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Delineation of Groundwater Potential Zones in Parts of Vaigai River Basin – Tamil Nadu, India using Remote Sensing and GIS Technique

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ABSTRACT Water resource development and management necessarily depends on proper planning, implementation, operation and continuous monitoring. In India, potable water supply to all people in both rural and urban is main unsolvable problem, because of increasing population and availability of less water resources. The study was done in located area around the Theni district using remote sensing and GIS technology. Remote sensing and GIS technology has vital role in water resource studies, and it has to be effectively used to replace, complement and supplement the earth resources with time and cost effective. In this study, digital image processing based interpretation and classification of Landsat ETM + FCC imagery were used to identify and extract landform features, and SOI toposheet with 1:50000 scale was used to delineated drainage patterns, aquifers, lineaments, existing water bodies, recharge beds and other water relevant features using visual and digital image interpretation, and ground truth verification, etc. All the spatial and non spatial, statistical information were inputted in to computer installed GIS software to analysis and produce modeling by the GIS functions such as Density, Overlay, and Integration analysis also. Finally to select suitable site ground water potential in the study area.

KEYWORDS : Remote sensing and GIS Technique, Thematic maps, Groundwater potential area identification.

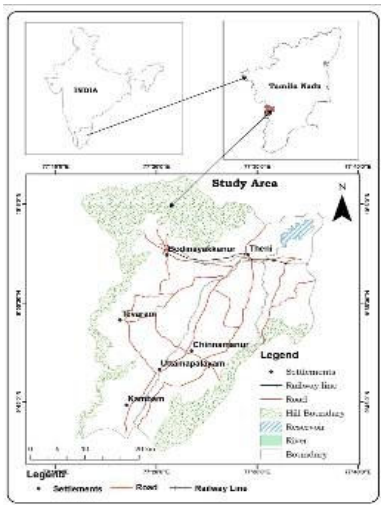
INTRODUCTION

Water is the most valuable and vital resource for sustenance of life and also for any developmental activity. With the surface water sources dwindling to meet the various demands, groundwater has become the only reliable resource. The indiscriminate use of this vital natural resource is creating groundwater problem in various parts of world. Hence, the groundwater resource should be evaluated thoroughly, carefully and reliably on a real-time basis to meet the ever growing needs. Remote Sensing (RS), with its advantage of spatial, spectral and temporal availability. Geographical Information System (GIS) is a powerful environment for real time database development, especially in studies such as delineating groundwater potential zones studies.

Many researchers such as Teeuw (1995), Saraf and Chowdhary (1998), Goyal et al. (1999), Murthy (2000) and Naga Rajani et al. (2006) have used RS and GIS techniques for groundwater exploration and identification of artificial recharge sites. Ravi and Mishra (1993), Kamaraju et al. (1995), Krishnamurthy et al. (1996), Ravindran and Jeyaram (1997), Subba and Prathap (1999), Kamaleshwar et al. (2000), Subba Rao et al. (2001), Shahid and Nath (2001), Singh and Prakash (2002), Jothiprakash et al. (2003), Srinivasa rao et al., Elkadi et al. (1994), Shahid et al. (2000), Boutt et al. (2001) and Rokade et al. (2007), have carried out groundwater modeling through the application of GIS. In the present study Landsat ETM + geocoded at the scale of 1:50,000 and Survey of India (SOI) toposheet have been used for preparation of various thematic maps such as base, drainage, drainage density, lineament. Lineament density, geology, geomorphology, soil and land use/land cover. An attempt has been made to integrate these data through the application of GIS to delineate the groundwater potential zones in the parts of vaigai river basin.

STUDY AREA

The study area covers 1538 sq. km falling in parts of Tamil Nadu State (India), geographical position North Latitude between 9°,30',00" and 10°,30',00" East Longitude between 77°,00',00" and 78°,30',00". The region is entirely covered by alluvial deposits of quaternary to recent age consisting of clay and sand. Kankar, gravel, cemented and unconsolidated sand are also found in the beds. The elevation varies from 1 to 80 degree from mean sea level; the district may be divided in hilly terrain units. Various physiographic details are shown in the base map in (Figure. 1).



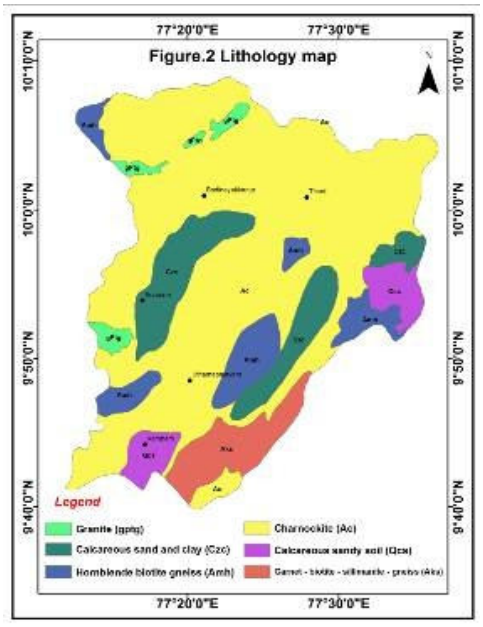
METHODOLOGY

Survey of India topographic data from 58 F/4, F/8, F/12, G1, G2, G5, G6, G9, and G10 on 1:50,000 Scale. Landsat ETM+ (Enhanced Thematic Mapper) data and ASTER DEM, Software used ArcGIS 9.3 and ENVI: 4.3 versions. The data sources like satellite and topographic data and other secondary data were used for generation of various spatial parameters. The development and assessment of geology, geomorphology maps. The main task of the current study the primary and secondary data are assembled together in GIS platform. The spatial data are assembled in digital format and properly registered to take the spatial component referenced. The namely sensed data provides more reliable information on the different themes. Hence in the present study various thematic maps were prepared by visual interpretation of satellite imagery, SOI Toposheets.

GEOLOGY

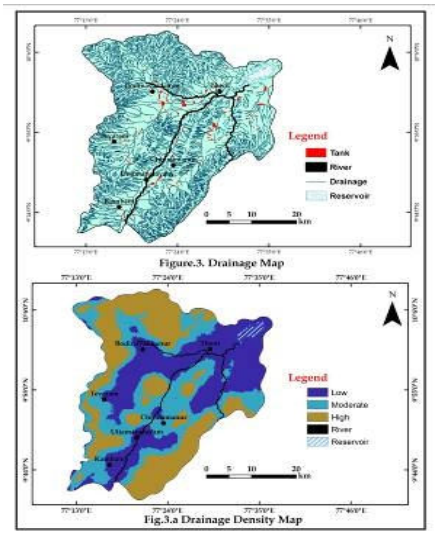
The geology map was prepared by using already existing geological data collected from the geological survey of India map (the resource map of Tamil Nadu) with the scale of 1:250000(Fig.2). Predominant geological formations Charnockites, calcareous gritty sandstone and clcy, Garnet biotite gneiss, Hornblende biotite gneiss and Granites. The study area (Theni District) is predominantly underlain by hard Archean crystalline formations Krishnan (1972), Jones (1934). Western Ghats comprises Charnockite Group of rocks. The plains are underlain by hornblende – biotite gneiss, silimanite

garnet biotite gneiss. Quartzites are seen as ridge and associated with gneisses in the central part of kambam area. The colluvio-fluvial deposit of sand, silt and gravel deposits forms a thick overburden on the Archeam formations in Kambam, Tevaram, Bodi and south of Andipatti areas. Eolian sand dunes area predominantly seen south of Bodi around Silamalai of Red sandy soil and fine loamy soil are found to occur in this area. The crystalline rocks of Archean age in this study area are highly metamorphosed and structurally deformated (Figure.2).



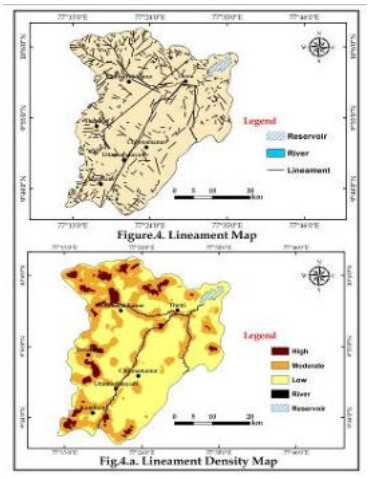
DRAINAGE

Vaigai river has its origin in the eastern slope of Western Ghat at Gandamanayakanur. Suruliar, Theniar, Varahanadhi and Manjalar are its main tributaries. The regional drainage pattern is dentritic and major direction of the flow of river is easterly (east, southeast and northeast) from this Western Ghat hills.The drainage Density map was prepared in Arc MAP, which was finally classified into different classes varying from High, Moderate and Low. The zones of high drainage density will have poor groundwater prospects and gradually the zones of lower and lower drainage density zones will have better groundwater prospects (Figure.3 & 3.a).



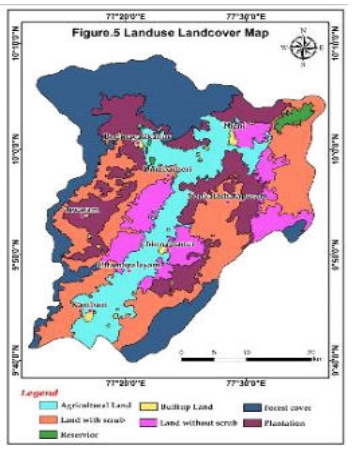
LINEAMENT MAPPING

Lineaments, being surface manifestations of structurally controlled linear or curvilinear features, are identified on the satellite imagery by their relatively straight tonal alignments. According to Ramsamy et.al (1986), lineament is defined as long linear or curvilinear features which are structurally tectonically controlled and can be seen only through aerial photographs or satellite imageries. A lineament is defined as large-scale linear feature, which expresses itself in terms of topography of the underlying structural features. Lineaments can be joints, fractures, dyke systems, straight course of streams and vegetation patterns. In hard rock terrains, lineaments represent zones of faulting and fracturing resulting in increased secondary porosity and permeability. They are good indicators for accumulation and provide the path ways for groundwater movement and are hydrogeologically very important. Photo-lineaments generally represent the surface traces of fractures in bedrock, projected more or less vertically upwards to the erosion surface by various mechanisms. Lineament mapping using LANDSAT ETM +, of the study area was based on tonal, textural, topographic and curvilinearities and rectilinear (Figure.4 & 4.a). The NE-SW lineaments are found parallel to the Vaigai and Suruliar rivers. N – S trending lineaments are less common.



LAND USE / LAND COVER

The land use land cover study area has been attempted in order to identify and map the various types of land use/land cover classes in the area by visual interpretation. The classification system was developed by Remote sensing Agency (NRSA 1990), Land use refers to man s activities and various use which are carried on land " Land cover refers to " Natural vegetation, Water bodies, rock / soil , artificial cover and other resulted due to land transformation. Land use classification of the specified area using remotely sensed data. Land use map was prepared from satellite data using the photo recognition elements such as Tone, Texture, Drainage, Structural fabric and Relief found in the image and comparing it with topographic sheet. It was further confirmed by limited field check the following are the different Land use/Land cover classes of the study area Plantation, Built-up land, Forest Cover, Land with Scrub, Land without Scrub and water bodies (Figure.5). The forest and forest plantation gives light reddish brown tone with white patches and fine to medium texture with irregular shape and varying size. Although, these areas have good ground water prospects.



GEOMORPHOLOGY

Geomorphologically the study area has special credential owing to the occurrence of hilly terrain landforms. Based on the photo recognition techniques study area geomorphology map has prepared using Landsat ETM+ satellite data are is characterised predominantly by structural and denudational land forms viz., structural hills, vally fill, Piedmont zone, Bazada zone, colluvial fill, flood plain and pediment. Bazada zone is found well developed at the foot hills on the western and northern part of the study area (Figure.6). The valleys are characterised by colluvio-fluvial sediments. The hilly terrain act as catchment area and runoff zones while the bazada zone bordering the hills form a good recharge zones (Table.1)

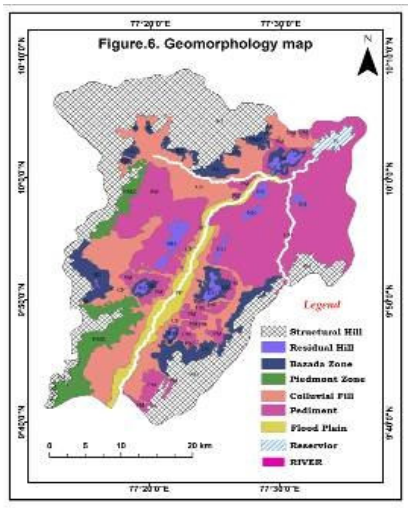


TABLE – 1. Hydro geomorphic unit their characteristic and groundwater potential

Features	Description	Influence on GW regime	Potential
Structural hill	Linear to arcuate hills showing definite structural trends.	Mainly act as run-off-zone. Large hills contribute significant recharge to the narrow valleys and other favorable zones with in the hills and to the adjoining plains.	Poor to moderate
Valley fill	Valleys of different shape and size occupied by valley fill material.	Forms moderately shallow aquifers, subject to thickness of valley fill material, its composition and recharge conditions	Good to Very Good
Pediment	Gently undulating plains dotted with rocky outcrops with or without thin soil cover.	Forms run-off and recharge zones with limited prospects along favorable locales.	Poor to moderate
Piedmont Zone	Piedmont alluvium deposited foot hill zone due to sudden loss of gradient by rivers, streams in humid and sub-humid climate.	Piedmont alluvium forms good shallow aquifer depending on its thickness, composition and recharge conditions.	Good to Very good
Bazada zone	out-wash of varying grains size deposited along the foot hill zone in arid and semi-arid climate.	Forms highly productive shallow aquifers subject to the thickness of deposited material and recharge condition.	Good
Flood Plain	Alluvium deposited along the river / streams courses due to repeated flooding.	FP receives good recharge and form good shallow aquifers depending on the type of sediments, their thickness and recharges conditions.	Good to Very Good

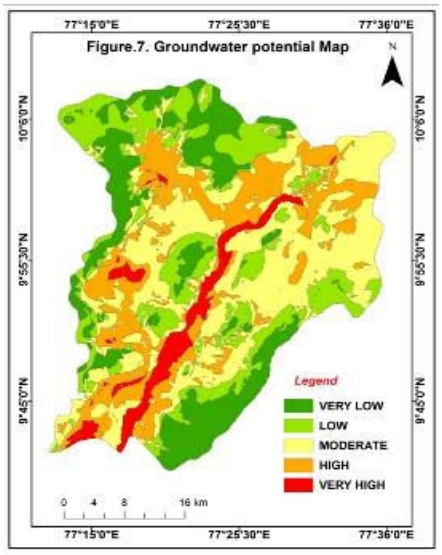
GENERATION OF GROUNDWATER POTENTIAL ZONES MAP

In the present study, each theme considered is assigned a weightage depending on its influence on storage and transmission of groundwater. These weightages represent the relative importance of a theme vis-a-vis the objective. The different units in each theme are assigned knowledge-based hierarchy of weightage from 1 - 5 on the basis of their significance with reference to their groundwater potential (Table.2). In this weightage, 1.Very Good, 2.Good, 3 Moderate, and 4 Poor groundwater potential (Figure.7). Various thematic maps are reclassified on the basis of weightage assigned and brought into the "Raster Calculator" function of 'Spatial Analyst' tool of Arc GIS software. The 'Spatial Analyst' tool consisting of mathematical and boolean operators has been used for integration.The weightages for different layers have been assigned considering similar work carried by many researchers such as Krishnamurthy et al. (1996), Jothiprakash et al. (2003), Rokade et al. (2007), Prasad et al. (2008) and Chowdhury et al. (2009). A "Simple Arithmetical Model" in Arc GIS software has been adopted to integrate various thematic maps by averaging the weightages, classifying potential zones based on decision rules and groundwater potential zones map has been generated.

Geomorphology Weightage – 10		
CLASS	RANK	SCORE
Structural & Residual Hill	1	10
Pediments	2	20
Water bodies & Piedmont	3	30
Colluvial fill	3	30
Bazada Zone	4	40
Vally Fill	4	40
Flood plains	5	50
Lithology Weightage - 8		
Granite	1	8
Garnet - biotite - sillimanite - gneiss	2	16
Calcareous Sand &Clay	3	24
Calcareous sandy soil	4	32
Hornblende biotite gneiss	4	32
Charnockite	5	40
Lineament Density Weightage - 7		
High	5	35
Moderate	3	21
Low	1	7
Drainage Density – Weightagee – 4		
Low	5	20
Moderate	3	12

High	1	4
LULC Weightage - 3		
Land without Scrub	1	3
Land with Scrub & Built-up Land	2	6
Forest Cover & Reservoir	2	6
Plantation	4	12
Agricultural Land	5	15

TABLE.2 Rank, weight and scores for attributes for various themes with respect Groundwater potential.



CONCLUSIONS

A study was carried out to delineate groundwater potential zones in Vaigai basin of Tamilnadu using Remote Sensing and GIS techniques. In the present study, Landsat ETM geocoded at the scale of 1:50,000, ASTER DEM and Survey of India toposheets have been used for preparation of various thematic maps such as base, drainage, geology, geomorphology, slope, drainage-density and land use/land cover. The different units in each theme are assigned knowledge-based hierarchy of weightage from 1 - 5 on the basis of their significance with reference to their groundwater potential. The layers were then integrated in the GIS environment using Arc GIS software to delineate various groundwater potential zones in the study area. The study area was categorized into four groundwater potential zones namely 'very good', 'good', 'moderate', and 'poor' covering different percentages of the study area. Further, the results of this study demonstrated that the Integrated Remote Sensing and GIS based approach is a powerful tool for assessing groundwater potential based on which suitable locations for groundwater withdrawals could be identified.

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