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IDENTIFICATION OF GROUNDWATER POTENTIAL ZONES IN HARD ROCK TERRAIN OF THIRUVANNAMALAI-TAMILNADU, INDIA – A GEOMATICS BASED APPROACH

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Abstract

Ground water is interest due to scarcity of good quality subsurface water and growing need of water for domestic, agricultural and industrial purpose usage. It has become crucial not only for target for groundwater potential zones, but also important monitoring and conserving this important resource (CGWB, 1985). In hard rock terrains, available for groundwater is of particularly limited. Occurrence of groundwater in such rocks is essentially confined to fractured and weathered horizons (Uday Kumar et. al., 2010).The present work accentuated the expediency of Remote sensing and Geographic Information System (GIS) applications in subsurface water studies, especially in the identified as potential zone of groundwater in hard rock terrain. The information on geology, geomorphology, slope, lineaments and land use/land cover was gathered from Landsat ETM + data and Survey of India (SOI) toposheets of scale 1:50,000 in addition, The composite map generated under GIS platform was further classified according to the spatial variation of the groundwater potential. Three categories of groundwater potential zones namely poor, moderate, good were demarcated. The geomorphological units like deep pediment, valley fills,bazada zone and alluvial plain ranked to potential zones for groundwater exploration and development, valley fills associated with lineaments is highly promising area for groundwater potential zones. The spatial variation of the potential zone indicates that groundwater occurrence is controlled by structure of geology, slope and landforms.
Key words: GIS, Groundwater Potential Areas, Hydrology, Surface Runoff

INTRODUCTION

Ground water is a dynamic and replenishable natural resource but in a hard rock terrain availability of groundwater is of limited and its occurrence is essentially confined to fractured and weathered zones (saraf and choudhury, 1998).as it is the largest available source of fresh water lying beneath the ground it has became crucial not only for targeting of groundwater potential zones but also monitoring and conserving this important resource. The ground water conditions in hard rock terrain is multivariate because of the heterogeneous nature of the water subsurface aquifer, owing to the varying composition compaction and its density of fracturing and degree of weathering .as a result targeting of groundwater in such terrain has proven to be a complex phenomenon. The need of the study is selected specific water related problems in the study area due to massive agriculture and horticulture Groundwater conditions are broadly pertained as over exploited. Even though the area possess Major River Cheyyar. (Chengam). the water scarcity for domestic purpose still exist due declining of rainfall in this area published by (TNWBD). It is zone that the jawadhu hills and parts of puthupalayam, and chengam which are depicted as critical area of 90-100%, over exploited region of ground water source. Being with this fact the present study is to identify groundwater potentiality with in the study area.

STUDY AREA

The study area, jawadhu hills area of Thiruvannamalai district is located near the east coast of Tamil Nadu. Thiruvannaamalai District has an area of 6,191 km². The Thiruvannamalai district is divided into 6 Taluks, 18 blocks and 1061 villages covering an area of 6, 31,205 ha of land. The Thiruvannamalai district comes under the Eastern Ghats (TN uplands) and Deccan plateau, hot semiarid region with red loamy soil with cropping period of 90 to 150 days. Excepting hills, the district falls in the North Eastern agro climatic zone of Tamil Nadu.The area under study is located in between 12° 45’ 00’’ to 12° 15’ 00’’N latitude and 78° 45’ 00’’ to79° 00’ 00’’E longitudes. It is covered by survey of India topographical sheets Nos.57L/14, 15 in the scale of 1:50,000 physiography the area is a plain and is characterized by pediments, tanks and flood plains etc. the cheyyar river flows through this area. The average means annual rainfall for the 1046 mm. The following table sourced by Dinamalar Newspaper – Trichy edition dated: 02-01-2012 shows the Rainfall acquired in the District in the northwest monsoon period. Study area climate condition is the semi arid region, the average maximum temperature ranged from 28.2 to 38.9 ^{0}C and the minimum from 19.5 to 24. 8 ^{0}C. The differences between the mean maximum temperature and the mean minimum temperature are maximum in the month of March (Fig.1).

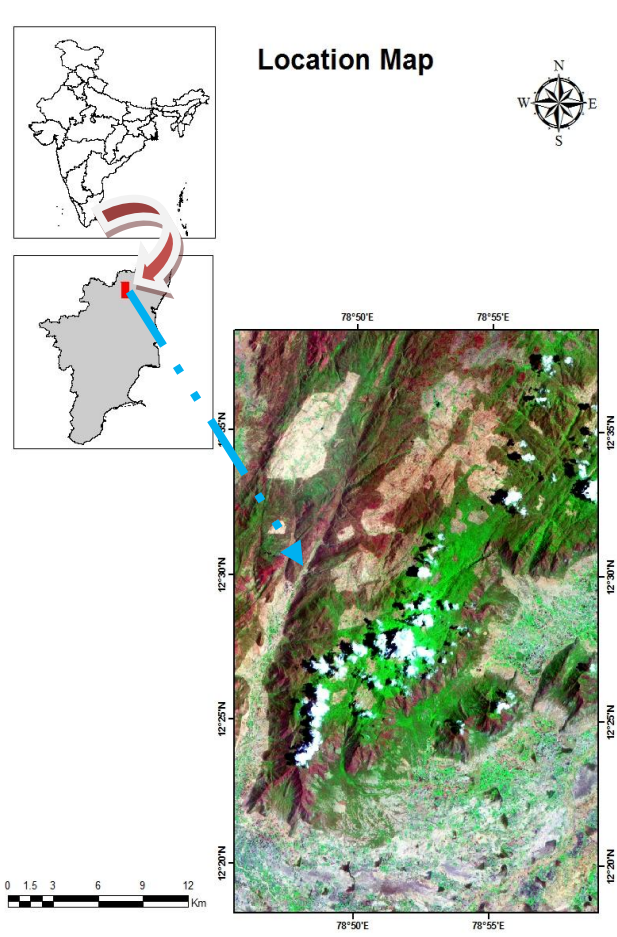

Fig.1.Study area location map

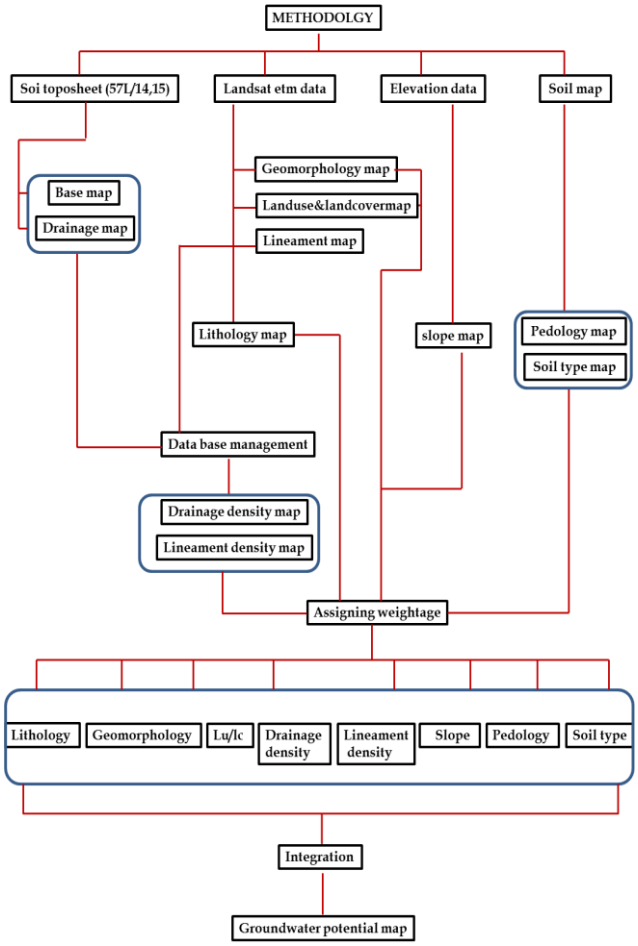

Fig 2.methodology flow chart

MATERIALS AND METHODS

The main objective of the present study is to identify the Groundwater potential zones in hard terrain of Thiruvannamalai district. The data products used for the study comprised both satellite data and other conventional data collected from various departments. Following data products are used for this study. Survey of India topographical map no. 57L/14, 15 ON 1:50,000 scale. Land sat – ETM DATA using remote sensing and GIS techniques. In order to demarcate the groundwater potential zones of study area different thematic maps on 1:50000 scale were prepared from remote sensing data, topographic maps, source of geological maps and reports, and field data. Drainage map was prepared from SOI toposheets and updated from the satellite data. Geological map of the area was prepared from Geological Quadrangle Map of the area published by GSI. Based on the character, the features in different thematic layers were assigned with different weightages values according to the potential for groundwater. After the layers were integrated using GIS and then the area can be classified as the different polygons final thematic layer were qualitatively visualized into one of the categories like (i) poor to nil, (ii) poor, (iii) poor to moderate, (iv) Moderate to good and (v) good in terms of their importance with respect to the groundwater occurrence. The choice of software packages selections generally based on the user requirement. There are standard commercial GIS packages now available in the markets (Arc GIS 9.3+).ENVI 4.6 (Fig.2).

The following schematic diagram shows the methodology of the present work.

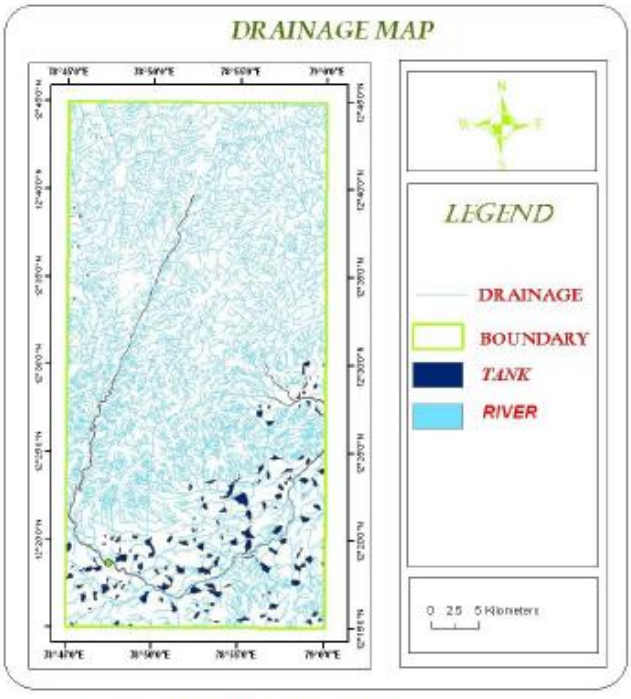

Fig3 Drainage map

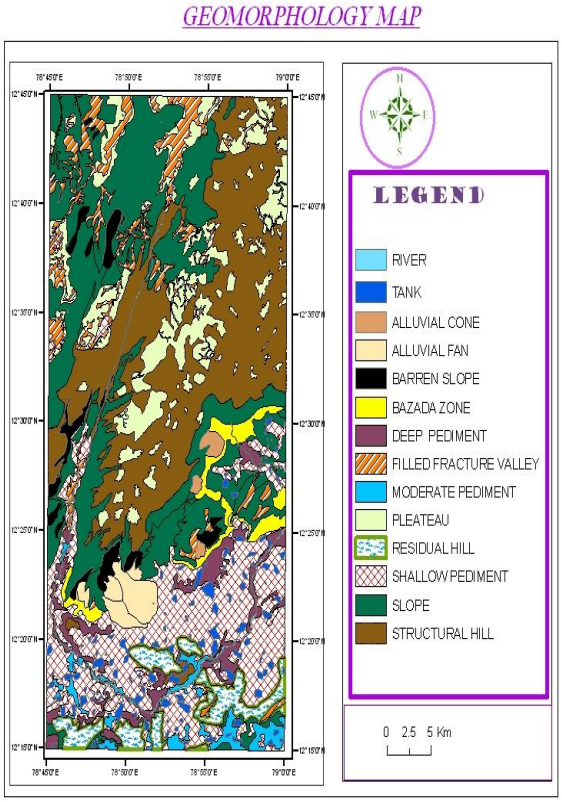

Fig4 Geomorphology map

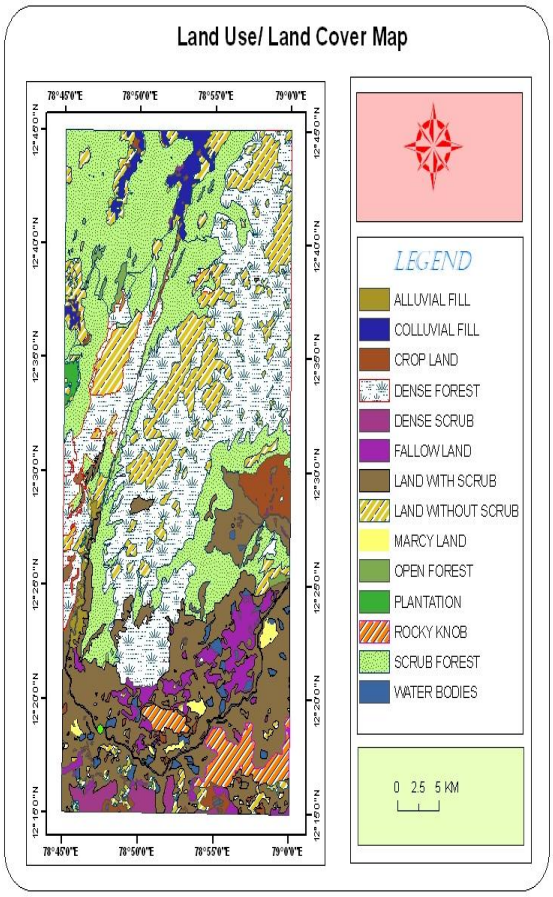

Fig5 Land use /Land cover map

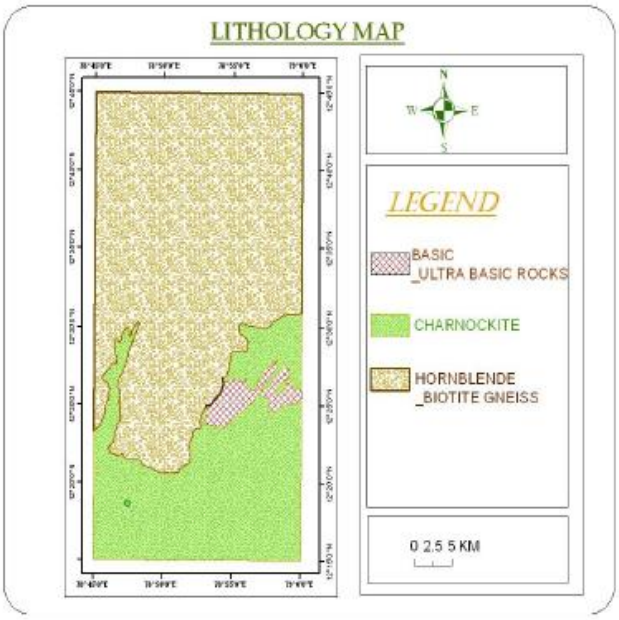

Fig6 Lithology map

TABLE1: WEIGHTAGE FOR GEOMORPHOLOGY BASED ON GROUNDWATER PROSPECTS

S.No	Criteria	Features	Weightage	Rank
1.	Geomorphology	Alluvial cone	3	High
2.		Alluvial fan	3	
3.		Bazada zone	3	
4.		Deep pediment	3	
5.		Filled fracture valley	2	Moderate
6.		Moderate pediment	2	
7.		Barren slope	1	low
8.		Plateau	1	
9.		Residual hill	1	
10.		Shallow pediment	1	
11.		slope	1	
12.		Structural hill	1	
13.		Rocky knob	1	

TABLE2: WEIGHTAGE FOR LANDUSE / LANDCOVER BASED ON GROUNDWATER PROSPECTS

S.No	Criteria	Features	Weightage	Rank
1.	Land use/land cover	Alluvial fill	3	High
2.		Colluvial fill	3	
3.		Plantation	3	
4.		Water bodies	3	
5.		Land with scrub	2	Moderate
6.		Land without scrub	2	
7.		Marshy land	2	
8.		Scrub forest	1	Low
9.		Rocky knob	1	
10.		Open forest	1	

TABLE3: WEIGHTAGE FOR SOIL BASED ON GROUNDWATER PROSPECT

S.No	Criteria	Features	Weightage	Rank
1.	**soil**	**Calcareous soil**	**5**	**Very deep**
2.		**Clay soil**	**4**	**Moderately deep**
3.		**Loamy soil**	**3**	**Moderately shallow**
4.		**Gravely clay soil**	**2**	**Shallow**
5.		**Gravely loam soil**	**1**	**Very shallow**

Drainage map ((fig-3)) was prepared from the SOI Toposheet (57L/14,15). Here all the possible rivers, streams and tanks were digitized. Cheyar River, is the major stream in the area. Cheyar river flows NE –SW direction. Geomorphology, the sculpture of the earth is an important feature for groundwater studies; geomorphic landforms control the occurrence and movement of groundwater, hence for evaluating groundwater potential of an area, study of geomorphic landforms forms the basis. The geomorphologic features and associated landforms were recognized on the basis of photo recognition elements as well as terrain elements like tone, contrast, size shape pattern, association, drainage pattern, fluvial characteristics and erosional features. The mapped geomorphic features are buried pediment (deep, shallow, and moderate), bazada, residual hills, and filled fracture valley (fig-4). Landsat ETM imagery was used for preparing land use /land cover map on 1:50,000 scales that describe how parcel of land is used. Land cover describes the materials such as vegetation, rocks or buildings that are present on the surface. The land use and land cover pattern are classified based on the NRSA nomenclature. (fig-5) The land use / land cover patterns of the study area is classified from the satellite imagery based on the image interpretation techniques based on tonal variations, texture, pattern, size, shape and association etc., and mapped in ArcGIS software. Using the district resource map the lithology (fig-6) of the area has been mapped as a layer. Hard rock comprising mainly of Gneisses Charnockites and Gondwana Sedimentary formations in the northern part of Cheyyar and Arni (Table4).

TABLE.4: GEOLOGICAL SUCCESSION OF THE STUDY AREA

Map symbol	Rock type	Nature of rock type	Group	Age
HBG	Hornblende biotite gneisses	Methamorphic rock sediments	Peninsular gnisses complex	2,200-2550ma late archean to protereozoic era
UB	Basic and ultra basic rocks	Hard rock sediments	Charnockites	2,600ma late archean era
CH	charnockites	Hard and easily weathered rocks		2,600ma archean era

Source: District Resources Map, Geological Survey of India, 1994

DATA INTEGARTION

Weighted Index Overlay model:

The final stage involves combining all thematic layers using the Weighed Index Overlay Model

(WIOM) using this formule.

$$\overline{S} = \frac{\sum_{i}^{n} S_U W_I}{\sum_{I}^{n} W_I}$$

Where,

S is weighted score for an area object (polygon),
WI is weighted score for the i…th input map
SIJ is score for the j…th class of the i…th map.

Determination of weightage of each class is the most crucial in integrated analysis, as the output is largely depends on the assignment of appropriate weightage. Consideration of relative importance leads to a better representation of the actual ground condition (choudhury, 1999). Considering the hydro- geomorphic conditions of the area, weighted indexing has following parameter namely Geology, Geomorphology and land use / Land cover the weightage values were assigned and integrated in GIS environment.

RESULTS AND DISCUSSION

On the basis of weight assign to layers are taken in consideration to attain the groundwater potentiality from the study area. The weightage assigned layers are integrated using RASTER CALCULTOR of ArcGIS extension. The resultant varies in range between 11-23 for their more the result and range is classified in to five equal distributions namely (Table.5).

TABLE.5 WEIGHTAGE ASSIGNED CATEGORIZED RANGE:

S.no	Category	Range
1	Very low	11-13
2	Low	13-15
3	Moderate	15-17
4	High	17-19
5	Very high	19-23

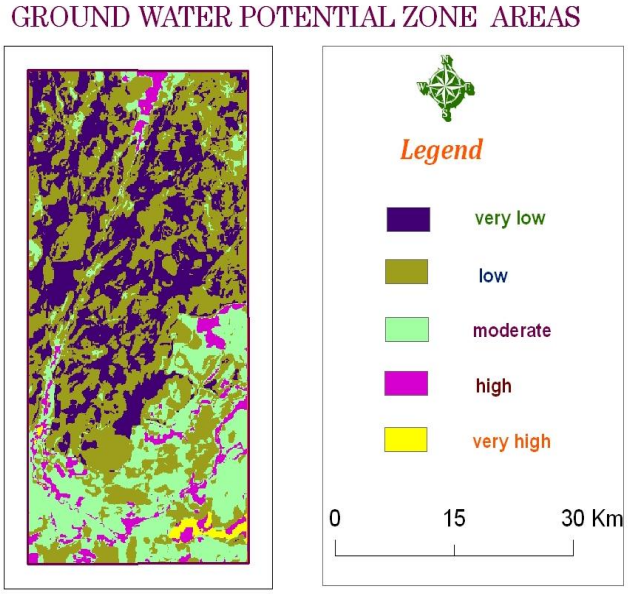

Fig7 Groundwater Potential Zone map

The quality of a drainage network depends on lithology, which provides an important index of the percolation rate. The 1&2nd drainage stream density on overlay analysis with Groundwater potential map revealed that Very High and High potentiality is controlled by geomorphic Features like Alluvial cone, Alluvial fan, Bazada zone, Deep pediment, Filled fracture valley over weathered Charnokite and Hornblende Biotite Gneiss that are parameterized by **N E – S W – Direction** of lineaments. Since the stream density is carried only in the first and second order streams as it is because this stream are more prone in runoff conditions yet it poses high dissection level with fractures due to its hard rock condition. More over by analysing the same to drainage density it delivered a clear presentation of groundwater potentiality conditions favoured by the same as in the stream density analysis. (Table.6).

S. NO	**Category**	**1st &2nd stream density + Groundwater Potential Zone + Geomorphology**	**Area (in %)**	**Drainage density + Groundwater Potential Zone + Geomorphology**	**Area (in %)**	**Slope**	**Lineament density + Geology**
1.	**VERY HIGH**	**Alluvial cone,**	0.001	**Alluvial cone,**	0.082	Gentle	**N E – S W – Direction ,groundwater potential zone**
		Alluvial fan,	0.169	**Alluvial fan,**	0.413		
		Bazada zone,	0.795	**Bazada zone,**	1.793		
		Deep pediment.	2.115	**Deep pediment.**	3.054		
2.	**MODERATE**	**Shallow pediment**	1.07	**Shallow pediment**	0.351	moderate	
		Slope	0.349	**Plateau**	1.435		
		Plateau	0.228				
3.	**HIGH**	**Filled fracture valley**	0.707	**Filled fracture valley**	1.293	steep	
		Moderate pediment	0.874	**Moderate pediment**	1.154		
				Slope	0.386		

Conclusion

The present study reveals that remote sensing is a splendid technique for natural resource assessment for terrain analysis. In order to identify the areas suitable for the groundwater prospects different thematic layers pertaining to geology, geomorphology. Lineaments, drainage, slope, were analyzed in GIS environment. Based on analysis the probability of occurrence of groundwater in the study area have been rated from very good to poor has been indicated in the (fig-7). It has been observed that the floodplain and

deep pediment, bazada zone, alluvial fan & cone has better groundwater prospect present near to Chengam, Puthupattu, Valayampatti, Japtikaraiyandal, Kattavarampalayum, Venkatapalayam, Kandapalayum. The moderate pediment, filled fracture valley, areas have moderate groundwater prospects. The residual hills plateau, barren slope, rocky knob is generally behaved as a runoff zones and the groundwater occurrence is restricted to the area with very poor groundwater prospects. The study gave a detailed knowledge about the potentiality of groundwater in hard rock terrain as well as the controlling landforms of the terrain which induces in acquiring this potentiality.

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