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Geomorphological Mapping for Identification of Groundwater Potential Zones in Hard Rock Areas Using Geospatial Information- a Case Study of Nagavati Watershed in Dharmapuri District, Tamil Nadu, India

KEYWORDS: Groundwater, Remote sensing and GIS

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ABSTRACT *Groundwater recharge is an important process for the management of both surface and subsurface water resources. Nagavati watershed is located in part of Dharmapuri district of Tamil Nadu in South India. It lies between latitudes 11°45'N to 12°15' N and 77°30' E to 78°30 E longitudes. It covers within the Survey of India toposheet nos. 57H/16, 57L/4, 58E/13, and 58I/1 covering an area of about 500 sq.km. Nagavathi is a major river which is ephemeral stream flowing from northeast to southwest direction and has 32 km length and surrounded by west part Masakkallu reserve forest, eastern part Thamboran malai and central part Elagiri reserve forest in the south west by Mettur Stanley reservoir. The purpose of this study was to investigate new water sources in the study area. The thematic layers considered in this study are Geology, Geomorphology, Lineament, Drainage, Soil, and surface water body, which were prepared using the IRS-P6 LISS-III satellite imagery and conventional data. In addition, soil and drainage maps were digitized from published maps. The thematic layers were finally integrated using Arc GIS 9.3 software. On the basis of different geomorphic units, five categories of groundwater potential zones were delineated as 'Very good,' 'good', 'Medium,' Very poor and 'Poor'. It is concluded that the RS and GIS techniques are very efficient and useful for the identification of groundwater potential zones.*

INTRODUCTION

Groundwater is one of the Nation's most important natural resources. Groundwater is also the source of much of the water used for irrigation. It is the Nation's principal reserve of fresh water and represents much of the potential future water supply. Groundwater is a major contributor to flow in many streams and rivers and has a strong influence on river and wetland habitats for plants and animals. Delineating the potential groundwater zones using remote sensing and GIS is an effective tool. In recent years, extensive use of satellite data along with conventional maps and rectified ground truth data has made it easier to establish the base line information for groundwater potential zones [1-6]. More recently, some interesting works stressed the importance of the relationships between geomorphology and groundwater approaches with other emerging scientific study in Geomorphological Mapping for Identification of Groundwater Potential Zones in Hard Rock Areas Using Geo-spatial Information – A Case Study in Malur Taluk, Kolar District, Karnataka, India [7]. A systematic integration of these data with follow up of hydrogeological investigation provides rapid and cost-effective delineation of groundwater potential zones. Although it has been possible to integrate these data visually and delineate groundwater potential zones, however, it becomes time consuming, difficult and introduces manual error. In the recent years digital technique is used to integrate various data to delineate not only groundwater potential zone but also solve other problems related to groundwater. These various data are prepared in the form of thematic map using geographical information system (GIS) software tool. These thematic maps are then integrated using "Spatial Analyst" tool. The "Spatial Analyst" tool operators is then used to develop model depending on objective of problem at hand, such as of groundwater potential zones [8-10].

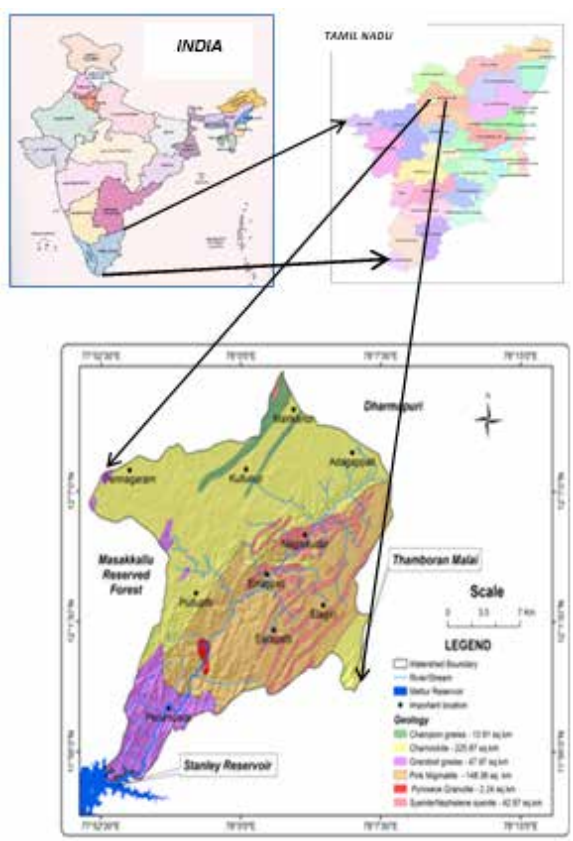

Fig 1: Geology map

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MATERIALS AND METHODS

The thematic layers considered in this study are Geology, Geomorphology, Lineament, Drainage, Soil, and surface water body, which were prepared using the IRS-P6 LISS-III satellite imagery The Survey of India toposheet maps 57H/16, 57L/4, 58E/13, and 58I/1 on a scale of 1:50,000 equal to the corresponding imagery were used for the preparation of thematic maps. The various hydrogeomorphic units have been delineated by following the Standard Technical Guidelines (NRSA 2000). The ground verification of interpreted data was checked out in the field and necessary modifications were made in the thematic maps. The lineament map has been prepared through the analysis of satellite data considering mainly the drainage lineaments and vegetation anomaly. All the prepared primary input drainage, hydrogeomorphology and lineament details were scanned and digitized. The Arc GIS software was used for used to create layouts for output generation.

GEOLOGY OF THE STUDY AREA

Nagavati watershed is located in part of Dharmapuri District of Tamil Nadu in South India. It lies between latitudes 11°45'N to 12°15' N and 77°30' E to 78°30 E longitudes. It falls in Survey of India map in 57H/16, 57L/4, 58E/13, and 58I/1 covering an area of about 500 sq.km (Fig.1). Geology of area is underlined by a wide range of igneous and metamorphic rocks. The geological formations of the study area are under Archean group of rocks. Crystalline rocks comprising Charnockite, Champion gneiss, syenite, pink pegmatite and pyroxene granulite. The charnockites and associated pink migmatities mostly occupy the study area. Recent alluvial and colluvial deposits and it is highly pink migmatized at many places and show deep weathering.

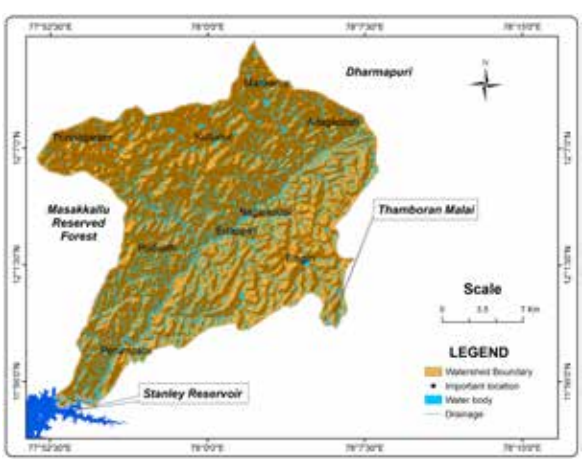

Fig 2: Drainage and water body Map

DRAINAGE SYSTEM AND SOILS

A large number of streams join these rivers. All these streams exhibit dendritic to sub dendrite type of drainage. Nagavathi is a major river which is ephemeral stream flowing from northeast to southwest direction and has 32 km length and surrounded by west part Masakkallu reserve forest, eastern part Thamboran malai and central part Elagiri reserve forest in the south west by Mettur Stanley reservoir. A large number of minor irrigation dug wells and dug-cum-bore wells are the major sources, followed by tanks and canals. Which are constructed across streams and watershed shown in (Fig.2). The Soil type from Alfsoil, Entisoils, Verti soil, Incepti soil ans Hill soil are found in the watershed. Generally the soil is low in Nitrogen and Phosphate content. This soil is particularly suitable for growing Groundnut, Paddy, Ragi, Sugarcane, Coconut, Jowar (Cholam), Cotton and Pulses are the important crops grown in the study area shown in (Fig.3).

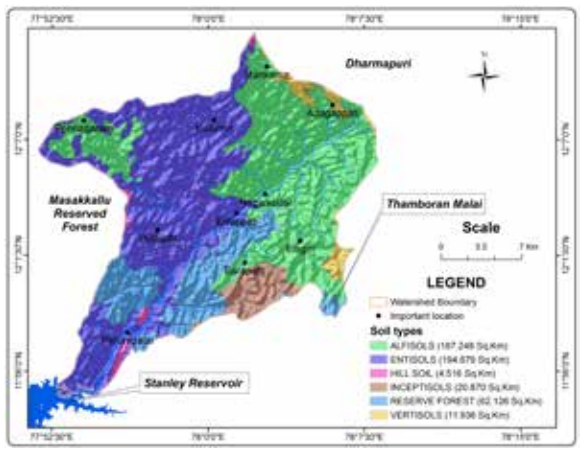

Fig 3: Soil map

LINEAMENTS

Lineaments, the large-scale linear features which are surficial expressions of underlying structural features like faults or joints in hard rock areas, are considered as potential good water zones. The lineament map has been prepared in ArcGIS and has got three major trending lineaments such as (NE-SW) to (NNE-SSW) from (NNW-SSE) to (NW-SE), and (E-W) shown in (Fig.4).

HYDROGEOLOGY

The important aquifer systems in the watershed are constituted by weathered and fractured crystalline rocks. Groundwater occurs under phreatic conditions in the weathered residuum and under semi-confined to confined conditions in deeper fracture zones. Recent alluvial deposits are found to form localized, discontinuous aquifers with low to moderate yield potentials. The southwest monsoon of 30.56 % (711.22 mm), Northeast monsoon of 40.71 % (854.21 mm), Pre monsoon of 23.75% (474.98 mm) and the post monsoon of 4.98 % (14.75 mm) of the total mean annual rainfall. During NE monsoon period, the station Pennagaram recorded the maximum average rainfall of 990 mm and Perumbalai recorded the minimum of 435 mm. SW Monsoon the second highest precipitation was received in the Dharmapuri and Perumbalai rainfall stations during the study period (2003-2014). Pre monsoon season highest precipitation was received in the year of 2006 and lowest precipitation received in the year of 2009. Post monsoon lowest precipitation received in the year of 2003 – 2014. The average water level being lower than 4.70 m bgl , there is arise in parts of central, southern, and SE regions of upto 5.80 m bgl and deepening below 4.70 m bgl in eastern, western and northern regions. The rise and fall depends upon the amount, duration and intensity of precipitation, depth of weathering, specific yield of the formation etc.

HYDROGEOMORPHOLOGY

Dome and Ridge type Residual hills are with an area of 68.05 Sq.Km. They are scattered in the south-western part of the study area. The groundwater prospect in this zone is also described as poor. Dome type Denudational hills (48.43 Sq.Km) are formed due to differential erosion and weathering. These occupy the center of the study area.

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The groundwater prospect in this zone is also described as poor. Inselberg (8.11 Sq.Km) Isolated, very steep conical hill and groundwater potential in poor. Shallow weathered Pediplain (211.90 Sq.Km): These areas are covered with shallow weathering material ranging from 0 to 6.5 m. Most of the study area is occupied by this unit. The groundwater prospect in such zone is described as Medium. Moderately buried pediplain: These areas are described as nearly flat terrain with gentle slope. These are found almost along all the major drainage courses. In the study area, this unit covers an area of 0.27 Sq.Km and good groundwater potential. Valleys fill (48.40 Sq.Km) of different shapes and sizes occupied by valley fill partly detrital and partly weathered material. The groundwater potential ranges from good to very good. These valleys are developed along the fractures and such places can be exploited for groundwater through deep bores. In general, it is observed that adequate recharge source of groundwater is met within valley fillings it is shown in (Fig.5).

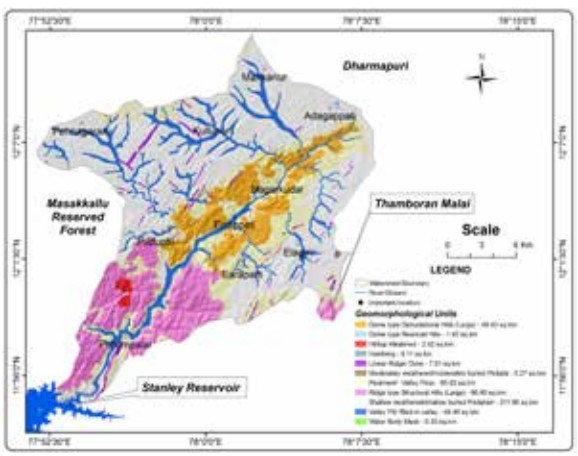

Fig 5: Hydrogeomorphology Map

GROUNDWATER POTENTIAL ZONES

The full potential of remote sensing and GIS can be utilized when an integrated approach is adopted. Integration of the two technologies has proven to be an efficient tool in groundwater studies [11]. After the integration of all thematic maps, resulted map has been classified into five groundwater potential zones namely: Very Poor, Poor, Medium, Good, Very Good covering 63.336 Sq.Km,115.124 Sq. Km, 134.240 Sq. Km, 85.595 Sq. Km and 75.799 Sq. Km area, respectively (Fig.6). The geomorphologic units such as valley fill shallow and pediplain moderate are very good to good Groundwater potential zones and considered most favourable zones for groundwater exploration while pediplain shallow areas are good to Medium, pediment inselberg complex and pediment zones are Medium to poor and Denudational hills, Residual hills and Inselbergs are considered as poor to very poor groundwater potential zones in the watershed. Geomorphological mapping with methodological integrated approach, based on remote sensing and GIS techniques coupled with ground truth investigation, will definitely be helpful in demarcating potential groundwater zones in hard rock areas.

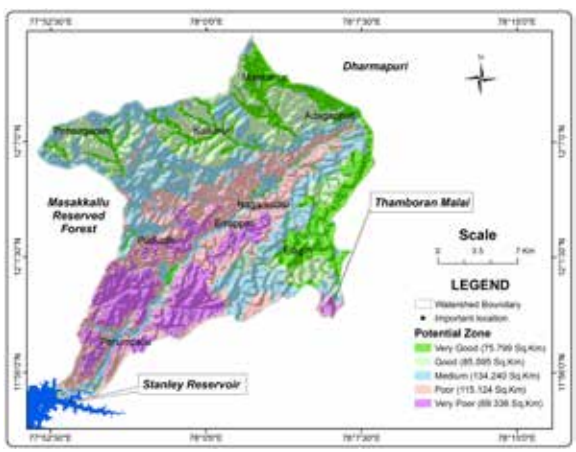

Fig 6: Groundwater Potential Map

CONCLUSION

In the present study, identifying groundwater potential zones in hard rock terrain is a challenging task. Using remote sensing and GIS have proved as vital tools in groundwater potential zones based on the integration of various thematic layers. The geomorphological units such as valley fill shallow and pediplain Medium are very good to good Groundwater potential zones and considered most favourable zones for groundwater exploration while pediplain shallow areas are good to moderate, pediment inselberg complex and pediment zones are moderate to poor and denudational hills, residual hills and inselbergs are considered as poor to very poor Groundwater potential zones in the Nagavathi watershed.

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