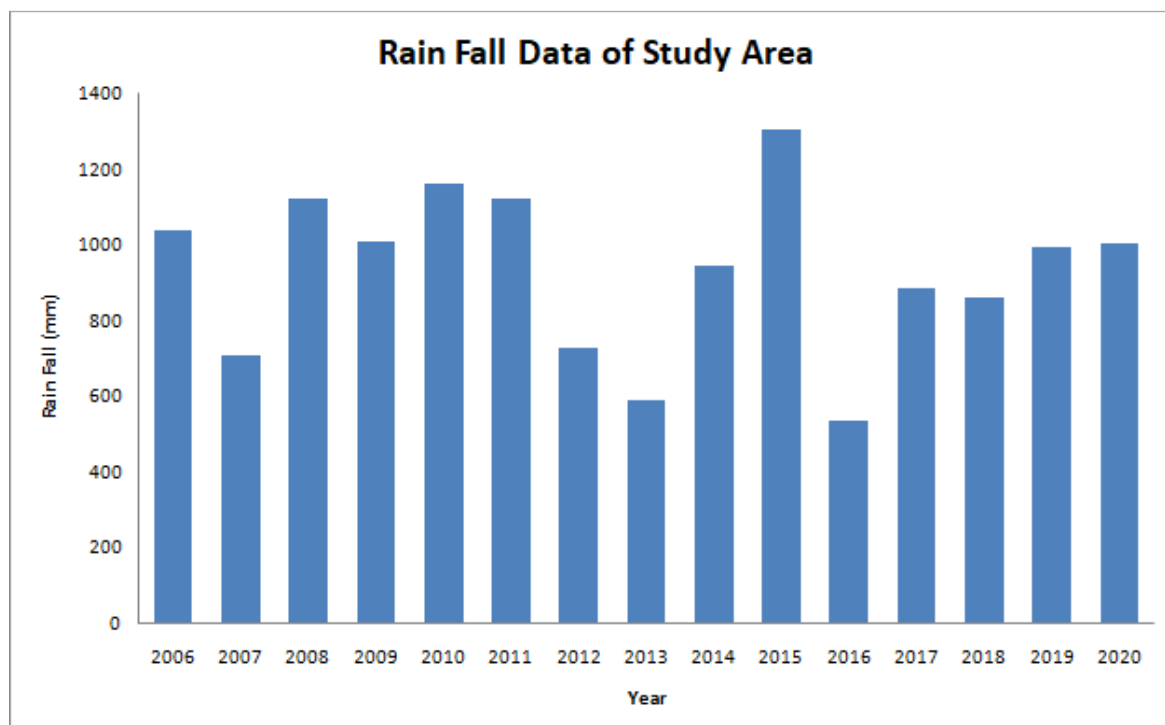


Fig 5.3 Rainfall Data of the study area

Rainfall data were collected from the State Ground and Surface Water Resources Data Center from 2006 to 2020 for the specific study area. They vary from 591 mm to 1308.2 mm. Their average rainfall is 993.95 mm. So what we know from this is that there will be enough rain here during the rainy season (Figure 5.3). Therefore the use of ground water jab will not have a large impact in this area

5.2.3 Ground Water Quality

5.2.3.1 pH :

The term pH expressed to describe the intensity of acidic and alkaline nature of a solution. The pH value of the groundwater samples in the study area lie in between 7.7 and 8.5. All the groundwater samples belonged to the safe limit for irrigation purpose.

5.2.3.2 Total Hardness (TH)

In water quality, TH is an important parameter whether it has been used for domestic, irrigation, and industrial purpose. The presence of alkaline Earth metals causes hardness of water which prevents the lather with soap and increases the boiling point. Amount of calcium and magnesium ions in some of the collected samples was high. When calcium reacts with water, either CaCO_3 is formed in the form of limestone and chalk, or CaSO_4 is formed. The major source of Mg in groundwater is dolomite, $\text{CaMg}(\text{CO}_3)_2$. Water can be categorized as soft ($<75 \text{ mg L}^{-1}$), moderately hard ($75 \text{ to } 150 \text{ mg L}^{-1}$), hard ($150 \text{ to } 300 \text{ mg L}^{-1}$), and very hard (above 300 mg L^{-1}). In the present study, Total Hardness varied from 105 to 385 mg L^{-1} , indicating hard to very hard nature of water.

5.2.3.3 Sodium Adsorption Ratio (SAR)

The alkali or sodium hazard can be expressed in terms of sodium adsorption ratio. Sodium hazard is the main parameter for assessment of groundwater suitability for irrigation purpose. Sodium enriched groundwater is unsuitable for irrigation of agricultural lands. Excess sodium in water produces undesirable effect of changing soil permeability and water infiltration due to breakdown in the physical structure of the soil. The SAR values ranging from 0 to 10 were measured as excellent, 10–18 were measured as good, and values greater than 18 were measured as unsuitable

for irrigation purpose. More SAR value in this study is 0-10. So the water in this study area is very suitable for irrigation purpose.

5.2.3.4 Soluble Sodium Percentage (SSP)

The percentage of soluble sodium is an important parameter in classifying irrigation water in terms of soil permeability. Sodium ion present in irrigation water tends to be exchanged by Mg^{2+} and Ca^{2+} ions present in clay particles. This exchange process reduces the permeability of soil and causes poor internal drainage and hardening of soil, which further adversely affects the soil quality and seedling emergence. Additionally, high levels of sodium encourage combination of sodium with chloride and carbonates generating salinity and alkalinity in soils. Excessive soil salinity and alkalinity are harmful for plant growth and crop productivity. We classified the irrigation water quality into 5 categories (excellent, good, permissible, doubtful, and unsuitable). In the present study, the soluble sodium percentage varied from 46.57 to 88.61%, which suggested that all the groundwater samples had Permissible to doubtful quality for irrigation purpose.

5.2.3.5 Residual Sodium Carbonate (RSC)

The quantity of carbonate and bicarbonate surplus to that of alkaline Earth metal ions (Ca^{2+} and Mg^{2+}) also influences the suitability of groundwater for irrigation purpose. This surplus amount of carbonate and bicarbonate is called residual sodium carbonate (RSC). Higher RSC values indicate that much of the calcium and some magnesium ions get precipitated from the solution, and thus, the percentage of sodium increases in water and soil particles, which in turn increases the potential for sodium hazard. The RSC values of the collected water samples varied in between -24 and 1.2 meq L^{-1} . Based on the RSC values, all samples were found to be safe for agriculture purpose.

5.3 GIS MAPPING

5.3.1 Geology Map

Geological formations play a crucial role within the occurrences of groundwater over a region. Lithological materials actively control the porosity and permeability. Major portion of the study area is under the influence of Cuddalore formation, which

consists of sands, white clays, sandy clays and unconsolidated sandstones mottled in colour with lignite seams. The Cuddalore formations are confined by an impervious clay bed which gives rise to several flowing artesian wells. These tertiary formations are overlain by alluvium.

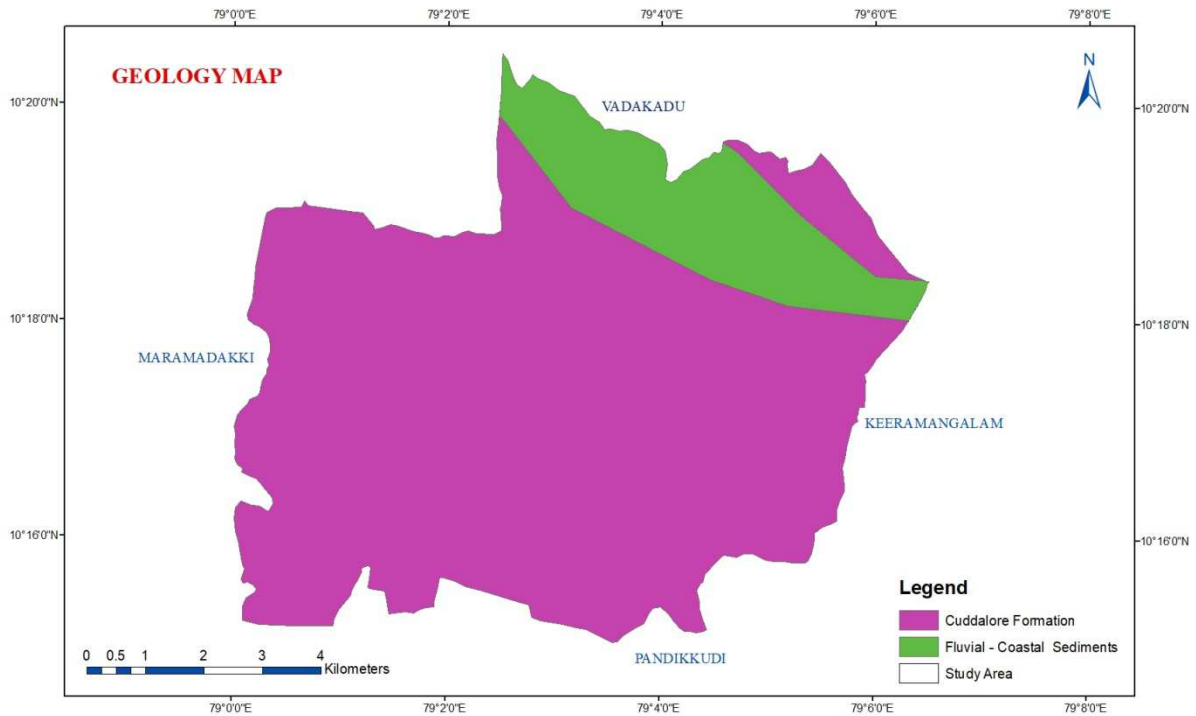


Fig 5.4 Geology map of the study area

The thickness of the sand formation ranges between 6m to 12m. This alluvial formation also acts as potential aquifers. Fluvial deposits are relatively alluvium, consisting of clayey fine to coarse gravel, silty or gravelly fine to coarse sand and silty sandy. Moderate to high or high productivity with intergranular flow and good quality and quantity status within the Upper Spey bedrock and localised sand and gravel aquifers. Groundwater within alluvial deposits would also be expected to be hydraulically connected to surface waters. Higher weights have been assigned to Cuddalore formation due to their potentiality to augment recharge, whereas lower weight has been assigned to Fluvial deposits formation due to their lower potential than Cuddalore formation to recharge.

5.3.2 Geomorphology Map

The study area composed of Active floodplain, Pediment Pedi plain and Water bodies. Pediment- Pedi plain comprises gently undulating plains covered with

weathered material that are favorable for groundwater recharge. It mainly comprises of hard rocks which act as runoff zone, hence characterized as moderate. Active flood plain has higher water level surface, and hence it is the best landform for high groundwater potential. Active flood plain is extremely suitable to groundwater recharge because of its unconsolidated nature, whereas it is relatively low just in case of weathered plain. Higher weights have been assigned to active flood plain, whereas lower weights assigned to Pediment Pedi plain because Groundwater recharge capacity of the Pediment Pedi plain is comparatively low.

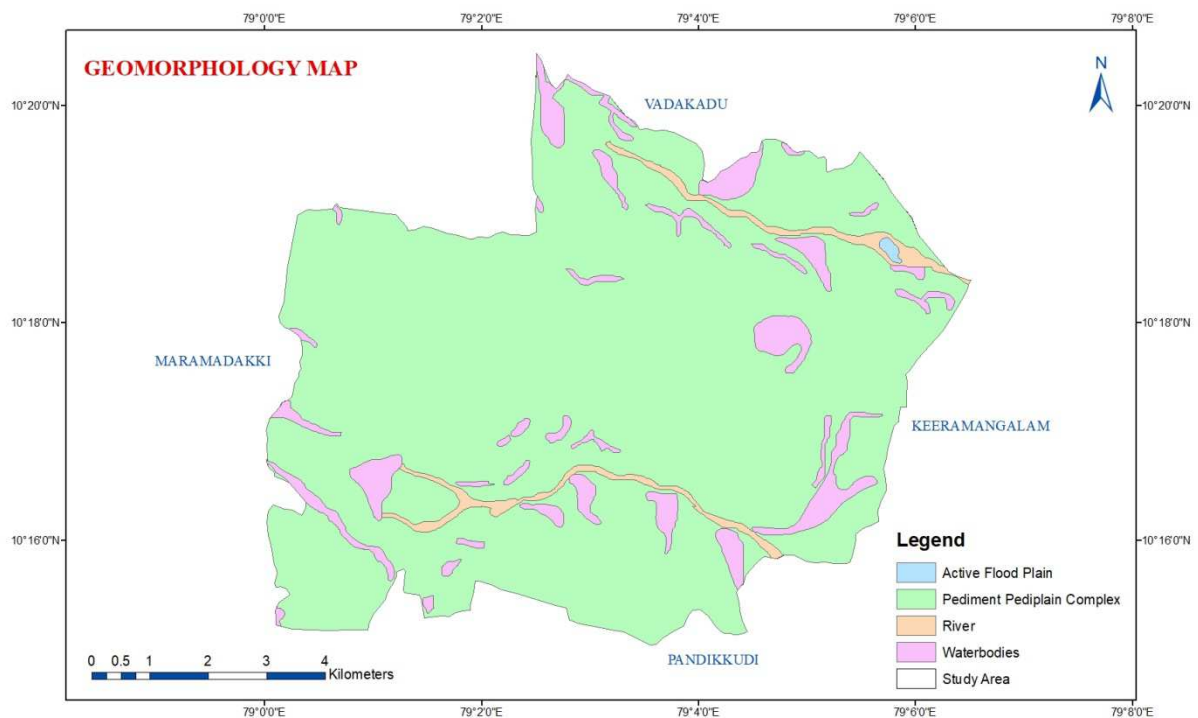


Fig 5.5 Geomorphology map of the study area

5.3.3 Lineament Map

A lineament is a linear feature in a very landscape that is an expression of an underlying geological structure like a joint, fault, or fracture. Lineaments are generally observed within the analysis of remote sensing of fractures or structures. It is well known that streaming potential is generated when groundwater flows in a permeable subsurface lineament due to a hydraulic pressure gradient. Although lineaments have been identified throughout the area, it is the lineaments in the Pedi plain or Active Flood plain which is considered significant from groundwater occurrence point of view. Presence of lineaments may act as a conduit for

groundwater movement which ends up in increased secondary porosity and thus, can function as groundwater potential zone.

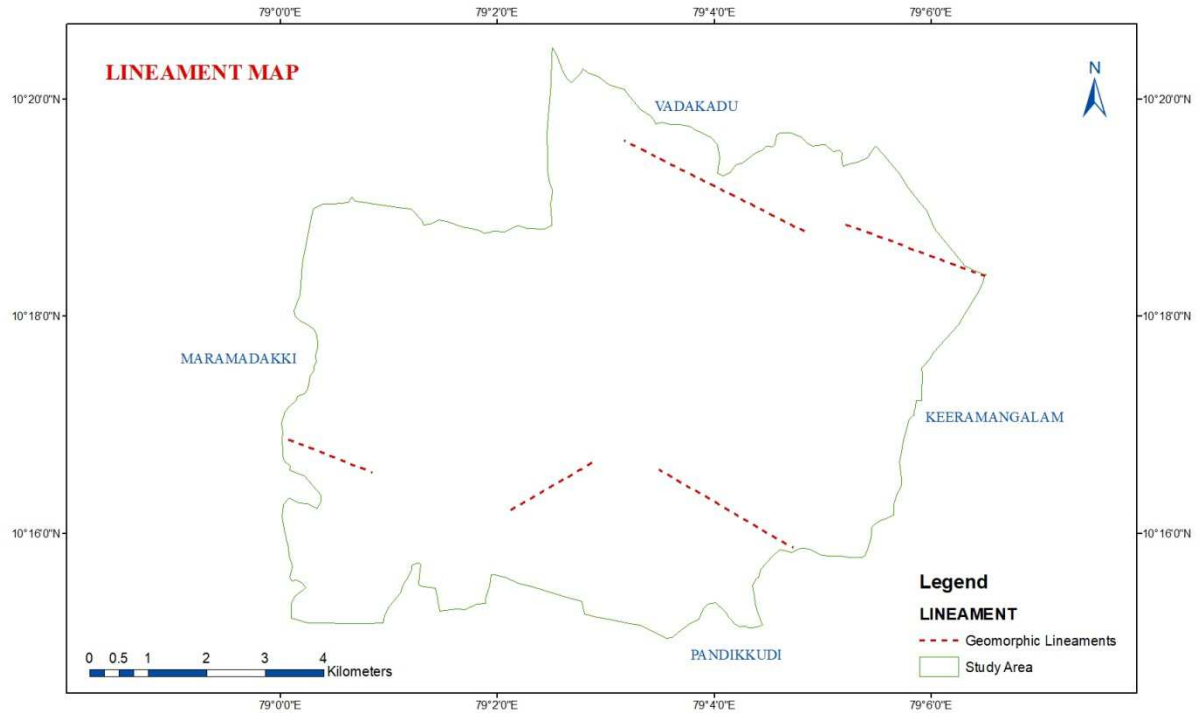


Fig 5.6 Lineament map of the study area

5.3.4 Soil Map

Soil is a very important factor for delineating the groundwater potential zones. Thematic layer map of soil type reveals that the study area is largely covered by the Alluvium soil. Alluvium is usually made from a spread of materials, including bigger particles of sand and gravel and fine particles of silt and clay. When this loose alluvial material is deposited prospects, while the open scrub has poor groundwater potential. Residential areas are covered with more impervious concrete surfaces and more will be the runoff and less water recharge will take place.

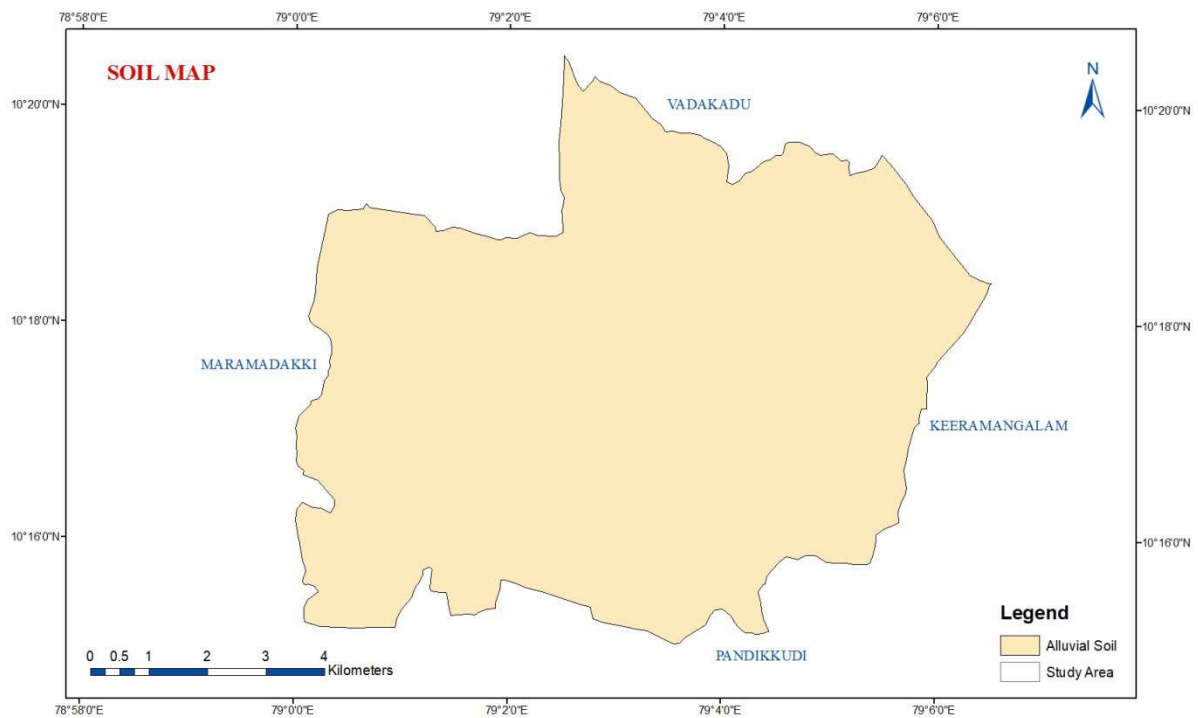


Fig 5.7 Soil map of the study area

5.3.5 Land Use & Land Cover Map

Land use Land cover is interpretable by satellite images. Various types of land use patterns are identified in the study area which includes five categories, such as Agriculture land, Vegetation, Water bodies, Residential area and open scrub. Vegetation are excellent sites for groundwater exploration by losing the soil and rocks by biological decomposition of roots and by reducing evaporation directly from the soil. Agriculture lands are considered to have good groundwater.

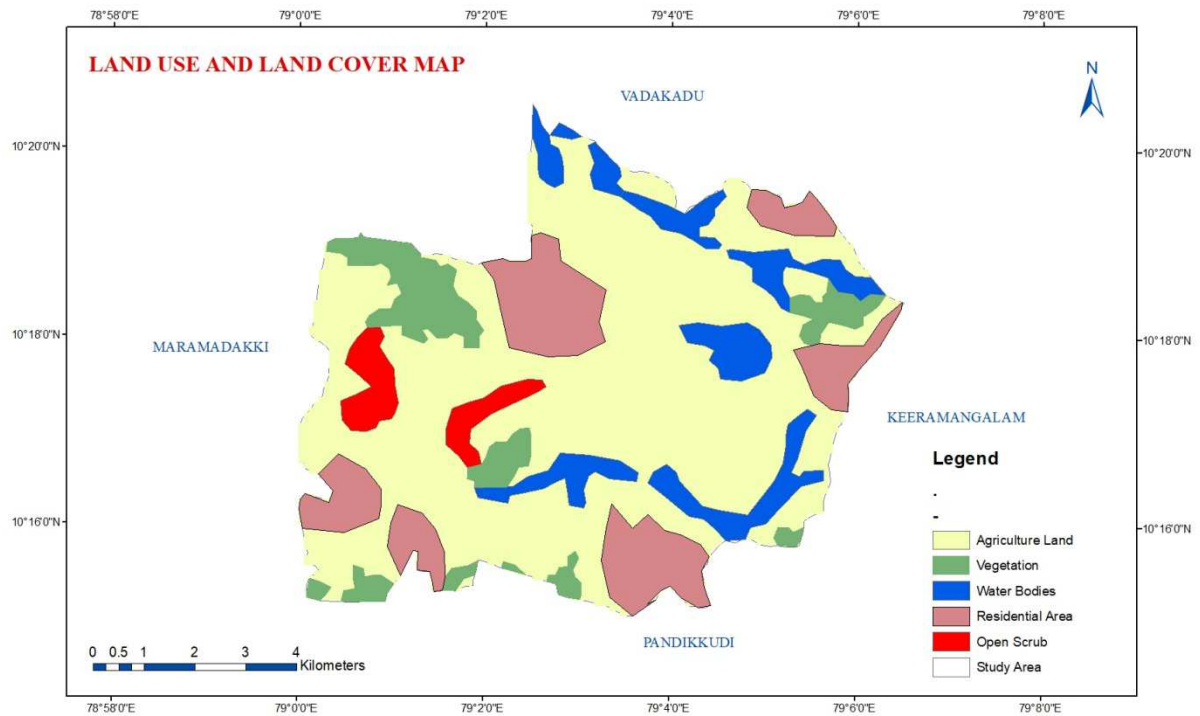


Fig 5.8 Land use & Land cover map of the study area

5.3.6 Slope Map

Slope is the rate of change of elevation, and it is considered the principal factor of the superficial flow since it determines the gravity effect on the movement. Slope is directly proportional to run-off. In steep slopes ground recharge will be less. The flow over the gently undulating plains is slow and adequate time is accessible to reinforce the infiltration rate of the underlying fractured aquifer. The slope was estimated using the Digital Elevation Model (DEM). Different classes of slopes are nearly level (-65 to -49), very gently sloping (-49 to -42), gently sloping (-42 to -35), moderately sloping (-35 to -26) and Strong sloping (-26 to -6). Moderate slopes were categorized as “good” because of slightly undulating topography which provides maximum percolation or partial runoff. The steep class (-26 to -6), having high surface runoff with a negligible amount of infiltration was assigned to the “poor” category.

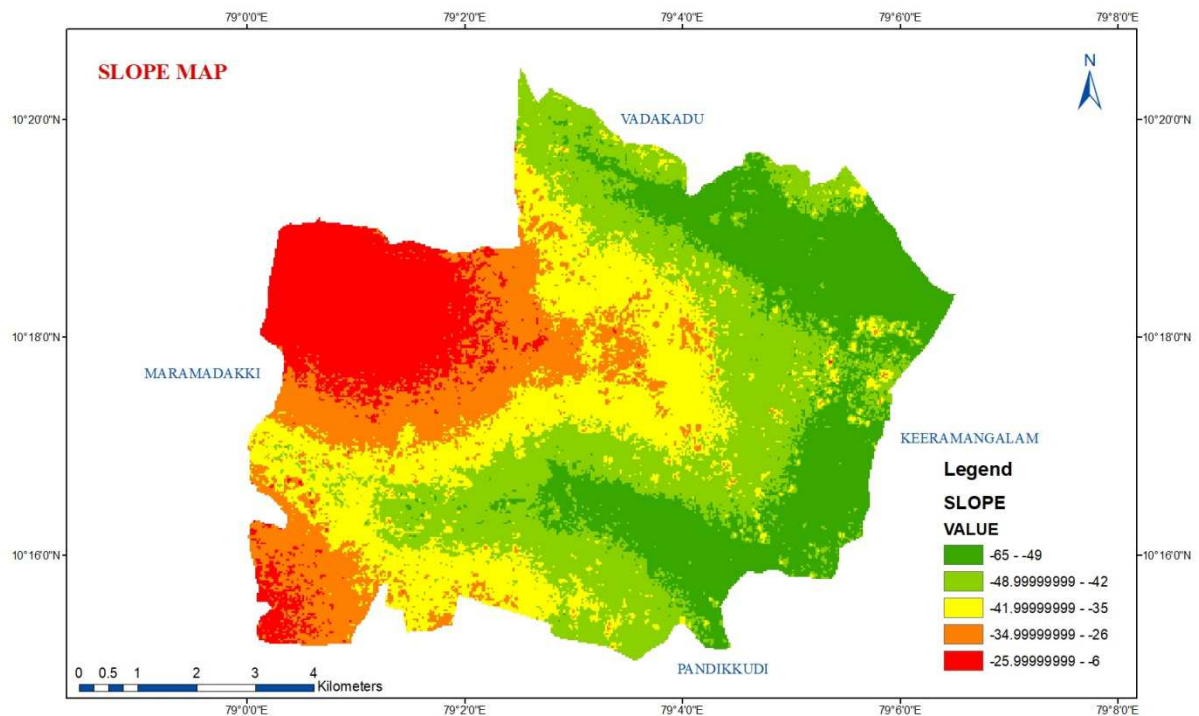


Fig 5.9 Slope map of the study area

5.3.7 Groundwater potential Map

This study has shown the large spatial variability in groundwater potential zonation. This variability closely followed the variability in the , geomorphology, land use and lineaments in the investigated area. The eastern part of the study area is under the very high to high potential zones because of the active flood plains. The southern region of the study area comes under the high and favourable potential zones, where most of the land is used for agricultural purposes. The major portion of the moderate to poor potential zonation occupies the western and eastern part of the study area. The majority of poor groundwater potential zones are located in the western part than the southern region of the study area. In the northwest portion of the study area, which is involved in the commercial development of the groundwater particularly during summer periods and also in the less rainfall period, should be protected against uncontrolled commercial extraction and this should be minimized to a greater extent.

Table 5.2 — Calculated minimum and maximum grid cell values for assessing favourable potential zonation

Map layer	Min. grid cell score	Max. grid cell score	Weightage of the layer	Min. grid cell value	Max. grid cell value
Geomorphology	1	9	17.21	17.21	154.89
Geology	1	7	8.63	8.63	60.41
Lineament	1	8	14.58	14.58	116.64
Soil	1	7	7.72	7.72	54.06
Land use Land cover	1	9	5.24	5.24	47.16

The groundwater potential of the study area (77.06 sq.km) is classified as very low – 7.454sq.km (9.5%); low – 33.408 sq.km (43%); moderate – 11.708 sq.km (15%); high – 24.403 sq.km (31.5%); very high – 0.08685 sq.km (1%) based on the thematic layers. The area that belongs to the very high groundwater potential zone is quite less in the entire study area (very high – 1 %; high – 31.5%; moderate – 15%; low – 43% and very low – 9.5%) which alarms the existing as well as the future development of the groundwater potential zones. By observing the trend of groundwater development especially for the commercial purposes and prevailing level fluctuations, the scanty proportion of good potential zones will also be stressed further. This shows that land and resources located in the study area are in the critical condition. The developed groundwater potential zonation mapping is also helpful for providing strategic measures to enhance the prevailing scenario for optimal development of aquifers. Hence the study argued the importance of conservation and recharging strategies in the identified hot spots in to sustain the resource base for future.

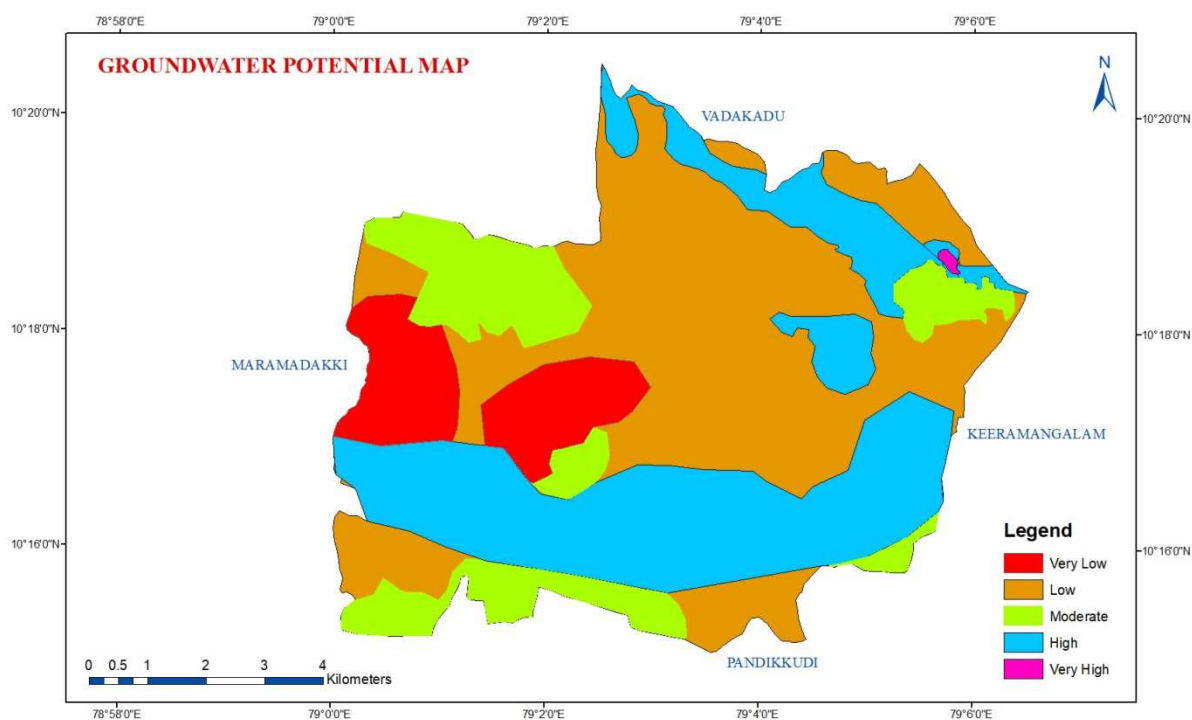


Fig 5.10 Groundwater potential map of the study area

5.4 Soil Testing Results

Table 5.3 Soil test results

S.No.	CaCO ₃	EC	pH	N	P	K	Fe	Mn	Zn	Cu
1	No	0.13	6.52	28	17.5	62	6.04	4.996	0.606	0.494
2	No	0.1	7.4	35	12.5	36	5.542	5.796	0.605	0.442
3	No	0.16	7.74	44.8	20	70	5.188	4.984	0.594	0.65
4	No	0.1	6.05	37.8	7.5	41	5.256	5.996	0.618	0.796
5	No	0.21	5.7	39.2	7.5	36	5.504	5.932	0.592	0.422
6	No	0.24	6.42	49	25	41	4.436	5.956	0.618	0.676
7	No	0.24	6.64	49	7.5	32	4.506	4.112	0.606	0.494
8	No	0.23	6.13	63	12.5	27	5.436	4.014	0.576	0.537
9	No	0.25	6.52	42	17.5	27	4.79	3.992	0.586	0.638
10	No	0.24	6.74	42	7.5	32	5.578	4.21	0.584	0.512
11	No	0.25	6.96	49	12.5	32	4.578	5.434	0.594	0.458
12	No	0.25	6.89	28	12.5	36	5.4	4.936	0.586	0.794
13	No	0.25	6.66	35	12.5	32	3.428	4.291	0.857	0.599
14	No	0.24	6.58	42	7.5	32	3.741	3.731	0.877	0.648
15	No	0.23	6.38	35	7.5	32	4.125	4.329	0.894	0.695

The soil pH range is 6 to 8 and the Electric Conductivity level is 0.1 to 0.25. It is also rich in Nitrogen, phosphorus, potassium, ferrous, magnesium, zinc and copper. So this soil is suitable for cultivation.

CHAPTER 6 SUMMARY AND CONCLUSION

6.1 GENERAL

The series of analysis were conducted on the selected study area by this project work, the groundwater potential zones on the drought prone area was investigated.

6.1.1 VES Survey

- From the fig 5.1 it can be seen that the water at the top is good and the salinity of the water increases as it goes down.
- So in this particular study area it is better to avoid taking water from greater depths and using it for agriculture.

6.1.2 Data Analysis

- The pH value of the groundwater samples in the study area lie in between 7.7 and 8.5. Total Hardness varied from 105 to 385 mg L⁻¹. More SAR value in this study is 0-10. From the above analyzed data the groundwater is suitable for irrigation.

6.1.3 GIS Mapping

From the thematic maps,

- The Cuddalore formations are confined by an impervious clay bed which provides rise to many flowing artesian wells.
- Active flood plain is extremely suitable to groundwater recharge due to its unconsolidated nature, whereas it's relatively low just in case of weathered plain.
- Lineaments are identified throughout the region, it is the lineaments within the Pedi plain or Active Flood plain which is considered significant from groundwater occurrence .

- The alluvial material is deposited prospects, while the Open Scrub has poor groundwater potential.
- Vegetation are excellent sites for groundwater exploration by losing the soil and rocks by biological decomposition of roots and by reducing evaporation directly from the soil.
- Moderate slopes were categorized as “good” due to slightly undulating topography which provides maximum percolation or partial runoff.

6.2 CONCLUSION

- From the VES survey results at this particular study area the resistivity at the top is high and the resistivity is low at the bottom. So it can be seen that the water at the top is good and the salinity of the water increases as it goes down.
- It is identified that the groundwater is suitable for irrigation purposes by the analysis of groundwater quality.
- The overlay analysis of various thematic maps and assigned weights are used for the delineation of the zone of groundwater potential.
- From groundwater potential mapping, it is indicated that the area belonging to very high categorization is quite less in the entire study area (0.086 sq.km - 1 %) which threatens the future developments of groundwater.
- By conducting the soil test, a sound scientific tool to assess inherent power of soil to supply plant nutrients. The soil present in the study area contains the right amount of all the nutrients needed to produce groundnuts and paddy crops.

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