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Delineation of groundwater potential zones in Coimbatore district, Tamil Nadu, using Remote sensing and GIS techniques

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Abstract - Groundwater is one of the important natural resources which support the human health, economic development and ecological diversity. The main aim of this study is evaluation of ground water potential zones for Coimbatore District, Tamil Nadu. Remote sensing and GIS Technology contributes on efficient and effective result oriented methods for studying the occurrence and movement of ground water resources. Integration of various thematic layers influencing the ground water such as, geology, lineament density, geomorphology, drainage and land use have been used to classify the ground water potential zones. Based on this concept, weightage and ranking scores were assigned to each thematic layer with respect of influencing rate of water percolation. Finally weightage, multiplied by ranking and computed all the multiply values for quick assessment of ground water potential zones in the study area.

Keywords: Ground water Potential zone, weighted overlay analysis, RS and GIS.

1. INTRODUCTION

Ground water constitutes about two thirds of the freshwater resources of the world. In India it is a major source for all purposes of water requirements. It plays a vital role in the country's economic development and in ensuring its food security. More than 90% of rural and nearly 30% of urban population depend on ground water for drinking water. 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 [1].

Satellite imagery by virtue of providing synoptic view of the terrain at regular intervals offer immense potential in generating the information on parameters required for ground water exploration, exploitation and development. Remote sensing and GIS have been increasingly used for recharge estimation, draft estimation, mapping of prospective zones, identification of over exploited and under developed/ undeveloped areas and prioritization of areas for recharge structures which conjunctively facilitate systematic planning, development and management of ground water resources on a sustainable basis. This research paper is an effort to have

better understanding of the ground water occurrence and resources in the study area by using Remote Sensing and GIS techniques in combination with field/ existing data at Coimbatore district.

2 STUDY AREA

Coimbatore is an important district in western part of Tamil Nadu. The district has an area extent of 7466 sq. km. of which forest land covers an area of 1,558 sq. km. and which are only 5.74% of the state area. The study area Coimbatore district (Figure1) lies between north latitudes 10° 13' 00" to 11° 23' 30" and east longitudes 76° 39'00" to 77° 30' 00" and falls in the survey of India topographical maps numbers 58A, 58B, 58E, and 58F. The district is bounded on the northwest by the Nilgiris district, on the northeast by Erode district and to the southeast by Dindigual district and on the west and south by Kerala state.

3 MATERIALS AND METHODS

3.1 Methodology

The method of study broadly confined to field and laboratory interpretation and analysis, which includes ground truth and interpretation of remote sensing data and analysis of the same under GIS environment. A synoptic view of the methodology adopted is noted in the flow chart (Figure 2).

Geographic Information System (GIS) has become an increasingly powerful and important tool for hydrologist in the study and management of water resources. Remotely sensed data from satellite provides quick and useful base line information on the factor controlling the occurrence, potential and movement of groundwater such as lithology, geological structure, geomorphology, soils, land and land cover [2]. Present study following data types (Table 1);

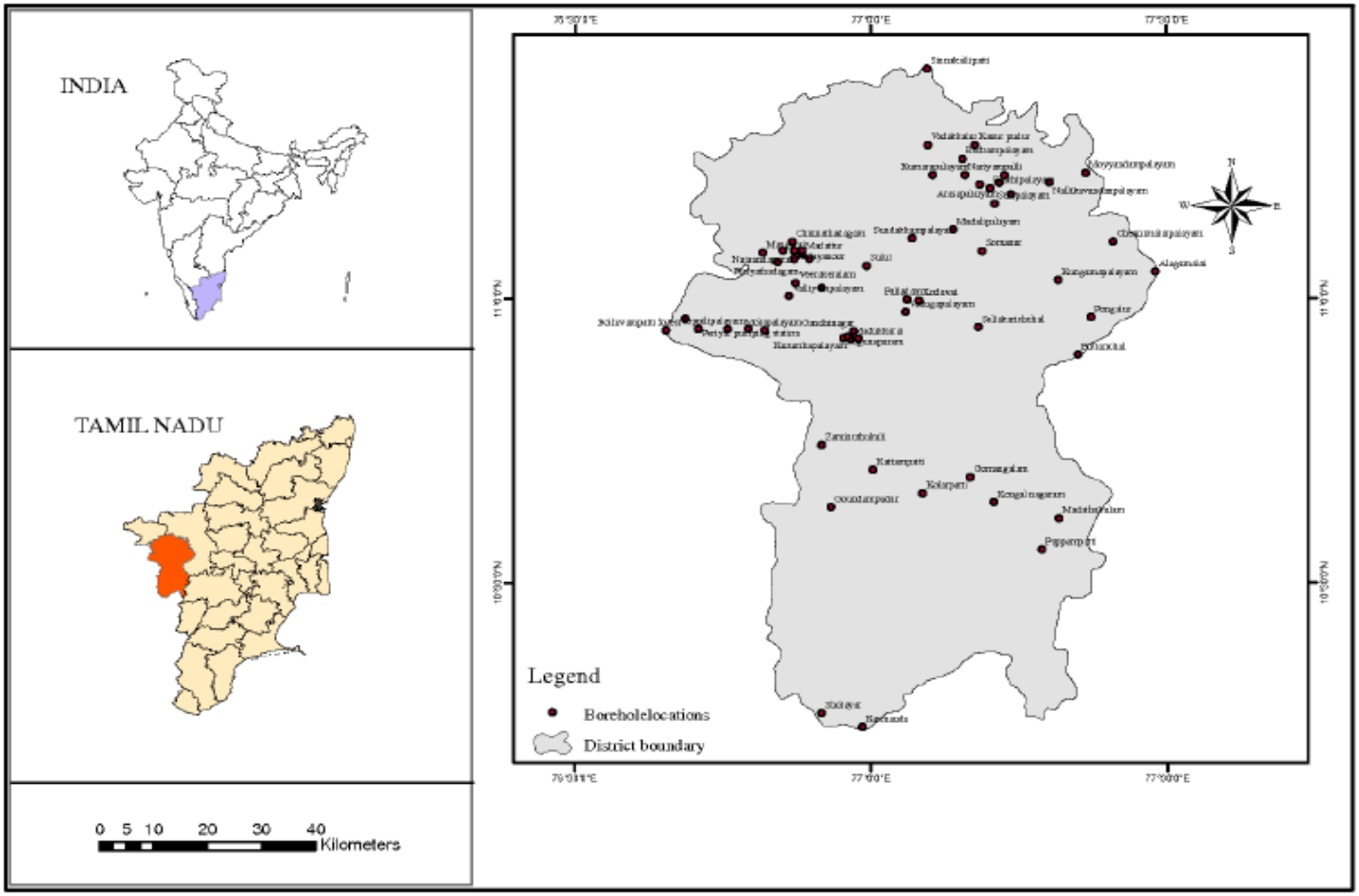

Figure 1: Study area and Location map of the Coimbatore district

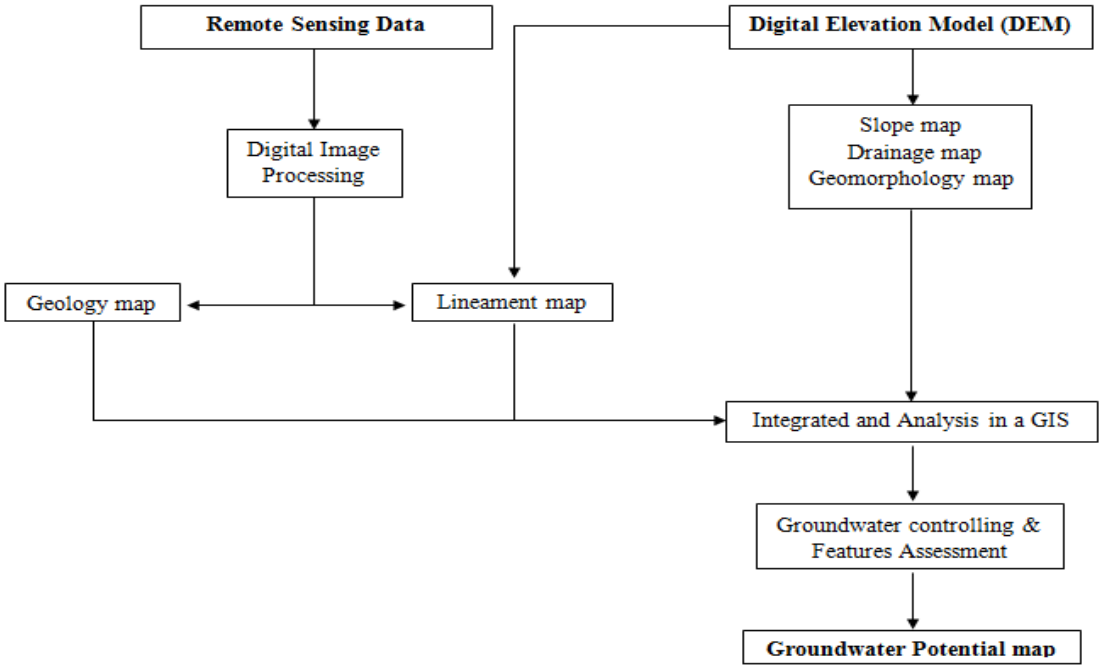

Figure 2: Flow chart showing methods employed for the study

Table 1. Details of various data sheets used

Types of Data	Details of Data	Source of Data
Toposheet	E 16 (1 : 50,000 scale)	Survey of India (SOI)
Thematic maps: Soil, Geology, Drainage, Gemorphology, Land use / Land cover, Lineament	Scale 1 : 50,000	National Bureau of Soil Survey and Land use planning (NBSS & LUP), Geological Survey of India (GSI), National Remote Sensing Centre (NRSC)
Slope		DEM
Satellite Sensor Resolution	IRS ID LISS III 23.5 meter	National Remote Sensing Centre (NRSC), Hyderabad

4 RESULTS AND DISCUSSION

Groundwater availability in Coimbatore district is mainly held by hard crystalline rocks which are devoid of primary openings. The occurrence and movement of groundwater in these rocks are controlled by the secondary openings like joints, fractures and fissures present in them. Due to heterogenous nature of crystalline rock, it requires careful planning and scientific approach to identify the groundwater potential zones. Remote sensing techniques using satellite imagery have proved to be an indispensable tool in morphometric analysis and groundwater studies [3].

As mentioned in the methodology the selected six parameters have been created using GIS techniques and it has been subjected to weightage analysis. The detailed discussion of each parameter is following;

4.1 Geology

Geology is one of the major factors which plays an important role in the distribution and occurrence of ground water. A detailed field investigation of the study area reveals an interesting igneous association set admits country rocks of Precambrian country rocks include Hornblende-Biotite-Gneisses, Garnet Sillimanite Gneiss, Granulites, Charnockites. Apart from these, older Ultrabasics occur as enclaves within Charnockites and gneisses. Granites and Quartz veins are also seen as intrusive bodies. The igneous association which are also Precambrian age consists of Magnesite bearing Ultrabasics and associated alkaline rocks (Figure 3). The weightage were assigned based on the rock's influence in the groundwater.

4.2 Lineament Density

Lineaments like joints, fractures and faults are hydrogeologically very important and may provide the pathways for groundwater movement [4].The Lineament map is generated from the satellite imagery by identifying the fault lines in the imagery using the ArcGIS. The density of the lineament is generated using the lineament map. The weights have been given by setting more threat levels to higher lineament density which is groundwater prone. The purpose of this is to analyze the spatial distribution of lineaments extracted from satellite images according to their density, intersection density, length and orientation in order to contribute to the understanding of the faults of the study area which is a important locations since they are weaker in nature and resulting in the percolation and storage of waves through these ruptured planes. Lineaments usually appear as straight lines or "edges" on the images which in all cases contributed by the tonal differences within the surface material. Lineament and Lineament density distribution for the district are as shown in figure 4.

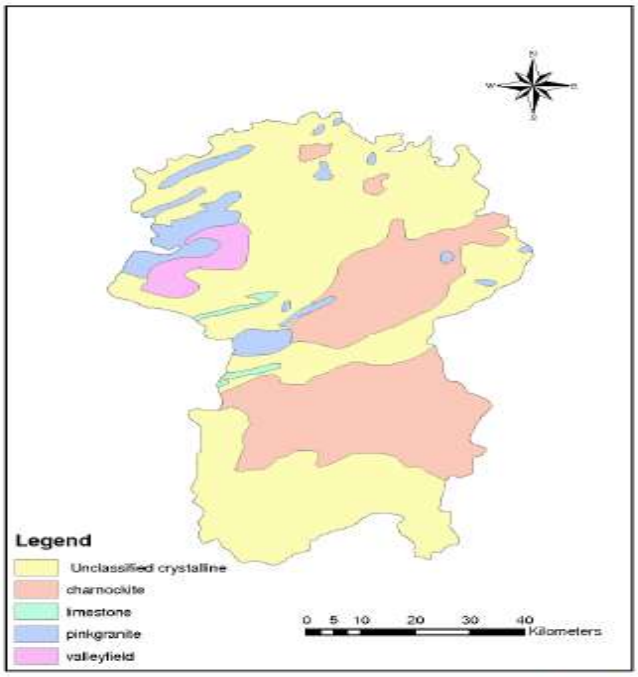

Figure 3: Geological Map of Coimbatore District

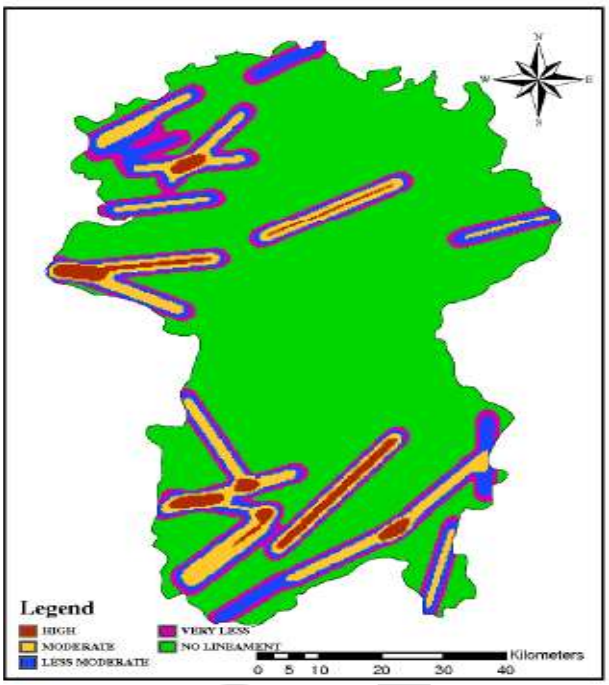

Figure 4: Lineament Density Map of the Study area

4.3 Geomorphology

Geomorphology is the study of earth structures and also helps in depict inherited process relating to the Groundwater potential zones also structural features. The area is marked by plateau landforms, structural, denudational and residual hills of Charnockites and Gneisses and linear ridges of basic Dykes. The gneisses and Ultra Basic hills have invariably generated a wide bazada zone. The various geomorphic units, as revealed from the studies are structural and residual hills, linear ridges, bazada zones, buried pediments, erosional plains, valley fills and uplands. A fractures and lineaments pattern are controling the geomorphology of the area and suggests that structural and denudational process predominate the fluvial process. The district has thick vegetation in hills and with agricultural activities in plains and valleys.

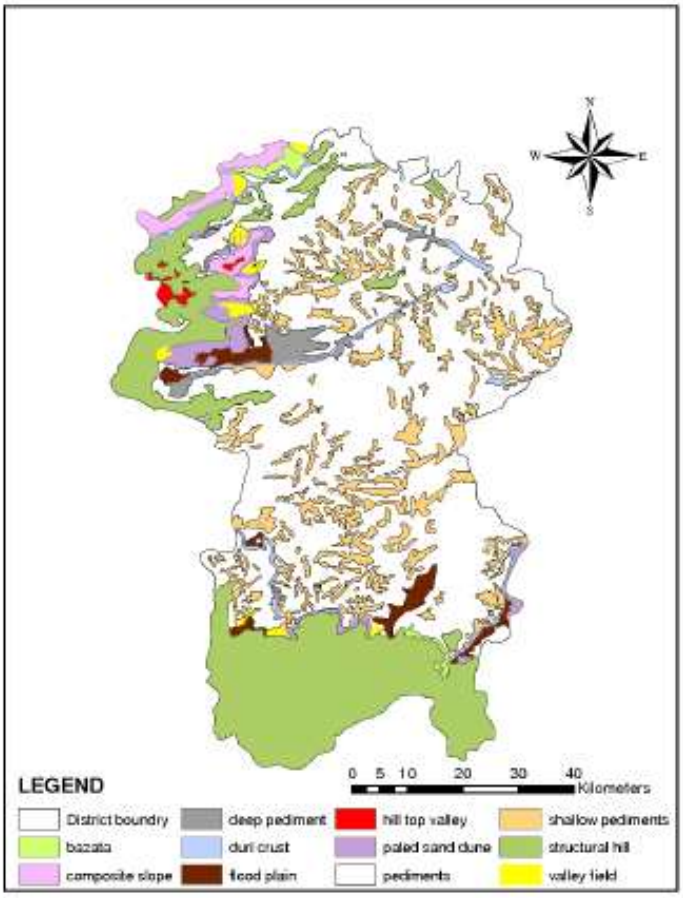

Figure 5: Geomorphology map of the study area

4.4 Drainage

The drainage is one of the factors which play the important role in groundwater occurrence. The scanty rainfall in the Coimbatore district leads to dependency of agricultural activities with respect to wells, irrigation project, tanks etc. The ephemeral rivers are Bhavani, Noyil, Palar, Aliyar and Amaravathi, which have been fully exploited by means of several anaicuts and dams built across them for irrigation purposes. There are number of masonary and earthen reservoirs and dams present here such as Amaravathi, Thirmurthi Parambikulam, Sholaiyar, Aliyar, etc.

The river drains an area of 1056 Sq.km with in this district. Five surface reservoirs are located on this river, which form part of the Parambikulam Aliyar project. The drainage pattern in the district (Figure 6) is mostly controlled by the structural features. Among the different drainage pattern and associated features recognized in this district, the following are noteworthy Radial, Parallel, Valley fills and Dendritic to Subdentritic. The drainage density map for the study area is shown in figure 6.

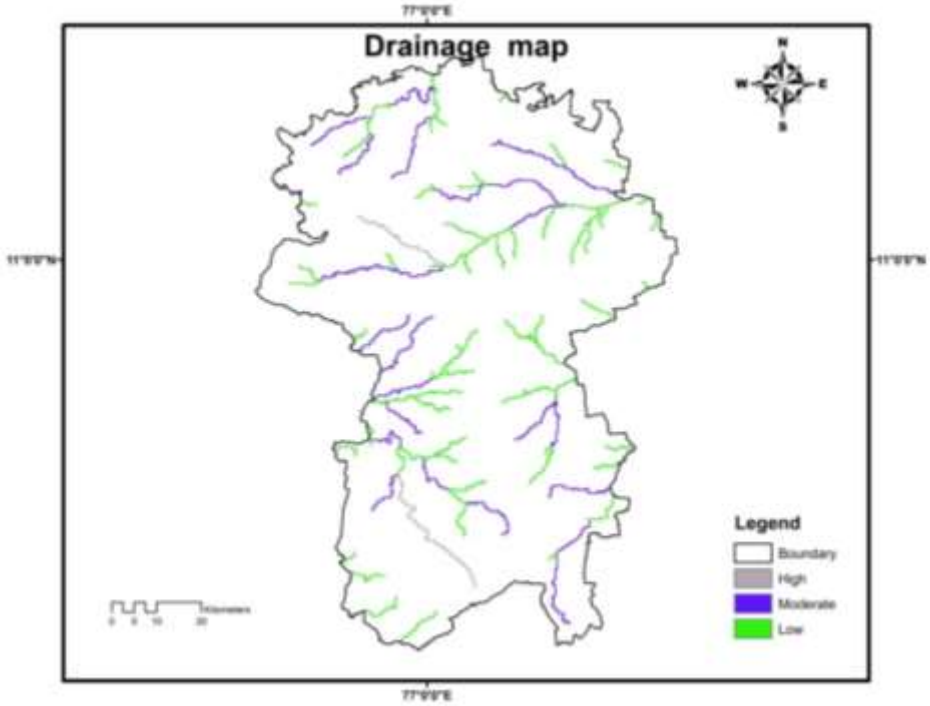

Figure 6: Drainage system and density of the Study area

4.5 Slope

The slope angle is considered as an important input as it has considerable influence in the study area for the identification of Groundwater potential zones. The slope of the study area was classified into six classes, such as less than 5 degree plain area, slope zone 5-15º, 15-25º, and 25-35º and above 45º and weightages of 5, 3, 2 and 1 was respectively assigned to them based on their groundwater prospects. In this case, higher weightage was given to shallow slopes and gradually lesser and lesser weightages were assigned steeper and steeper slopes because runoff is directly proportional to slope (Figure 7).

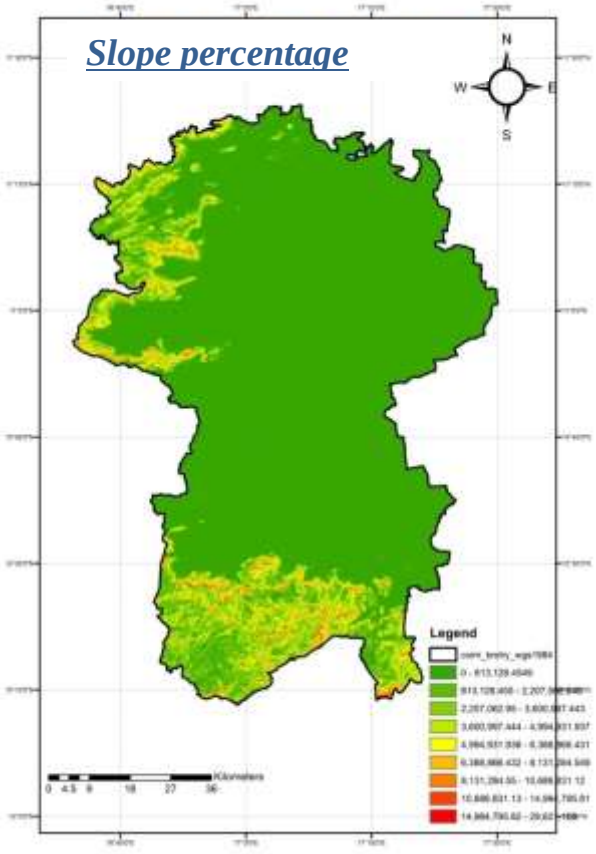

Figure 7: Slope Map of the study area

4.6 Land use and Land cover

Land use is clearly constrained by environmental factors such as soil characteristics, climate, topography, and vegetation. But it also reflects the importance of land as a key and finite resource for most human activities including agriculture, industry, forestry, energy production, settlement, recreation, and water catchments and storage.

The Land use/ Land cover map is generated from the satellite imagery and the area is classified in to Urban or Built up land, Residential, Commercial and Services, Industrial, Transportation, Communication and Utilities, Agricultural Land, Stony waste, Forest land, Water bodies and so on. The weights have been given based up on the threat levels. Land cover is the physical material at the surface of the earth includes grass, asphalt, trees, bare ground, water, etc. The Land cover map of the study area is shown in figure 8.

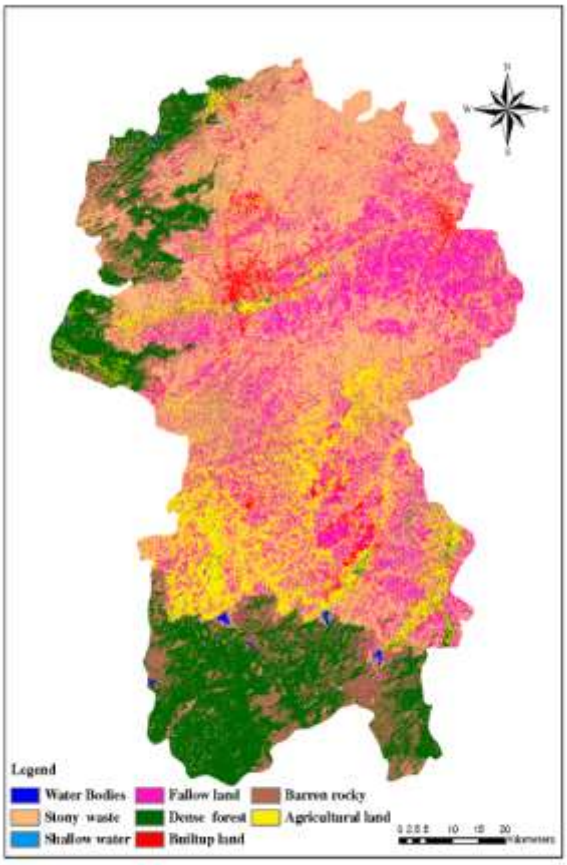

Figure 8: Land Cover Map of the study area

5. GIS INTEGRATION AND GROUNDWATER TARGETING

The above thematic vector layers were converted into to raster format. Using raster calculator in spatial analysis module of Arc GIS, all the raterised thematic layers were added one over the other and there from final integrated groundwater prospect map was derived (Figure 9). After generating the GIS layers on Geology, lineament density, geomorphology, slope, drainage, Landuse / Land cover, these six GIS layers were integrated one over the other using GIS Add function. Such GIS integration has resulted in to 2363 polygon classes and having weightage from 93 to 247. Such dynamic range of weightage of these 2363 polygon classes were grouped into three via: less than 93, 149-201 and more than 247. Accordingly, the polygon classes falling under these three weightage groups were dissolved and clubbed together and a GIS layer was prepared showing only the above three classes of polygons. Based on the weightages these were grouped into priority area I, II, and III for the groundwater potential zones. Such are weightages having more than 202 are favourable zones, if the weightages between 201 and 149 are moderately favourable zones and finally the weightages are less than 148 are grouped as low least favourable and are shown in figure 9.

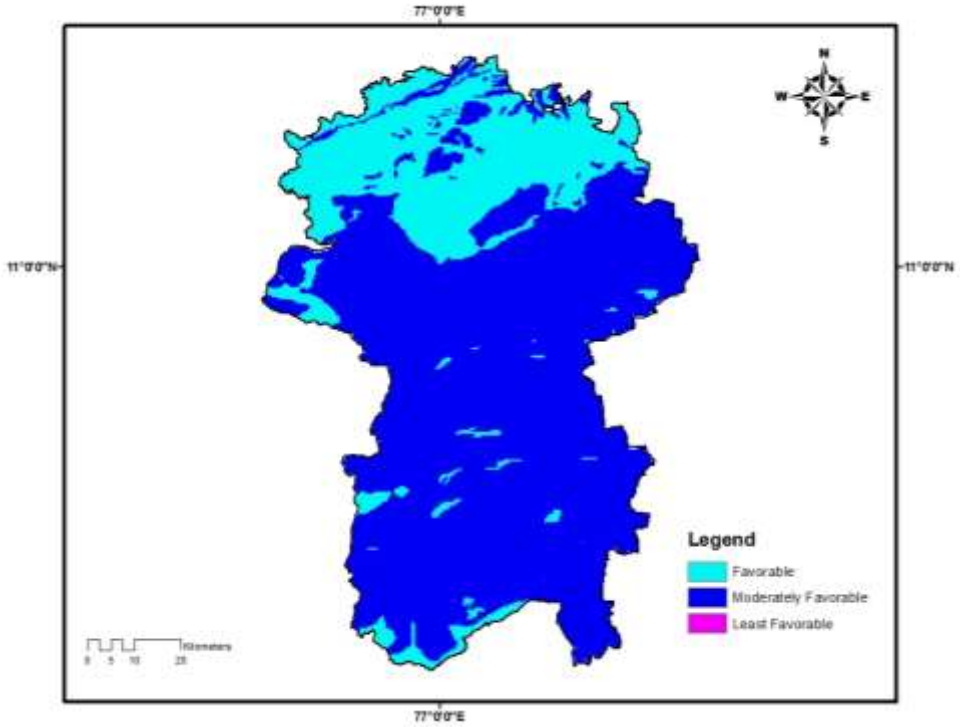

Figure 9: Integrated output and Groundwater potential zone

6. CONCLUSION

The study revealed that the usefulness of spatial data for assessment of groundwater for the study area and also demarcated the groundwater potential zones of Coimbatore district. From the analysis the weightages in the GIS layer was generated, for identifying the groundwater potential zones, different ranks and weightages of the thematic data sets was given and integrated using overlay functions of GIS analysis. Such weightages, the areas having more than 202 values buffered out as high groundwater potential zones. The areas having 149-201 are buffered out as moderately groundwater potential zones. And the area having less than 148 weightages are buffered out as low groundwater potential zones, the study area concern. For the study area, the high groundwater potential zones falling in major portions of Mettupalayam and Avinashi taluks and others are priority wise Coimabtore (north / south), Palladam, Pollachi and Velparai taluks.

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