RS and GIS aided Demarcation of Groundwater Potential Zones in Bangalore Urban District, Karnataka

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Abstract: The parameters of governing ground water resources and assessing to predict groundwater potential is essential for planning and developing in the metropolitan cities like Bangalore. This present research works depicts with the integrated approach of remote sensing and geographical information system (GIS) to delineate groundwater potential zones of Bangalore urban district, Karnataka.The various thematic maps like geomorphology, geology, drainage density and lineament have been generated and analyzed in the study. All these themes and their individual features were obtained by overlaying all the thematic maps weighted in terms of overlay method using spatial analysis ARC GIS 10.1. Demarcation of the Groundwater potential zone in the study area is derived and it indicates that around 50 % of the area in Bangalore urban district falls under moderate ground water potential zones. Hence the study will be effective and economical method for groundwater potential mapping.

Keywords: Groundwater, Remote Sensing, GIS, Potential Zone, Weighted Overlay.

1 INTRODUCTION

Globally groundwater is estimated to provide 36 percent of the total potable water supply, 43 percent of the water used for irrigation and 24 percent of the industrial water supply.Typically, groundwater is thought of as water flowing through shallow aquifers, but, in the technical sense,it can alsocontain soil moisture, permafrost (frozen soil), immobile water in very low permeability bedrock, and deepgeothermal or oil formation water. Groundwater is hypothesized to provide lubrication that can possibly influence the movement of faults. It is likely that much of Earth's subsurface contain some water, which may be mixed with other fluids in some instances. 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 it 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 and reduces percolation.Surface water bodies like rivers, ponds, etc., can act as good groundwater recharge zones.Most of the groundwater originates directly from excessrainfall infiltrating the land surface. Delineating of the potential groundwater zones using remote sensing and GIS is an effective practice presently. In recent years, extensive use of satellite data along with conventional maps and ground investigations has made it easier to establish the base line information for groundwater potential zones.

Remote sensing and GIS integration for the exploration of groundwater potential zones is used by a number of researchers around the world, and it is found that the input factors in determining the groundwater potential zones were different, and hence the results vary accordingly. (Biswaset al,

2012;Nezar et al, 2012; Subodh et al, 2012; Sudarsana et al, 2012; Murugesan et al, 2013). The derived results are found to be satisfactory based on field survey and it varies from one region to another because of varied geo-environmental conditions.Remote sensing not only provides a wide-range scale of the space-time distribution of observations, but also saves time and money (Murthy, 2000; Leblanc et al., 2003; Tweed et al., 2007). In addition it is widely used to characterize the earth surface (such as lineaments, drainage patterns and lithology) as well as to examine the groundwater recharge zones (Sener et al., 2005). The main objective of the present study is to identify the ground water potential zones in Bangalore Urban district based on remote sensing and GIS techniques. The study utilizes weighted overlay method for combined analysis of various themes.

2 STUDY AREA

The study area is Bangalore Urban district of Karnataka State. The district is located in the southeastern part of Karnataka. The areal extent of the study area is2190 sq.km and is geographically located between the North latitudes 12°39' 32''& 13°14' 13''and East longitudes 77°19'44''&77°50'13''. The district is bounded by Bangalore rural district in the East, West and North except in southeast, where the district is bounded by Krishnagiri district of Tamil Nadu state. The district is divided into four taluks namely Anekal, Bangalore North, Bangalore South and Bangalore East taluks. There are 17 hoblies, 9 municipal corporation and 668 villages in the district. Major part of the district is drained by Shimsha and Kanva rivers of Cauvery basin i.e., Bangalore north and South taluks. Anekaltaluk is drained by South Pennar river of Ponnaiyar basin, which takes its birth from Nandi hills and flows towards south.

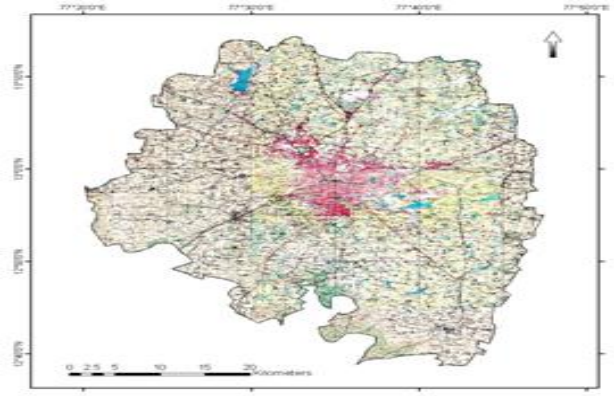

Fig. 1. Study Area Map

Physio graphically the district can be divided into rocky upland, plateau & flat topped hills at a general elevation of about 900m above mean sea level with its major part sloping towards south and south east forming denudational plateus interspersed with hills all along the western part. The denudational plateus form the major part of the district underlined by charnockites granites and gneiss with a maximum elevation of 850 to 950 m above msl. Major part of the denudational plateus constitute low relief area having matured dissected rolling topography with erosional land slope covered by a layer of red loamy soil of varied thickness. The Pedi plains are dissected by streamlets flowing in southern direction. The soils of the districts can be broadly grouped into red loamy soil and lateritic soil. Red loamy soils generally occur on hilly to undulating land slope on granite and gneissic terrain. It is mainly seen in the eastern and southern parts of Bangalore north and south taluks laterite soils occur on undulating terrain forming plain to gently sloping topography of peninsular gneissic region. It is mainly covered in Anekal taluk and western parts of Bangalore North and South taluks. Typical monsoonal climate prevails in the district with major contribution of rainfall during southwest monsoon. In general, pre-humid to semi-arid climatic conditions prevail in the district. Average temperature is 23.1°C. Normal annual rainfall Bangalore urban district received is 831mm ground water occurrence, movement and recharge to aquifers are controlled by the degree of weathering, fracture pattern, geomorphological setup and rainfall. Granites and Gneisses of peninsular gneissic group constitute major aquifers in the urban district. Ground water occurs in phreatic conditions in the weathered zone and under semi confined to confined conditions in fractured and

jointed rock formations. Laterites of Tertiary age occur as isolated patches capping crystalline rocks in Bangalore north taluk and ground water occur in phreatic condition. Alluvium of 20m thick, which occur along the river courses, though of limited thickness and aerial extent possess substantial ground water potential.

3 METHODOLOGY

The base map of the study area was prepared based on Survey of India (SOI) topographic maps on a 1:50,000 scale. The drainage network for the study area was extractedfrom the topographic maps using digitization from which the drainage density map was derived. The slope map was prepared using SRTM DEM data.

LISS Satellite Images of the study area (geo-coded, with UTM projection, spheroid and datum WGS 84, Zone 44 North) have been used for delineation of thematic layers such as land-use/land-cover, lineament, slope, etc. Soil and geology maps were collected as secondary data and integrated with the other thematic layers.The groundwater potential zones were identified by overlaying all the thematic maps in terms of weighted overlay methods using the spatial analysis toolsin GIS environment. During weighted overlay analysis, the ranking was given for each individual parameter of each thematic map, and weights were assigned according to the multi influencing factor (MIF) of that particular feature on the hydro-geological environment of the study area.

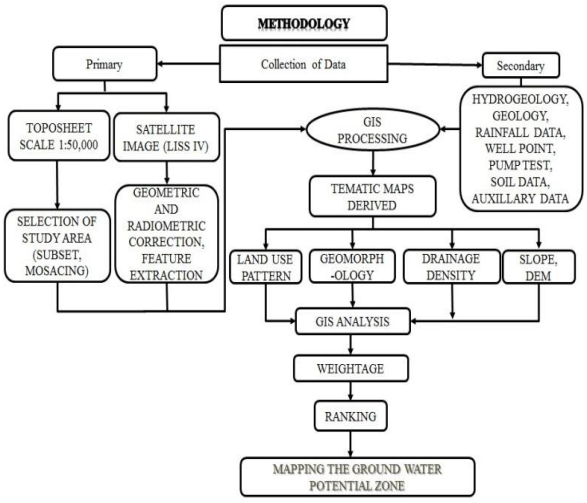

Fig. 2 Flow Chart of the Methodology

4 RESULTS AND DISCUSSION

Various thematic maps like geomorphology, geology, drainage density and lineament have beengenerated and analyzedin the study. A digital elevation model has been prepared for delineating the topographical characteristics. The study area has undulating terrain in the western and eastern and south-western periphery with low hills. The elevation is higher in the southwestern parts of the study area (more than 900 m above msl) compared to other portions. Middle portion of the study area is comparatively flatter. Drainage density is very high in the west, south-west and north-western parts.Most of the natural drainages are vanished in the middle portion of the study area due to the presence of concentrated settlements. Most of the lineaments are trending in NNW-SSE direction along with a few in E-W directions.

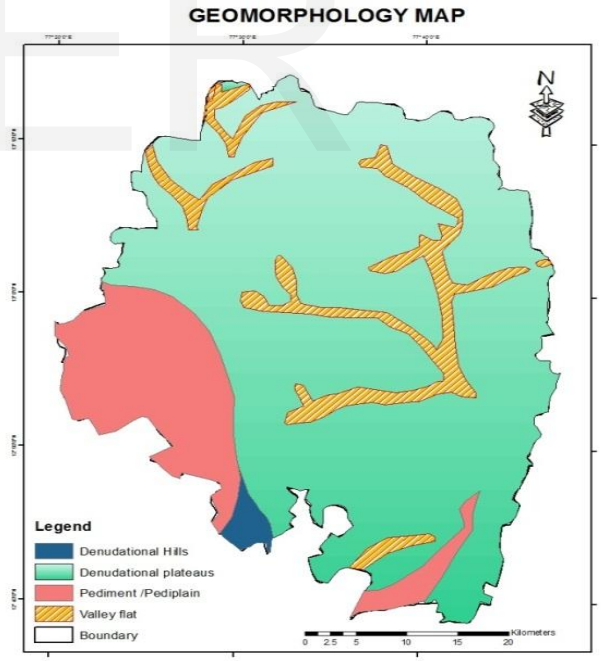

Fig. 3. Geomorphology map of the study area

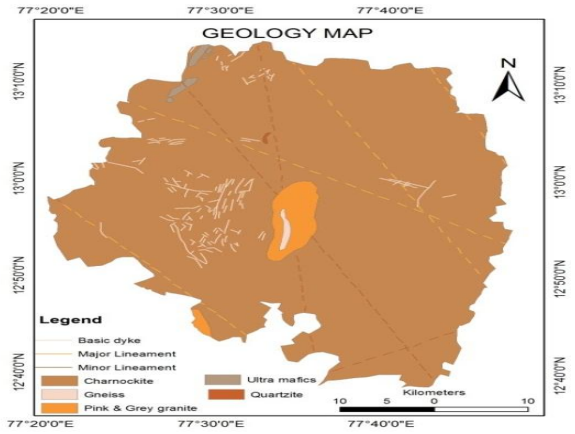

Fig. 4. Geology map of the study area

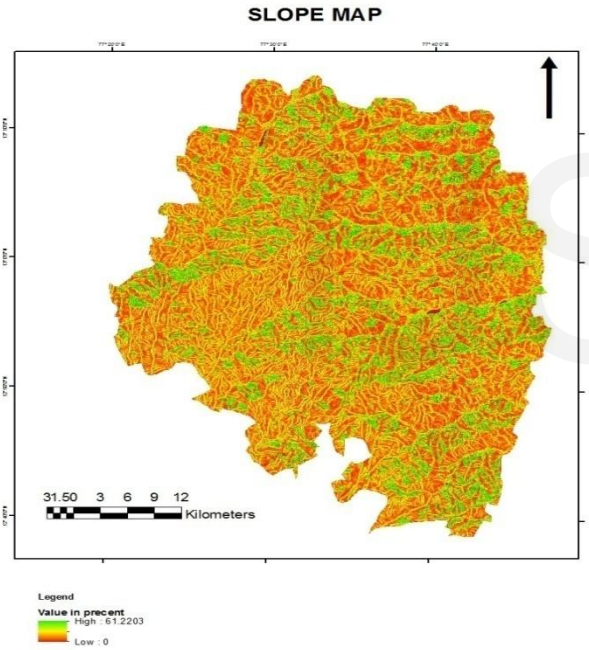

Fig. 5. Slope map of the study area

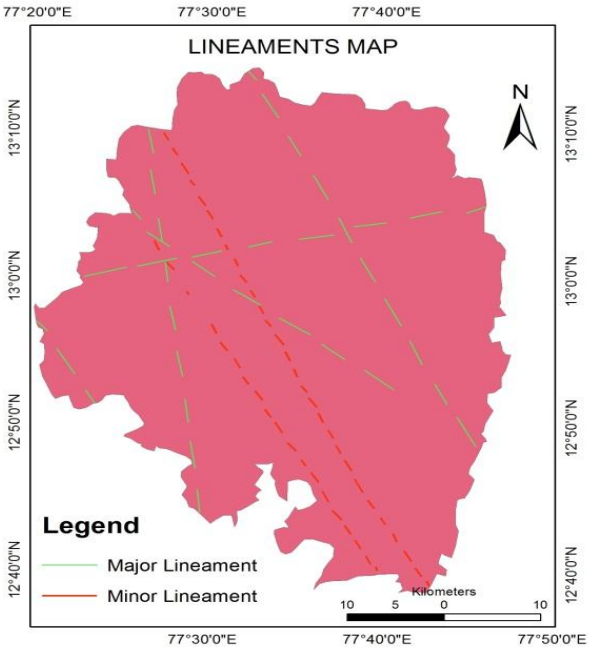

Fig. 6. Lineaments in the study area

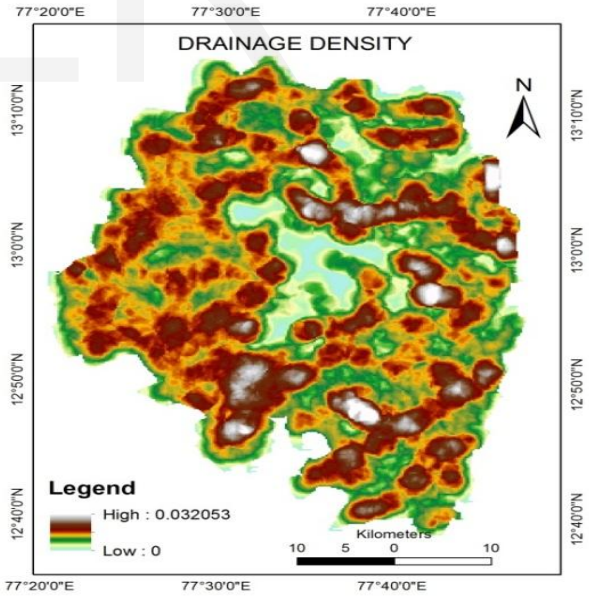

Fig. 7. Drainage density map

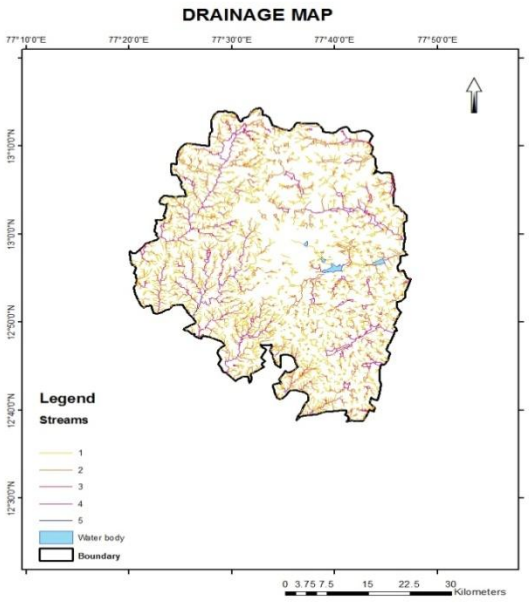

Fig. 8. Drainage map with stream ordering

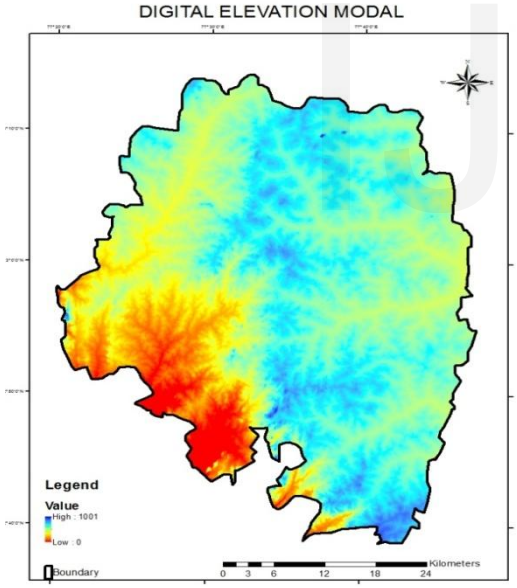

Fig. 9. DEM for study area

The groundwater potential zones have been obtained by overlaying all the thematic maps in terms of weighted overlay method using the spatial analysis tool in Arc GIS 10.1. During the weighted overlay analysis, the rank has been given for each individual parameter of the thematic mapson its weight pertinent to infiltration, percolation, water recharging capacity, etc. The theme weightage and ranking details are given in Table1.

Thematic Layers	Features	Class	Ranking
Geomorphology	Valley flat	Good	4
	Pediplain/pediments	Moderate	3
	Denudational Plateau	Moderate-poor	2
	Denudational hills	Poor	1
Geology	Charnockites	Good	4
	Ultra mafics	Moderate	3
	Quartzite /Banded magnetite quartzite	Moderate-poor	2
	Pink & Grey granite	Moderate-poor	1
	Gneiss/Migmatite/Granite	Poor	1
Soil	Medium deep, red clay soils	Poor	1
	Deep, alluvial clayey soils (salt affected in patches)	Moderate-poor	2
	Deep, lateritic clayey soils		
	Deep, red clayey soils	Moderate-poor	3
	Medium deep, red gravelly clay soils	Moderate-poor	3
	Deep, lateritic gravelly clay soils	Moderate	4
	Rockey land associated with shallow, red gravelly clay soils	Good	5
		Good	6
Slope	Nearly level/Very gentle, 0–3%	Good	6
	Gentle, 3–5%	Good	5
	Moderate, 5–10%	Moderate-poor	4
	Moderate steep, 10–15%	Moderate-poor	3
	Steep, 15–35%	Poor	2
	Very steep, 35–50%	Poor	1
Drainage Density	High	Poor	1
	Medium	Moderate	2
	Low	Good	3
Lineament Density	1-1.6	Poor	1
	1.6-2.2	Moderate-Poor	2
	2.2-2.8	Morderate	3
	2.8-3.4	Moderate	4
	3.4-4	Good	5

Table1. Theme Weightage and Ranking

Totally five types of groundwater potential zones have been identified in the study namely good, good to moderate, moderate, moderate to poor and poor. The ground water potential zone map is presented in the figure 10.Majority of the study area falls under moderate zone. Moderate zone is characterized by medium to high drainage density and moderate slopes. The good and good to moderate zones are mainly restricted to the middle parts of the study area. These areas have gentle slopes, low drainage density and characterized by intersection of lineaments. These areas have denudational plateus and valley flats as major landforms. Geologically majority of the study area consists of charnockites which have the high weightage for ground water. The granites are seen in the middle portion with joints and fractures due to intensive chemical weathering which can store sufficient water.The middle portion of the study area

has concentrated settlements compared to other parts of the study area. However a good number of tanks and parks can be observed in this region. The water bodies cover about 5 per cent of land in the Bangalore city. Moreover artificial recharging is practiced in many of the residential sites. Bangalore receives a rainfall 970 mm annually and the number of rainy days is 60. Highest amount of rainfall is received during April to November, while the rest of the months receive scanty rainfall. Peak runoff is 50 millimeters per hour. Due to the availability of sufficient rainwater, water is basically stored in these rainwater harvesting systems and used for non-potable purposes. Water from the rooftops is led into storage structures. The Moderate to poor and poor groundwater zones are seen in the denudation hills, steep slopes and regions with high drainage density

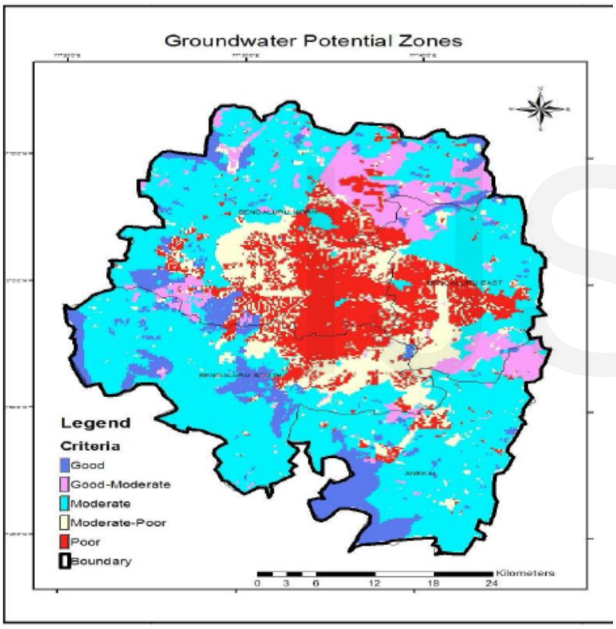

Fig. 10. Groundwater potential zone map

5 CONCLUSION

It is concluded that around fifty percent of the area in Bangalore district falls under moderate groundwater potential zone. The middle portion of the study area is having a good groundwater potential due to the presence of charnockites and weathered granites as lithological units, denudationalplateus and valley flats as landforms and due to gentle slope, low drainage density and intersection of lineaments. Presence of abundant tanks and lakes drained by the surrounding undulating terrain and the practice rainwater harvesting in the residential sites offer an excellent scope for ground water recharge in the middle portion of the study area. The study also concludes that RS and GIS based thematic multi-criteria weighted overlay analysis is an effective and economical method for groundwater mapping compared to conventional methods.

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