DELINEATION OF GROUNDWATER POTENTIAL ZONES USING REMOTE SENSING AND GIS TECHNIQUES IN VILLUPURAM DISTRICT, TAMIL NADU, INDIA

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ABSTRACT

The groundwater is the most precious resources around the world and is shrinking day by day. As the demand and needs of population towards water is growing the value of water is felt in all sectors. At the same time, surface water resources are becoming insufficient to fulfill the water demand. So that systematic planning of groundwater improvement using modern technique is fundamental for the proper management and utilization of this precious resource. Assessing the groundwater potential zone is particularly important for the safety of water quality and the management of groundwater system. But still groundwater resources have not yet been properly exploited, keeping this in view, the present study has been undertaken the groundwater potential zones in Villupuram District-Tamil Nadu, by using Remote Sensing and GIS (Geographical Information System). Thematic maps of Geology, Geomorphology, Soil, Slope, Drainage, Drainage Density, Lineament, Lineament Density, and Land Use/Land Cover were used and groundwater potential zones were used and groundwater potential zones were demarcated by Weighted Index Overlay Analysis (WIOA) in Arc GIS 10.6 software. During overlay analysis the ranking has been given for each individual parameter of each thematic map and weights were assigned according to the influence towards groundwater. Finally, four groundwater potential zones were delineated such as very good, good, moderate and poor. From the study it was concluded that groundwater potential zones are helpful for recognition of suitable locations to extract groundwater and for better planning and management.

KEYWORDS: Groundwater, Potential zone, Delineated, Suitable, Parameter, Planning.

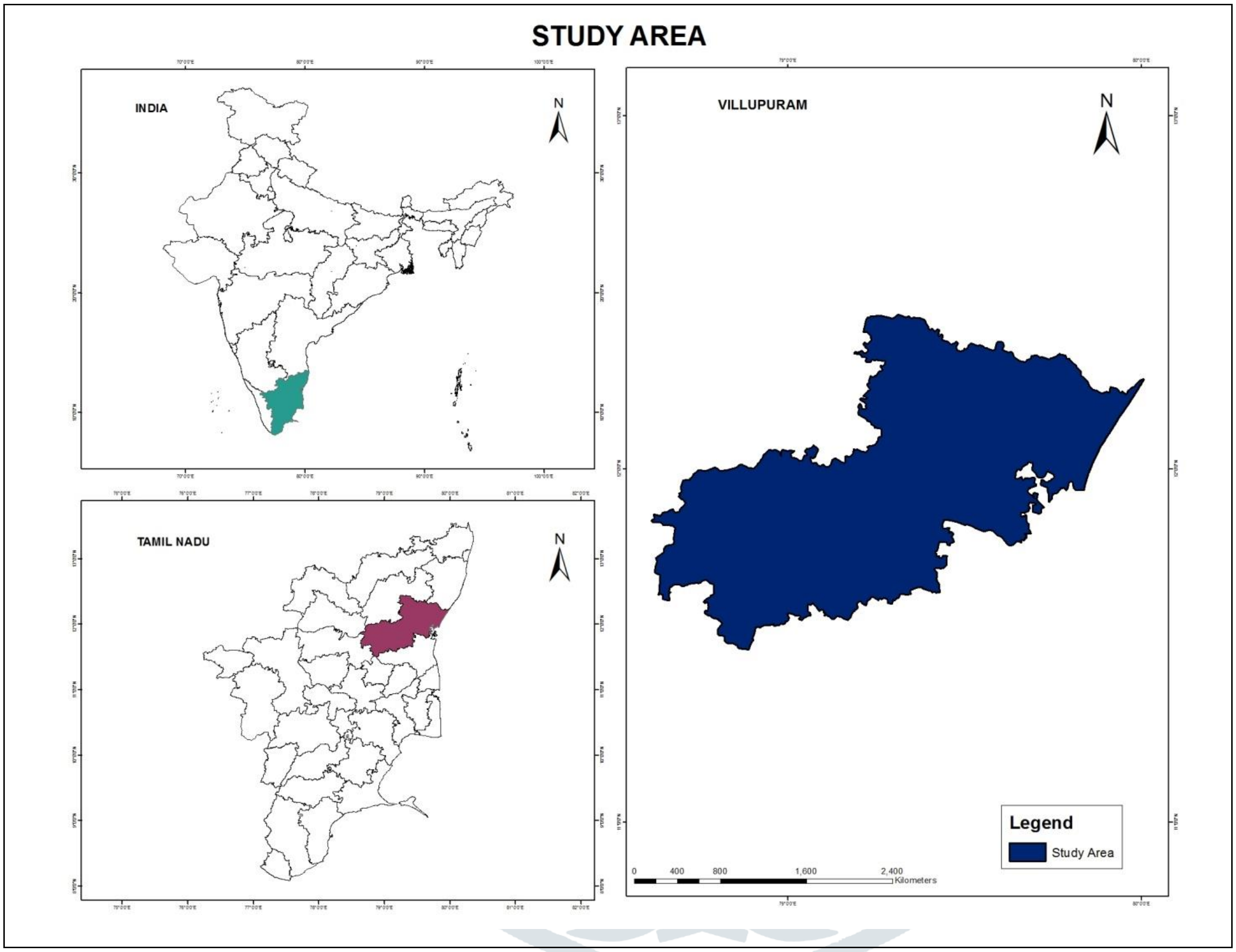
1. INTRODUCTION

Groundwater is one of the most valuable natural resources, which supports human health, economic development and ecological diversity. Because of its several inherent qualities it has become an immensely important and dependable source of water supplies in all climatic regions including both urban and rural areas of developed and developing countries. Groundwater is a form of water occupying all the voids within a geological stratum. Water bearing formations of the earth's crust act as conduits for transmission and as reservoirs for storing water. The groundwater occurrence in a geological formation and the scope for its exploitation primarily depends on the formation of porosity. High relief and steep slopes impart higher runoff, while topographical depressions increase infiltration. An area of high drainage density also increases surface runoff compared to a low drainage density area. Surface water bodies like rivers, ponds, etc., can act as recharge zones (Murugesan B. et al., 2012).Over the years the growing importance of groundwater based on an increasing need has led to unscientific exploitation of groundwater creating a water stress condition. This alarming situation calls for a cost and time effective technique for proper evaluation of groundwater resources and management practices. The groundwater development program requires a large volume of data from various sources. Hence, identification and quantization of these features are important for generating a groundwater potential model of a study area. Despite the extensive research and technological advancement, the study of groundwater has remained more risky, as there is no direct method to facilitate observation of water below the surface. Its presence or absence can only be inferred indirectly by studying the geological and surface parameters. The different hydro geological themes can be used to identify the groundwater potential zone of the present area. Remote sensing and Geographic information system (GIS) tools can open new path in water resource studies. Analysis of remote sensing data along with the topographical sheets of survey of India (SOI) and collateral information with necessary ground truth verifications help in generating the baseline information for groundwater targeting. Delineation of ground water occurrence locations using remote sensing data is based on indirect analysis of directly observable terrain features like geological structures, Slope, geomorphology, and their hydrologic characteristics. Also lineaments play significant role in groundwater exploration in all type of terrain. Application of GIS and Remote Sensing can also be considered for multi criteria analysis in resource evaluation and hydro geomorphologic mapping for water resource management. The use of remote sensing and GIS tools to extract detailed drainage slope and geomorphic features in Villupuram District suggests appropriate methods for groundwater potential zone studies.

2. STUDY AREA

Villupuram District is located in northern Tamil Nadu and is about 160km. south of Chennai. The District has an area of 7,194 sq.km. and it is bounded by Bay of Bengal and Pudhucherry in the East, Kanchipuram and Thiruvannamalai Districts in the North, Cuddalore District in the South and Dharmapuri and Salem Districts in West. In 1,076 km coastline of Tamil Nadu, Villupuram district has a coastline of 30 km. This district lies between 11°38’25’’ and 12°20’44’’ of north latitude and 78°15’00’’ and 79°42’55’’ of east longitude.

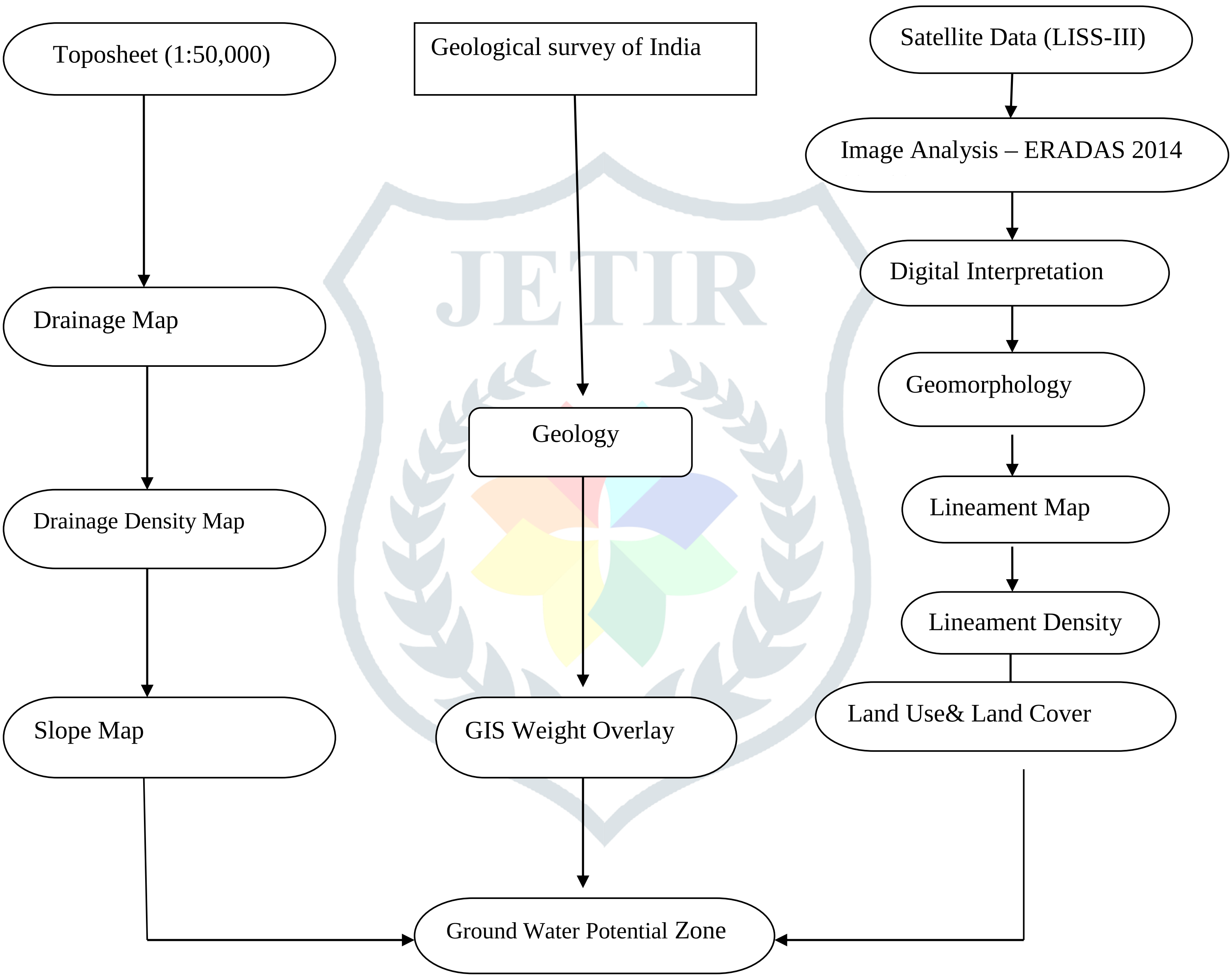
Villupuram District is well connected by rail and road. Villupuram junction connects all major cities of India. NH-45 and NH-66 passing through the Villupuram District which connects major cities and towns of Tamilnadu. The nearest port located at Pondicherry which is about 40 km eastern side of Villupuram. Study area map of the Villupuram district is shown in Map-1.



3. DATA BASE AND METHODOLOGY

ERDAS Imagine software have been used for analysis (LANDSAT – 8 Operational Land Imager (OLI) satellite data.In the present study, Survey of India toposheets with 1:50,000 scale have also been used. ArcGIS 10.6 software has been used for analysis and mapping of the individual layers. The base map of study area was prepared from Survey of India (SOI) toposheet. ArcGIS 10.6 was used to prepare various thematic maps such as Geology, Geomorphology, Soil, Slope, Drainage, Drainage Density, Lineament, Lineament Density and Land Use/Land Cover. Then all the thematic layers were integrated and ground water potential zone map is prepared by Weighted Overlay Analysis Method and classified as Poor, Moderate, Good, and Very Good.

FLOW CHART DEPICTING METHODOLOGY



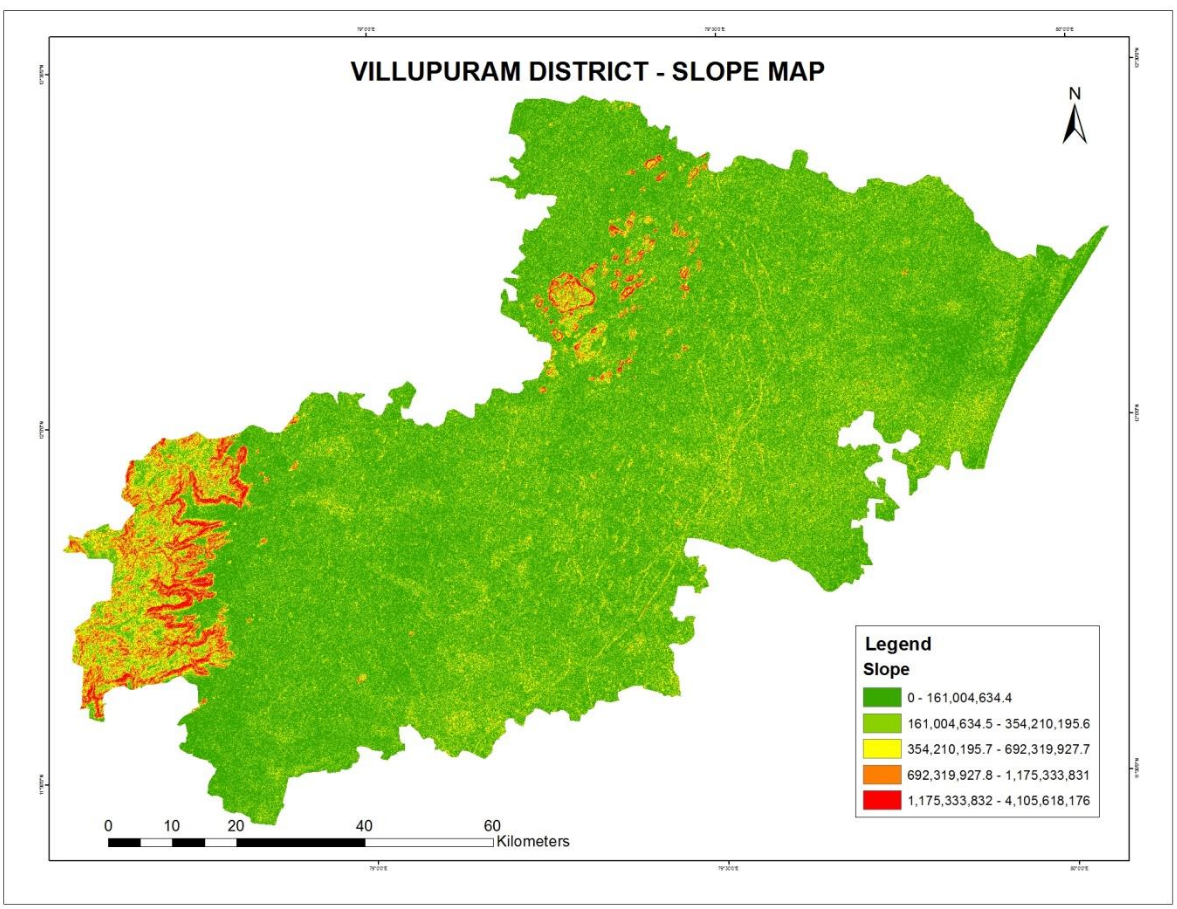
4. RAINFALL AND CLIMATE

The district receives rainfall from southwest monsoon (June – September), northeast monsoon (October – December) and non-monsoon periods (January – May). The rainfall is generally heavy during low-pressure depressions and cyclonic northeast monsoon period. The annual rainfall is normal with 1,119.8 mm (1901-1980) and higher towards coast. The area falls under tropical climate with temperature in the summer months of March to May. The average temperature varies from 26 to 410 C. The humidity is also high with80 % of saturation level. The wind speed is high during the months of July and August. The wind speed ranges from 7.4 to 12.6 km/hr, which increases from 100 to 120 km/hr during cyclone period.

5. RESULT AND DISCUSSION

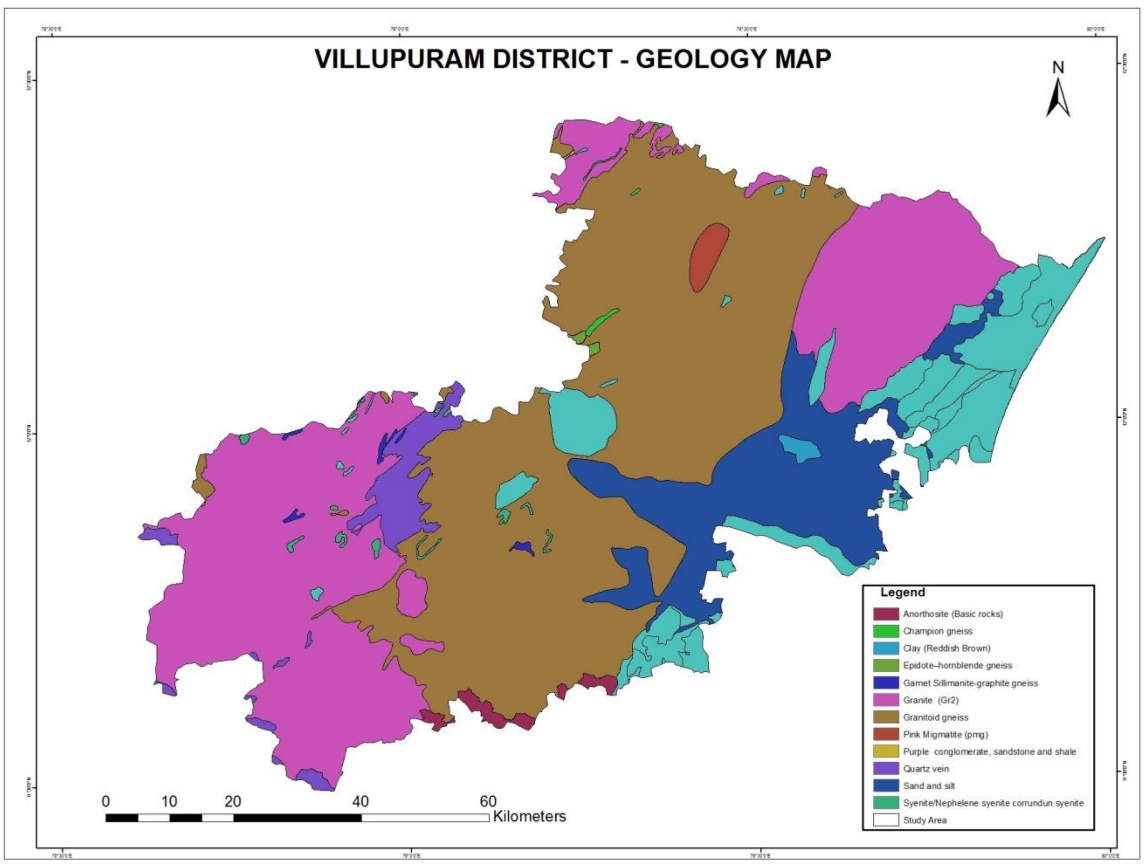
5.1 DIGITAL ELEVATION MODEL (DEM) AND SLOPE

Slope of a region is one of the controlling elements of groundwater energize. It impacts surface and subsurface stream of rain water and it is relative to the groundwater repository. Delicate slope of a territory gives more opportunity to penetrate lesser time coming about low invasion to fundamental groundwater stores. The slope guide of the examination territory has been set up from SRTM DEM. Map -2 displays the slope map.



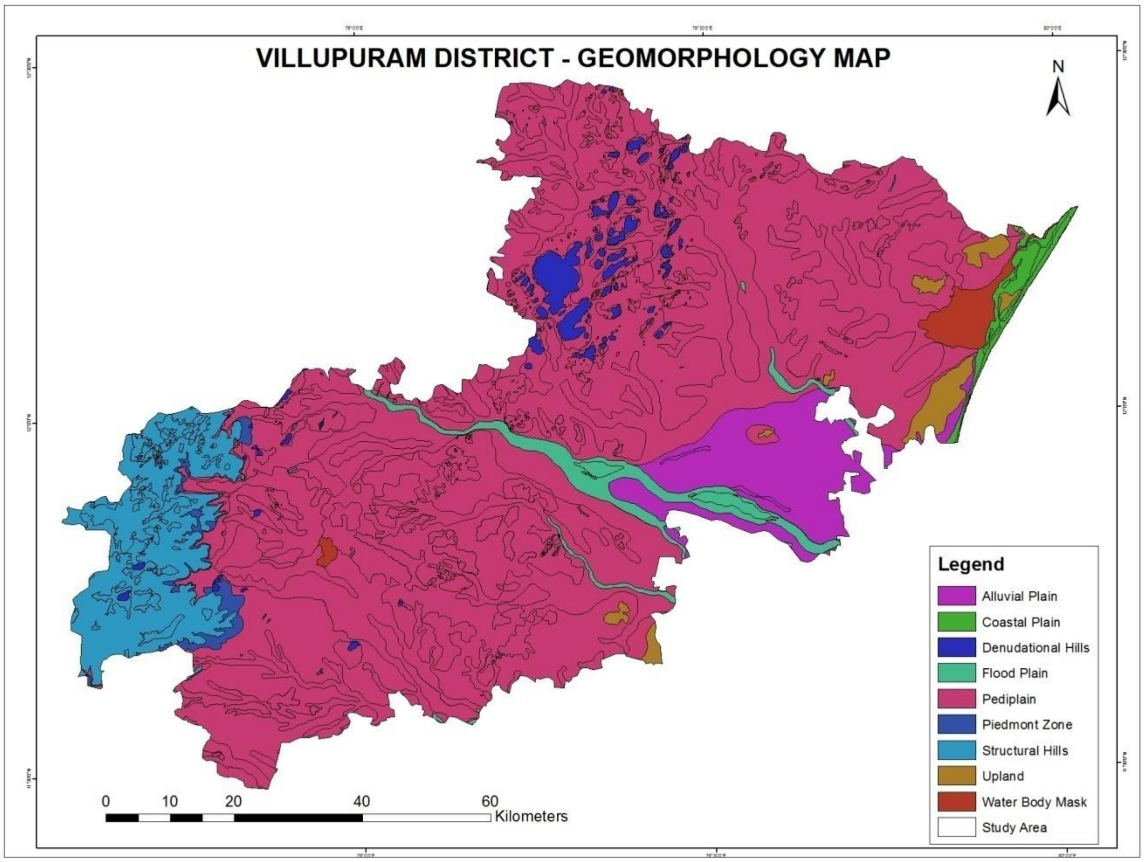
5.2 GEOLOGY

It is one of the most important factor which plays significant role in the distribution and occurrence of groundwater (Ramu et al., 2014). The storage capacity of the rock formations depends on porosity of the rock. In the rock formation the water moves from areas of recharge to areas of discharge under the influence of hydraulic gradients depending on the permeability or hydraulic conductivity (Manikandan et al., 2014). Map 3 shows the geological map of the Villupuram District. It is helpful to study the aquifer characteristics like aquifer thickness, type of aquifer, porosity, permeability etc. and also for selecting site for construction of check dam, ponds etc., (Radhakrishnan and Ramamoorthy, 2014).The study area can be divided into 3 classes viz., Hilly terrains, plain terrains and coastal plains. The hills are found in the western part of this district, and they are Kalrayan and Ginjee hills falling under Kallakurichi and Ginjee taluks respectively. Plain terrain occurs in the middle part of this district, while the coastal plains lie in the eastern part of the district in and around Marakanam and Vanur taluks. Granite and granite gneiss is the dominant lithology of the study area.



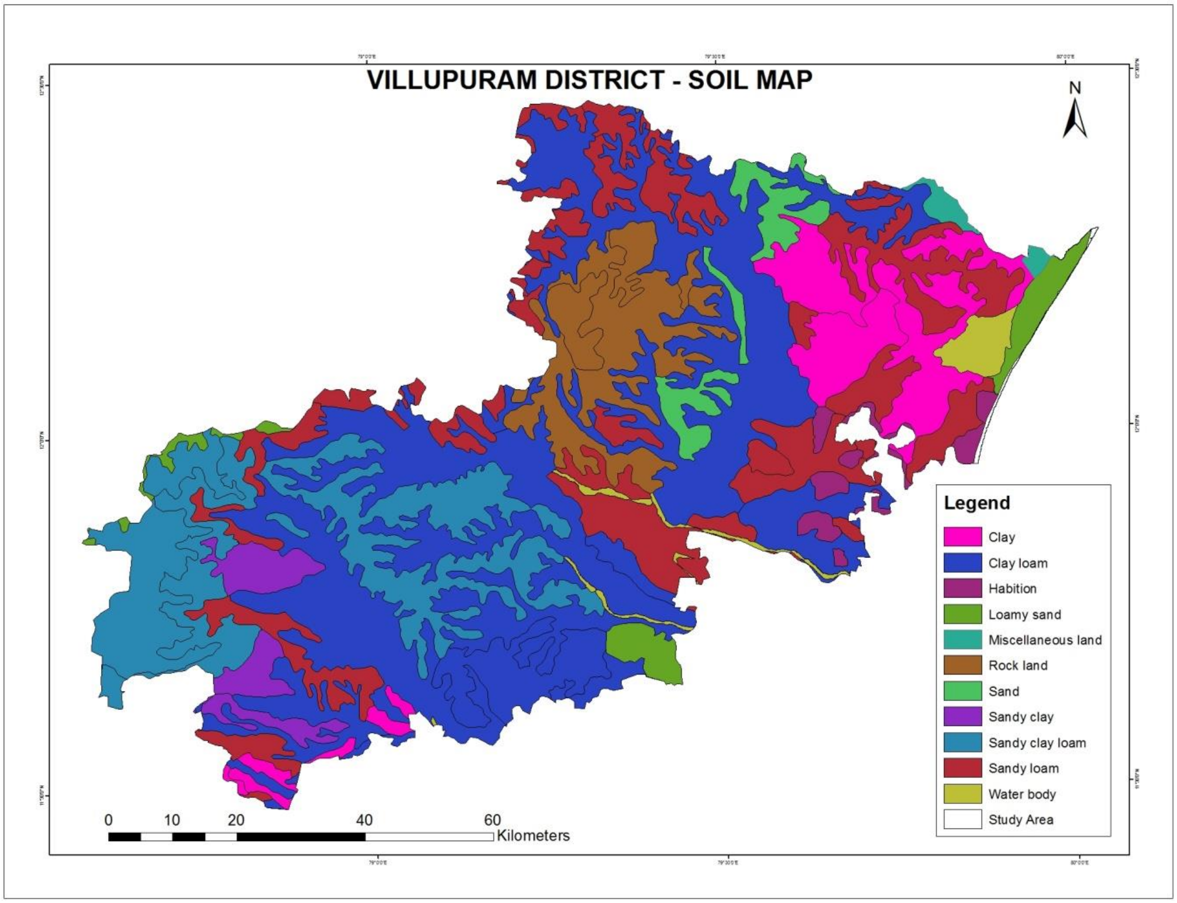
5.3 GEOMORPHOLOGY

The residual hills and denudational hills are common in Tirukoilur, Kallakurichi and Gingee taluks. Structural hills are noticed in the western part of the district. The shallow pediments and buried pediments are common in the central part of the district. Coastal areas are having older and younger flood plains and also beach landforms at places. The slope of the land is gentle towards the coast. The valley fill near Villupuram is thick, whichforms main ground water discharge zone. Lineaments are restricted to parts of Kallakurichi and Sankarapuram areas and productive fractures are noticed in select pockets. The crystalline sedimentary contact fault is having sympathetic. Fractures in hard rock's but mostly they are dry fractures. The pediplain is dominant of the study area as shown in the map (4)



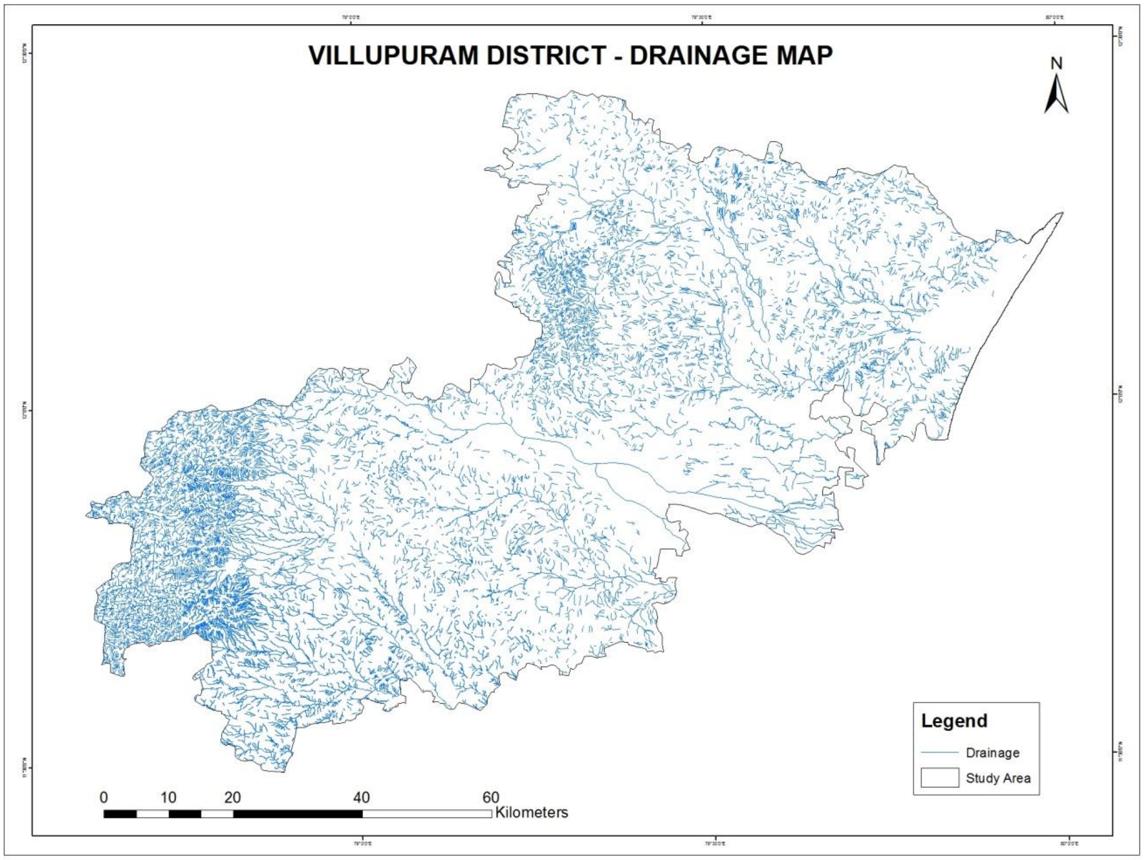
5.4 SOIL

The soil types in the district are mostly forest soil and red soil. Alluvial soils are found ineastern side bordering coast. Black soils are confined to low ground in select pockets inVanur taluk. Map-5 Soil is one of the natural resources, which is an important parameter to delineate potential groundwater zones and it plays a vital role in groundwater recharge and encounters the basic requirements of all agricultural production (Radhakrishnan and Ramamoorthy, 2014). Soil features invariably control penetration of surface water into groundwater system and they are directly related to rates of infiltration, percolation and permeability (Sedhuraman et al.,2014) and those affects the water holding and infiltrating capacity of a soil. Soil moisture and permeability is an indicator of potential zone (Jose et al.,2012). The clay loam is the dominant soil of the study area.



5.5 DRAINAGE

The Ponnaiyar, the Malattar and the Gadilam are the major rivers draining the district.The Ponnaiyar River flows from northwest to east in the district. The Manimukta nadioriginates in Kalrayan hills and drains the southern part of the district. The Pambaiyarand the Varaganadhi originate in the uplands of the district and join Bay of Bengal. The Varaganadhi is also known as the Gingee River and drains the parts of Gingee and Vanurtaluks of this district. The Malattar and Gadilam rivers also originate in the uplands within the district and flow eastwards to Cuddalore district. All the rivers are ephemeral in nature and carry only floodwater during monsoon period. The drainage pattern is mostly parallel to sub parallel and drainage density is very low. There are small reservoirs across rivers namely Gomukha, Vedur and Mahanathur Map 6 &7.


VILLUPURAM DISTRICT - DRAINAGE MAP
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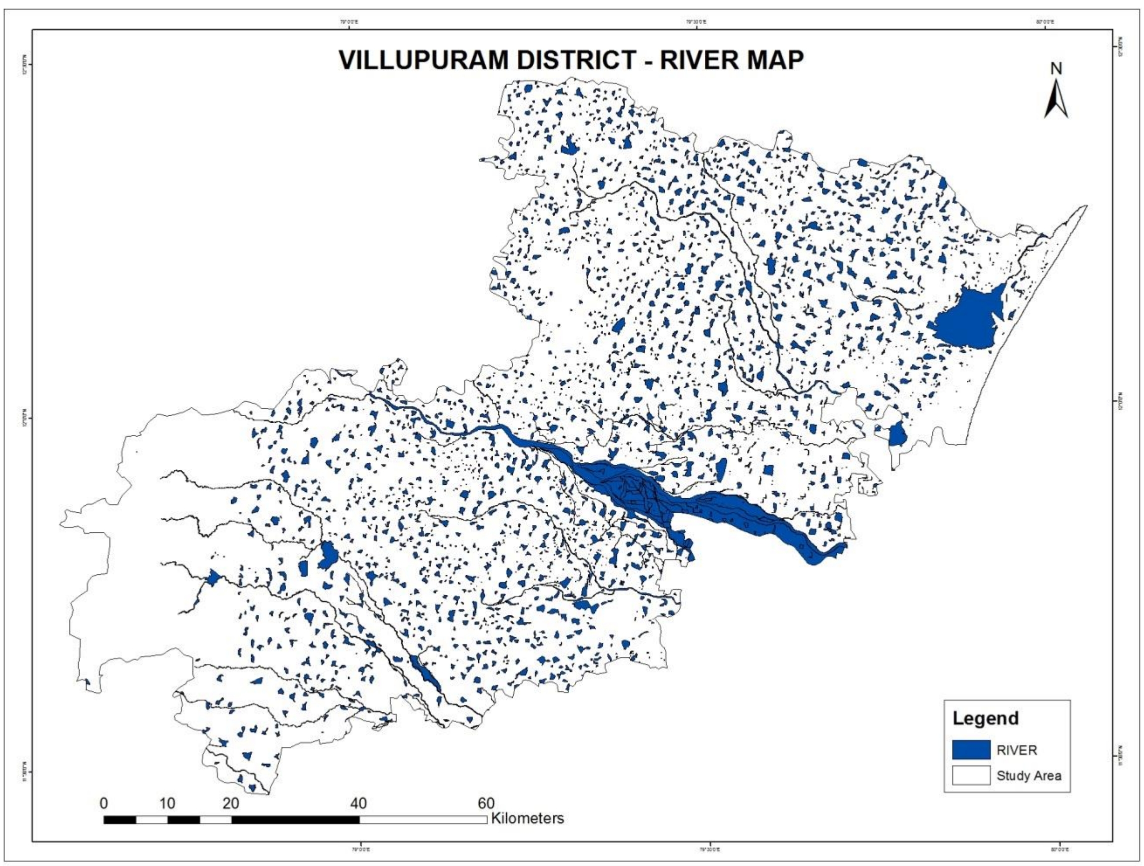
VILLUPURAM DISTRICT - RIVER MAP
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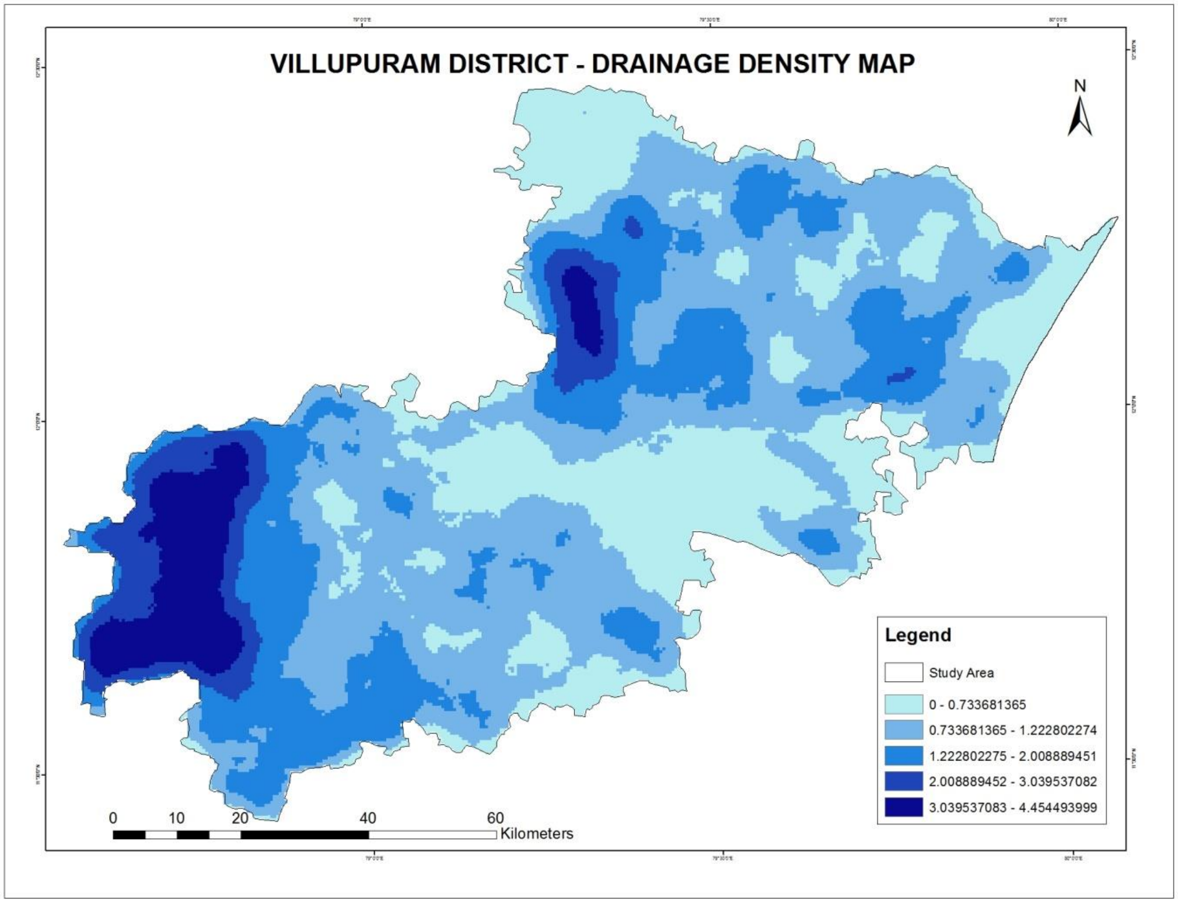
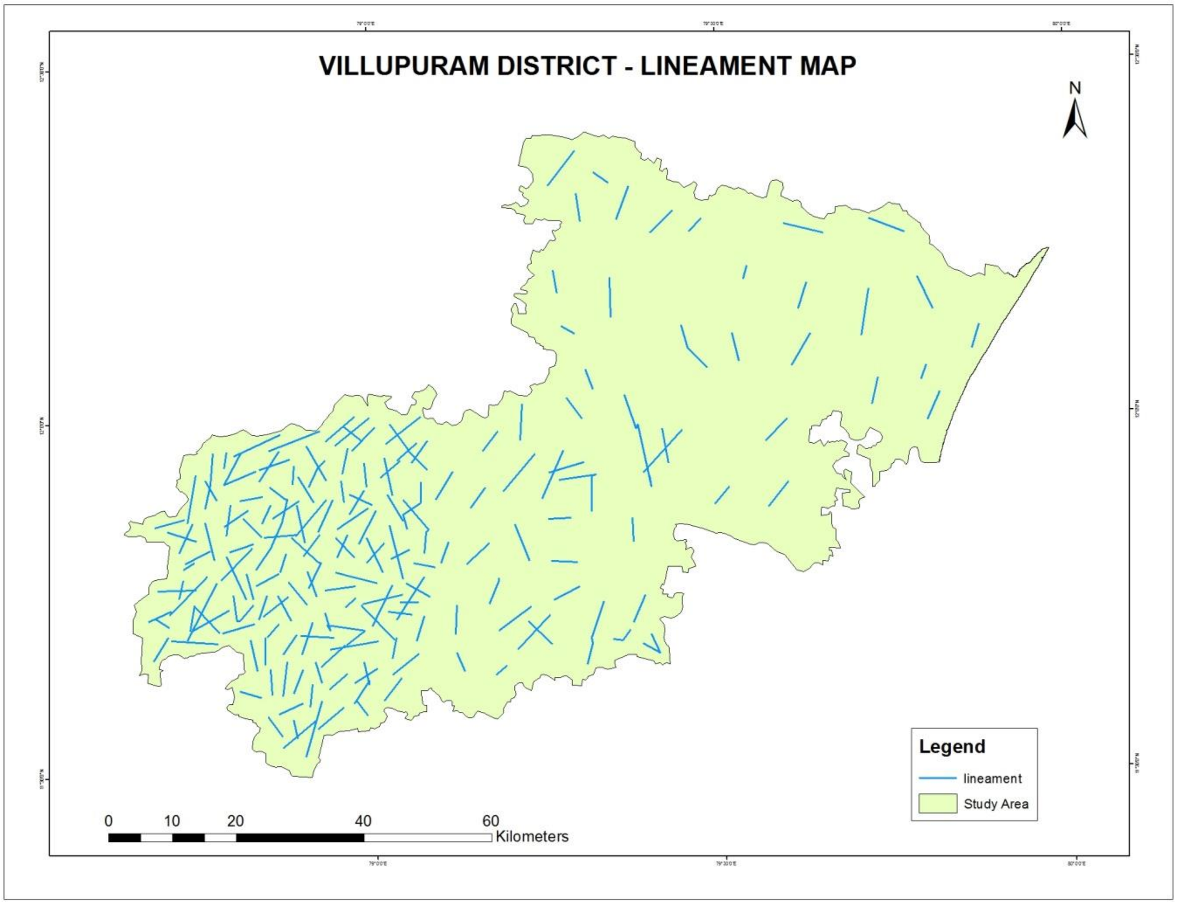
5.6 DRAINAGE DENSITY

Drainage density is defined as the closeness of spacing of stream networks because of its relation with surface runoff and permeability (Magesh et al., 2012). It is an inverse function of permeability. Sub-surface hydrological condition of any area is controlled by the drainage characteristics of the basin that leads to decipher the groundwater condition. The drainage density could indirectly point out the groundwater potential of an area due to its relation to surface runoff and permeability (Pradhan, 2009). If there is less permeable rock, the infiltration of rainfall would be less, which conversely tends to be concentrated in surface run-off (Hutti and Nijagunappa, 2011). Low drainage density generally found in the areas of highly resistant or permeable subsoil material, low relief and dense vegetation, similarly high drainage density is found in the areas of sparse vegetation, weak or impermeable subsurface material and mountainous relief (Choudhari et al., 2014). Normally, groundwater potential is found to be poor in very high drainage density areas because of the main part of the water poured over them during rainfall is lost as surface runoff with small infiltration to meet groundwater (Sitender and Rajeshwari, 2011). On the contrary areas of low drainage density permit more infiltration and recharge to the groundwater so that they have more potential for groundwater occurrence (Sitender and Rajeshwari, 2011). Low drainage density leads to coarse drainage texture while high drainage density leads to fine drainage texture (Choudhari et al., 2014),the drainage density map of the Villupuram District is shown in (fig- 8). The drainage density was classified in to five types, very low (0-0.73 km2), low (0.73-1.2 km2), moderate (1.2-2.00 km2), high (2.0-3.0 km2) and very high densities (3.0-4.4 km2).



5.7 LINEAMENT AND LINEAMENT DENSITY

Lineament are surface manifestation of the linear fractures like faults, joints and fractures, groundwater potential of high order is indicated where lineament run along and across the weathering rock deposit are intersect on another. In general lineament is considered as good potential zones for groundwater targeting as they reflect high porosity and hydraulic conductivity of the underlying materials (Subagunasekar Ma and M.C. Sashikkumarb, 2012). The Lineament and Lineament Density map of study area shown in Map-9& 10


VILLUPURAM DISTRICT - LINEAMENT MAP
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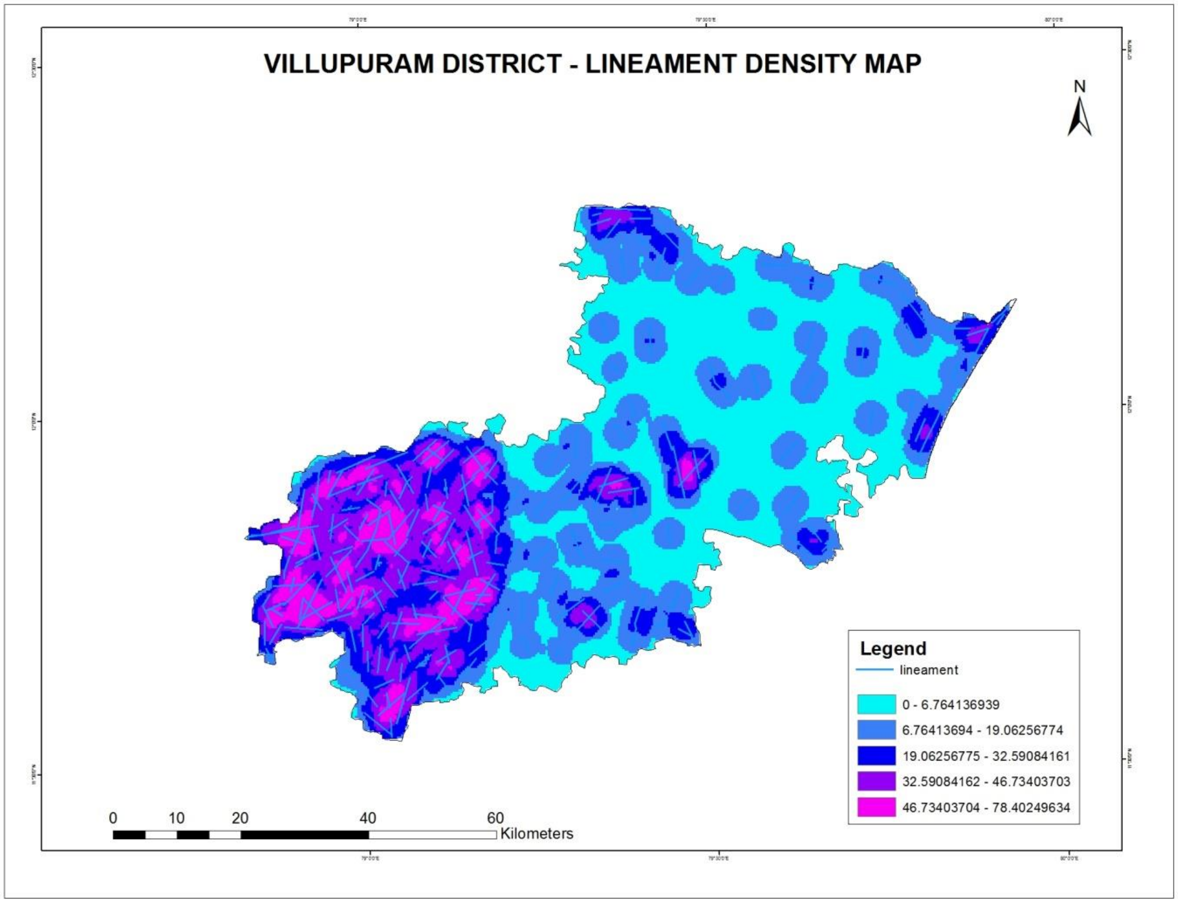
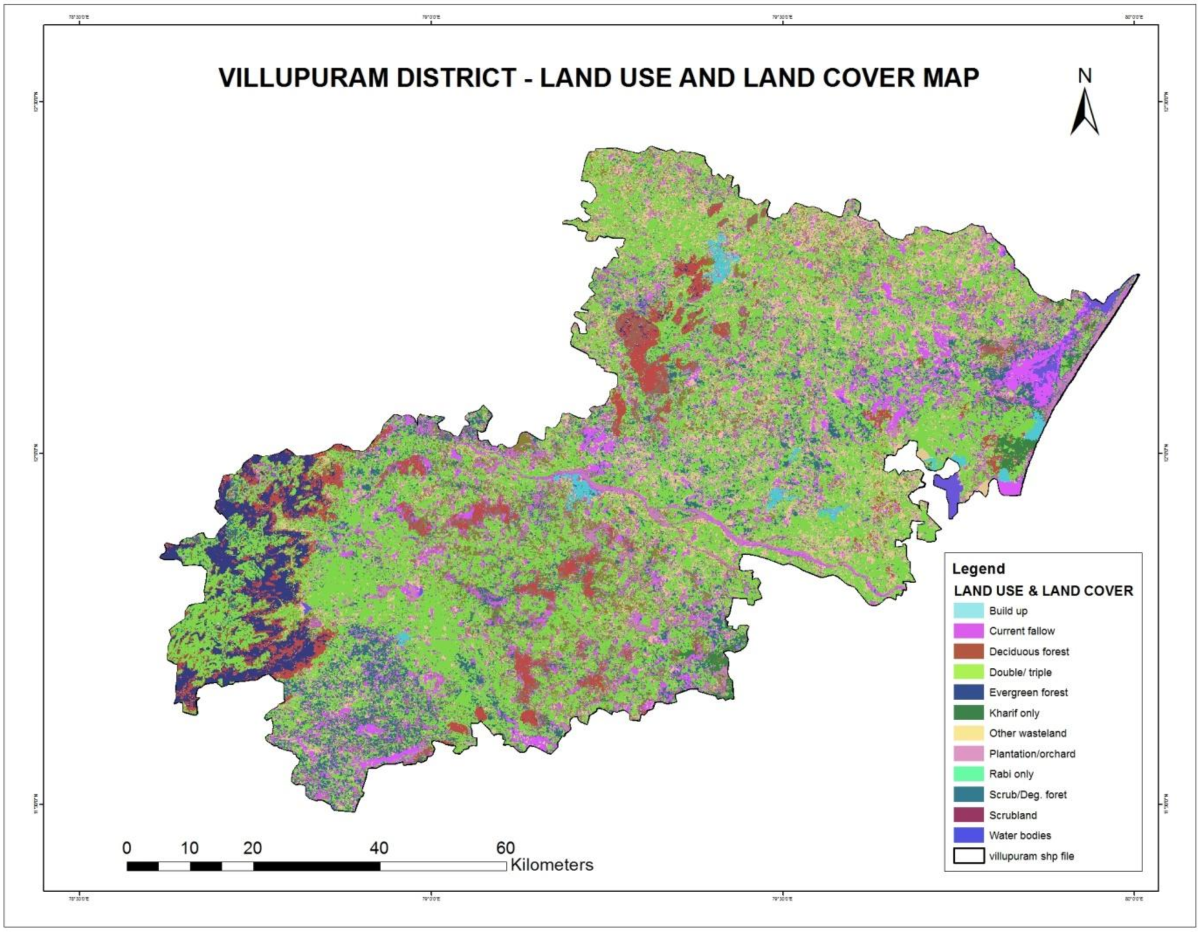


5.8 LAND USE/LAND COVER

Land use alludes to man's exercises and different uses, which are continued on land. Land cover refers to natural vegetation, water bodies, rock, soil, artificial land cover because of land use change. In spite of the fact that land use is for the most part surmised dependent on the cover, yet both the terms land use and land cover are firmly related and tradable. Data on the rate and sort of progress in the use of land assets is fundamental to the use of such assets. LANDSAT-8 Operational Land Imager (OLI) imagery has been used to develop the LULC map. Landsat-8 imagery consists of 11 bands. Map -11 displays the LULC map.



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5.9 Groundwater potential zoning

The thematic maps such as Geology, Geomorphology, Soil, Slope, Land use/land cover, Lineament, Lineament Density, Drainage and Drainage Density are integrated with Arc GIS software and assigning the weighted values and rank (Table – 1) the weightage of each criterion was finalized on the basis of the ranges of the maximum and minimum values within each theme. The groundwater potential zone map was prepared by weighted overlay analysis using the thematic maps on Geology, Geomorphology, Soil, Slope, Drainage Density and Land Use/Land cover. The ground water potential zones map Map-12 was prepared and classified as 1.Very good, 2.Good, 3.Moderate, 4.Poor.

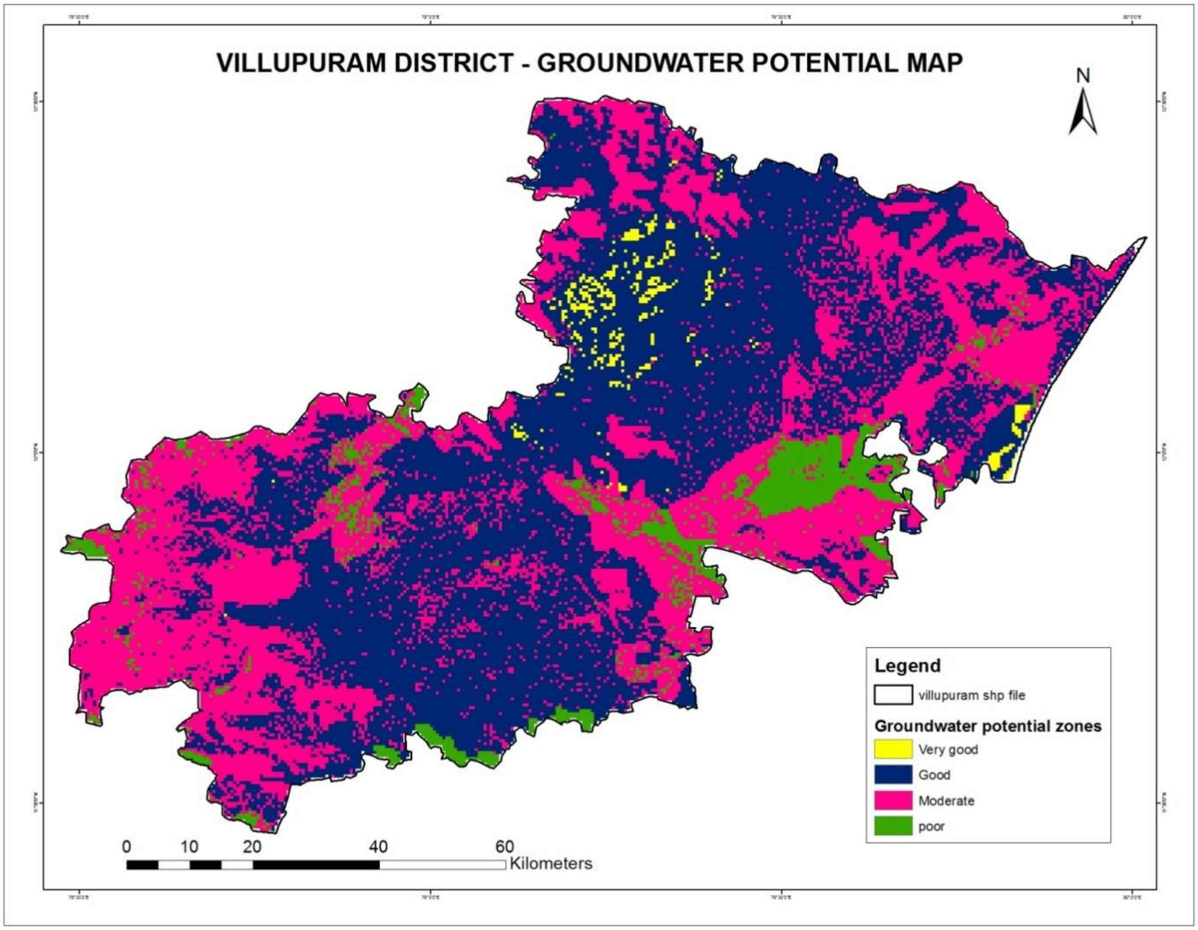

Table.1 Weights and percentage influence considered for parameters of Groundwater potential zones

Theme	Sub- Classes	Category	Weight	Influence (Weight) %
Geology	Peninsular gneiss	Very poor	**1**	25
	Dharwar super group	Poor	2	
	Sathyavedu formation upper	Good	8	
	Alluvium	Moderate	3	
	Alkali	Moderate	4	
	Acid Intrusive	Moderate to Good	5	
	Khondalite group	Good	8	
	Fluvio-marine-mangroves	Good	7	
	Sathya mangalam group	Very good	9	
	Clay loam	Moderate	4	
	Rock land	Very poor	1	
	Habition	Very poor	1	
	Loamy sand	Very good	9	
	Sandy clay loam	Moderate to Good	6	

Soil	Sandy clay	Good	8	15
	Waterbody	Very good	9	
	Miscellaneous	Good	7	
	Sandy loam	Good	7	
	Clay	Moderate to good	6	
	Sand	Moderate	4	
Geomorphology	Waterbody	Moderate to good	5	25
	Coatal plain	Moderate	4	
	upland	Moderate	3	
	Flood plain	Good	7	
	Alluvial plain	Good	8	
	Piedmont zone	Moderate to good	6	
	pediplain	Moderate to good	6	
	Denudation hills	Moderate to good	5	
	Structural hills	GOOD	8	
Slope	0.7.8	Good	8	10
	7.8-23.4	Good	7	
	23.4-41.0	Moderate to good	6	
	41.0-60.5	Moderate	4	
	60.5-497.8	Very poor	1	
Drainage density	0-69.9	Moderate to good	5	10
	69.9-163.9	Moderate	4	
	163.9-240.4	Moderate	4	
	240.4-330.0	Moderate	3	
	330.1-557.30	Very poor	1	
Land use/ land cover	Build up	Moderate to good	6	15
	Current fallow	Moderate	3	
	Deciduous forest	Moderate	5	
	Evergreen forest	Moderate	4	
	Kharif	Moderate to good	5	
	Other waste land	Moderate	3	
	Plantation/ orchard	Moderate to good	5	
	Rabi	Very good	8	
	Scrub	Moderate	4	
	Water bodies	Very good	8	

6. CONCLUSION

Ground water potential zones have been identified by integration of the geology map, geomorphology map, soil map, slope map, drainage map, lineament map, lineament density, drainage density, and land use/ land cover map. GIS plays a more important role in the evaluation of groundwater potential. It is a prime component for the integration and analysis of the spatial and non spatial information. By integrating all the thematic layers, the study area is classified into 1.Very good, 2.Good, 3.Moderate, 4.Poor groundwater potential zone. The study reveals that combination of Lineament and Drainage shows good source of groundwater. From this study observed that Remote sensing and GIS tool can utilize successfully to categorize the groundwater potential zones. This groundwater potential zone map will be useful for effective delineation of groundwater. It can be used for future development and management the groundwater source in the study area.

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