ISSN: 2582 - 6379
IJISEA Publications
International Journal for Interdisciplinary Sciences and Engineering Applications
IJISEA - An International Peer- Reviewed Journal
2024, Volume 5 Issue 1
www.ijisea.org

Ground water potential zone identification in hard rock terrain : A Case Study of Upper Chandrabhaga sub basin Central, India

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ABSTRACT

Present study area is part of Upper Chandrabhaga sub basin situated South West to the Nagpur district of Maharashtra. In the study area groundwater is primarily controlled by structures, hard basaltic rock type and landforms and to a lesser expanse soil, slope and drainage. Geology, geomorphology, slope and lineament were taken as the principal factors for the distribution and occurrence of groundwater in the given study area. Structure, drainage and Land cover or use and incorporated in characteristic expressions of geomorphologic and lithology. Geologically the study area comprises the basaltic lava flows which show the secondary porosity and hence the identification of groundwater potential zones map is very necessary. The integration of all the thematic maps e.g. lithology, structure, geomorphology, hydrology, land use land cover and lineaments with further analysis of data for ground water potential zones were delineated and classified. From the total 232.98 ^{2} km area the good ground water prospect zone is 89.91^{2} km, Moderate 35.64, Good to moderate 35.64, Moderate to poor 18.17, Poor 11.77, Poor to nil 2.85and Very good 50.97 square kilometer.

I.INTRODUCTION

Study of ground water is attracting and an ever increasing interest due to scarcity of good quality subsurface water and growing need of water for domestic, agricultural, and industrial uses. It has become crucial not only for targeting of groundwater potential zones, but also monitoring and conserving this important resource (CGWB, 1985, 2000). Watershed is further classified as sub-watershed, covering an area of about (30-50 km²), mini-watershed, (10-30 km²) and micro-watershed, (5-10 km2) (NRSA, 1995, 2007). The watershed or river basin is therefore an ideal management unit. Water (movement, cycling, use, quality, etc.) provides a focus for integrating various aspects of watershed use and for making regional and global connections. Satellite images data facilitate the preparation of lithological, structural, and geomorphological maps, especially at a regional and small scale according to the resolution of the images. The rock groups, such as structural features, lineaments and fractures, folds and different landforms, faults due to their comprehensive content and polarimetric ability (Siegal andGillespie, 1980, Drury, 1987, Kumar et. al., 2010). Optical explanation of remote sensing images is realize in an well organized and way using basic interpretation elements (Sabins, 1987). An exposition clue contain combinations of attribution features to identify device in an likeness. Classic key features are measurements, shape, tone, surface, pattern and color. Similarly many procedures are available for image data manipulation (Lillesand and Kiefer, 1994).

In the present scenario, remote sensing technique integrated with GIS is becoming a powerful tool for the identification and mapping of groundwater potential zones because of time consuming and cost effective manner (Moore et al., 1991; Krishnamurthy et al., 2000; Jha et al., 2012; Arkoprovo et al., 2012; Hammuori et al., 2012; Lee et al., 2012;Manjare, 2014, Davoodi et al., 2015; Manjare, 2017,Das and Pardeshi, 2018; Andualem and Demeke, 2019,Manjare and Pophare 2020). The GIS proposed spatial data management and analysis tools that can assist users in managing, keeping, checking, calculating and showing positional and important information about geographical data (Burrough, 1986, Krishnamurthy et al., 2000; Khan et al., 2006).The present study is tributary of Kolar River which is main tributary of of Kanhan River and designated as Chandrabhaga watershed.

II.AREA OF STUDY

The study area lies in the Survey of India toposheet no. 55 K/12, 16, 55 O/3, 55 O/4, 55L/13 and55P/1 bounded by the 20^{0} 50’ 00’’ N to 21^{0} 15’ 00’’ and 78 ^{0} 40’ 00’’ to 78 ^{0} 10’ 00’’. The Upper Chandrabhaga sub basin situated South West to the Nagpur district of Maharashtra. The Chandrabhaga River is tributary of Kolar River which is main tributary of of Kanhan River flows southeast from above the source (Fig.1). The total area of the upper Chandrabhaga sub watersheds comprising an area of is 232.98 sq. km.

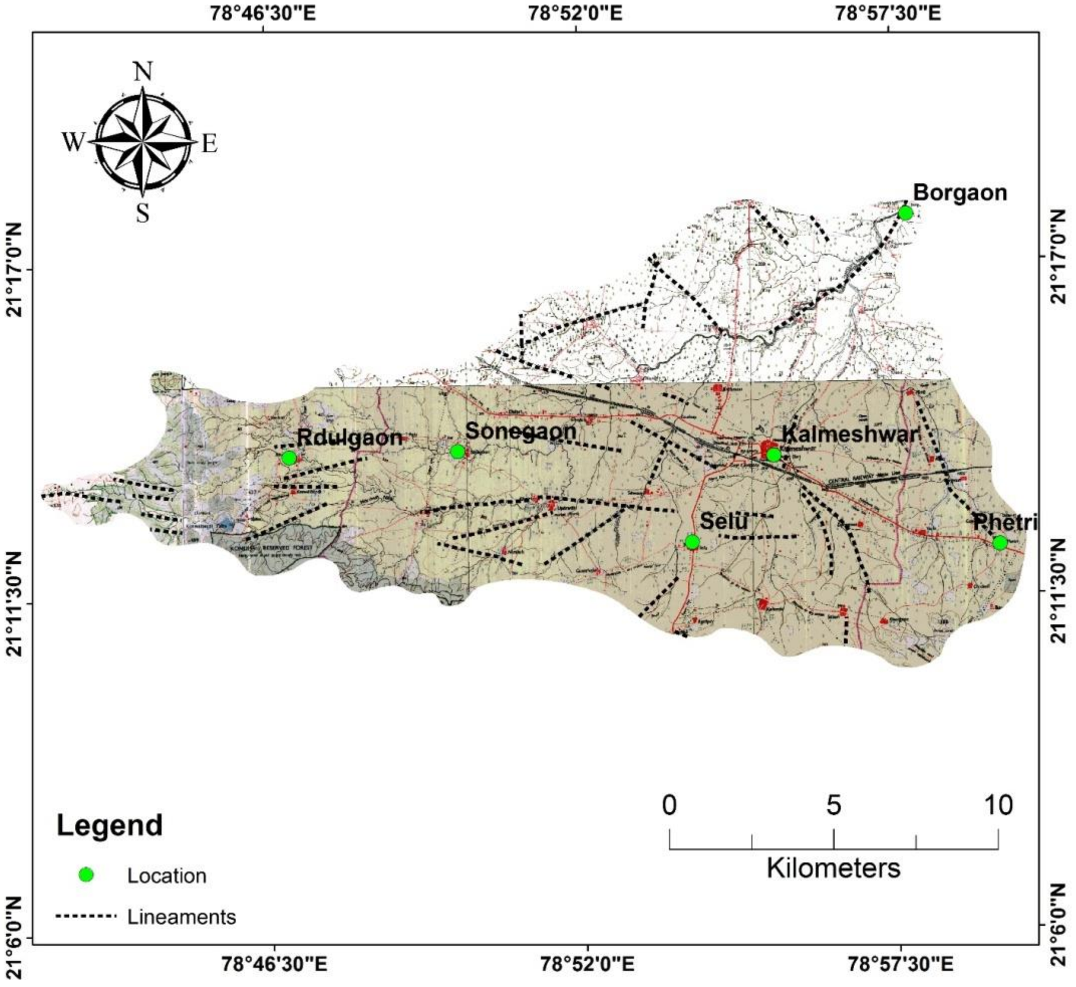

Fig.1: Location map with lineaments of the study area

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Data Used and Methodology

IRS - P6, LISS-III data 22 April 2009, geocoded at the scale of 1:50000 (Fig.2). Survey of India toposheet on scale 1:50,000 and District resources map. SRTM-GDEM 90m (USGS/NASA SRTM DEM data), available from http://www.gdem.SRTM.ersdac.or.jp (Fig.6).

The IRS P6 LISS-III is rectified geometrically and registered with SOI topographical maps on 1:50000 scale using ARC GIS (Ver.10.2) software through map to image registration technique. The FCC generated from green and near infrared (NIR) spectral bands (3, 2, and 4). Equalization, Linear and root enhancement techniques have been followed in enlarging the satellite imagery for better interpretation of the geomorphological, geological and structural information.ARC GIS (Ver.10.2) software has been used for digitization, editing and topology creation. Issuance of attention of different themes and classes integration of multi-confined and information of groundwater prospect map generated in ARC GIS environment. The cause of groundwater prospect map has been verified with field data to as fixed to methodology. SRTM DEM was used to extract slope and for landform mapping. All data were integrated in GIS study to evaluate the groundwater controlling features. Finally groundwater potential map was prepared based on GIS result.

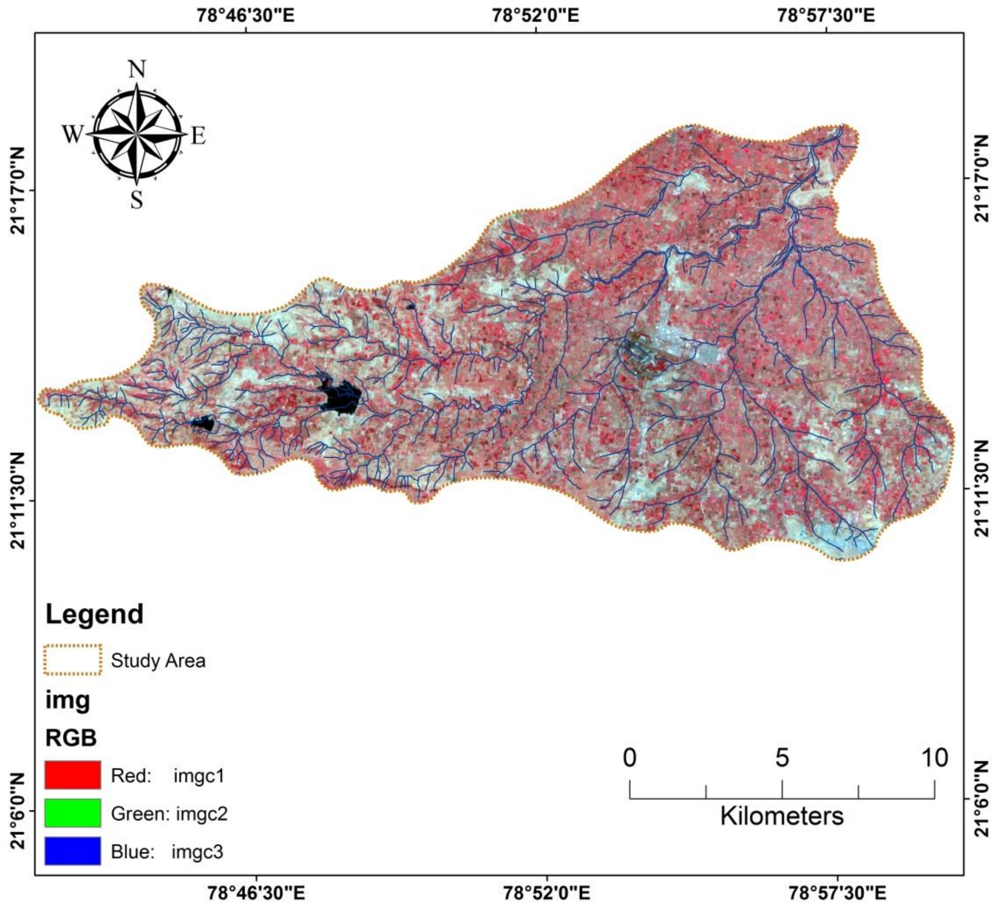

Fig.2: IRS LISS III false color composite map superimposing with drainage of the study area

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Data Integration in GIS Environment

Different favorable groundwater thematic maps have been integrated into a single groundwater prospect zone with the application of Geological Information System techniques. It required mainly three steps are spatial data base building spatial data analysis and data integration. One and all topical map such as geomorphology, lineament, geology, landuse, land cover and slope supply definite clue of groundwater existence. One and all theme is overlain on other theme to find the intersecting polygons. By this method a new map is obtained which is an integrated feature of different thematic maps in the final weightage of the polygons with integrated layer was obtained using simple arithmetic model.

Geology of the Area

Geology plays an important role in occurrence of groundwater and the distribution (Krihnamurthy and Srinivas, 1995). In the present study geological mapping was done by using DRM 2002. The lithology of study area basically consists mainly of Deccan Trap basalt, Sandstone and alluvium (Fig.3). At some places the presences of Intertrappean are also seen. According to area wise distribution of the geological unit of the upper Chandrabhaga sub basin demonstrated in the table 3.

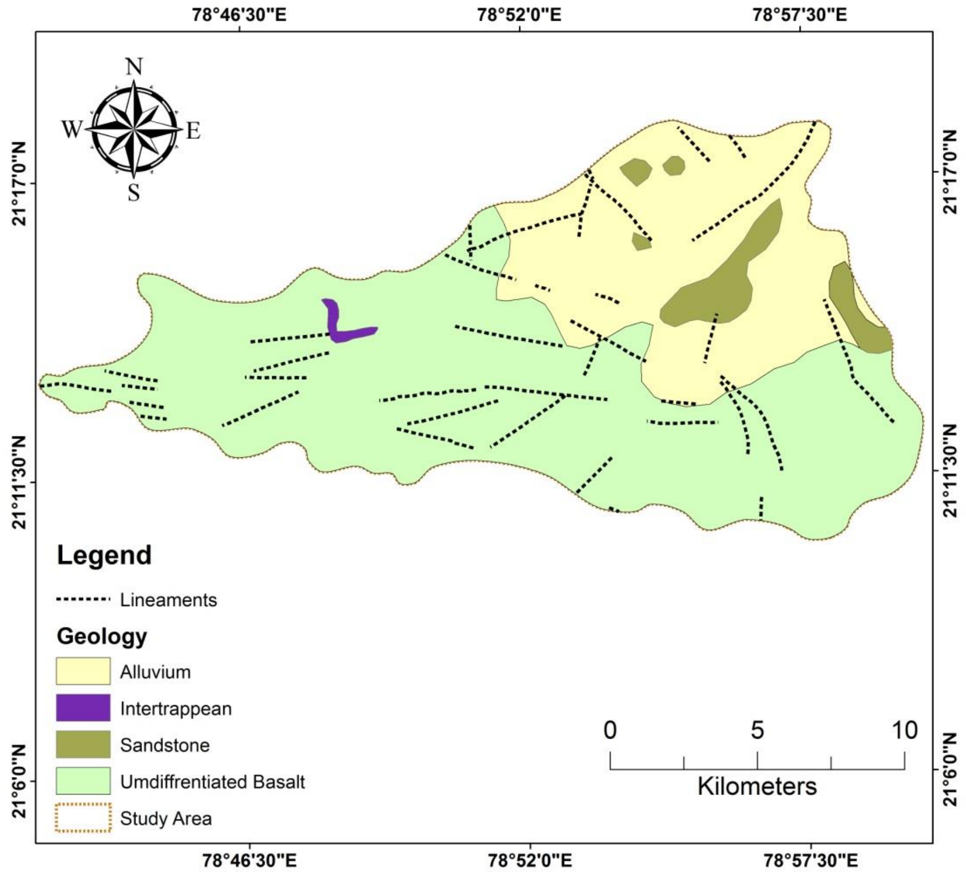

Fig.3 :Geological map superimposing with lineament of the study area

Geomorphology and drainage of the Area

Geomorphic features combined with controls the occurrence, structure motion and quality of groundwater. An evolution of landforms and combined study of the geology is useful to understand the occurrence of

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porous and permeable zones (Karanth, 1987). The different landforms in the district are of three types: fluvial, structural, denudational and. Dissected Basaltic Plateau (moderately, heighly or slightly dissected) is a characterized by flat topped hills and major geomorphic unit terraced features. Landforms are the most common features encountered by any one engaged in geological field works. If they are properly interpreted they throw light upon the structure, geologic history and lithology of a region (Thornbury 1986).

For the evaluation of groundwater resources, a geomorphological terrain classification leading to the delineation of hydromorphological is useful, taking both morphological and lithological factors in to consideration (Verstappen, 1983).. Denudational hill (large), structural hill (small), plateau top, upper plateau, middle plateau, pediments, pediplains, residual (Fig. 4). The drainage patter of the study area shows the dendretic to sub dendretic type (Fig. 5).

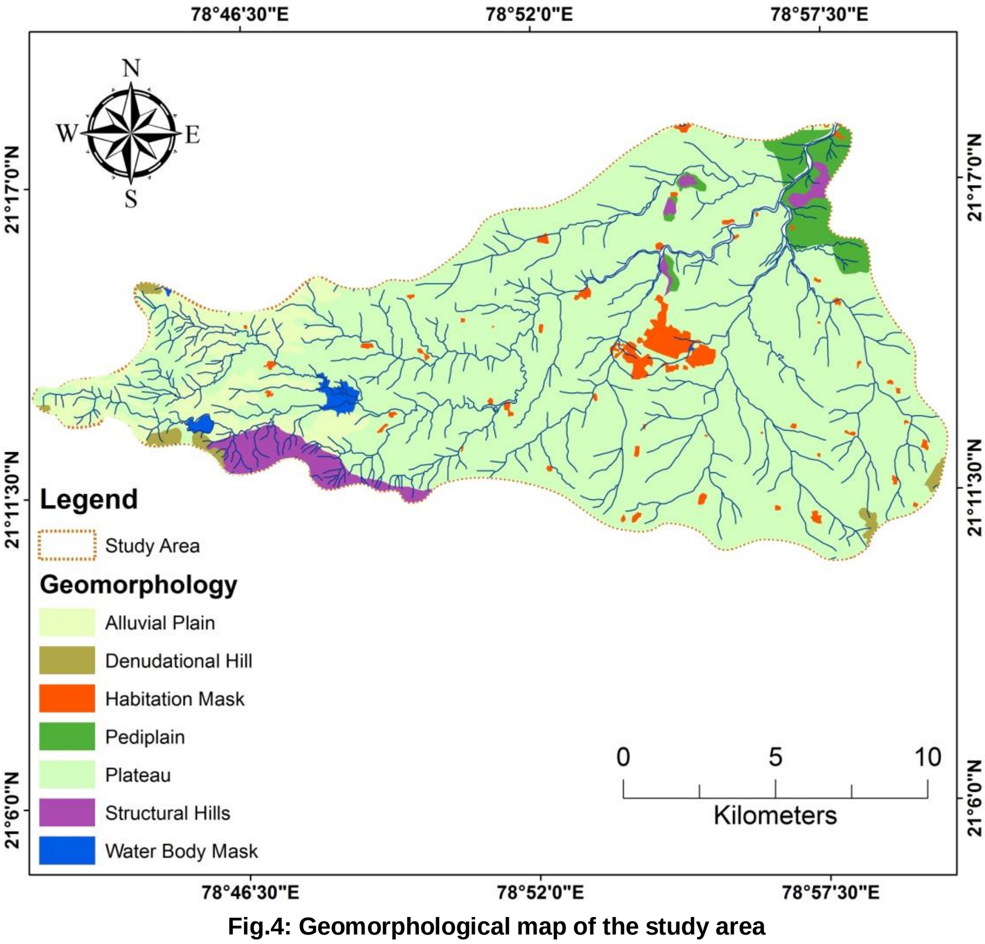

Fig.4: Geomorphological map of the study area

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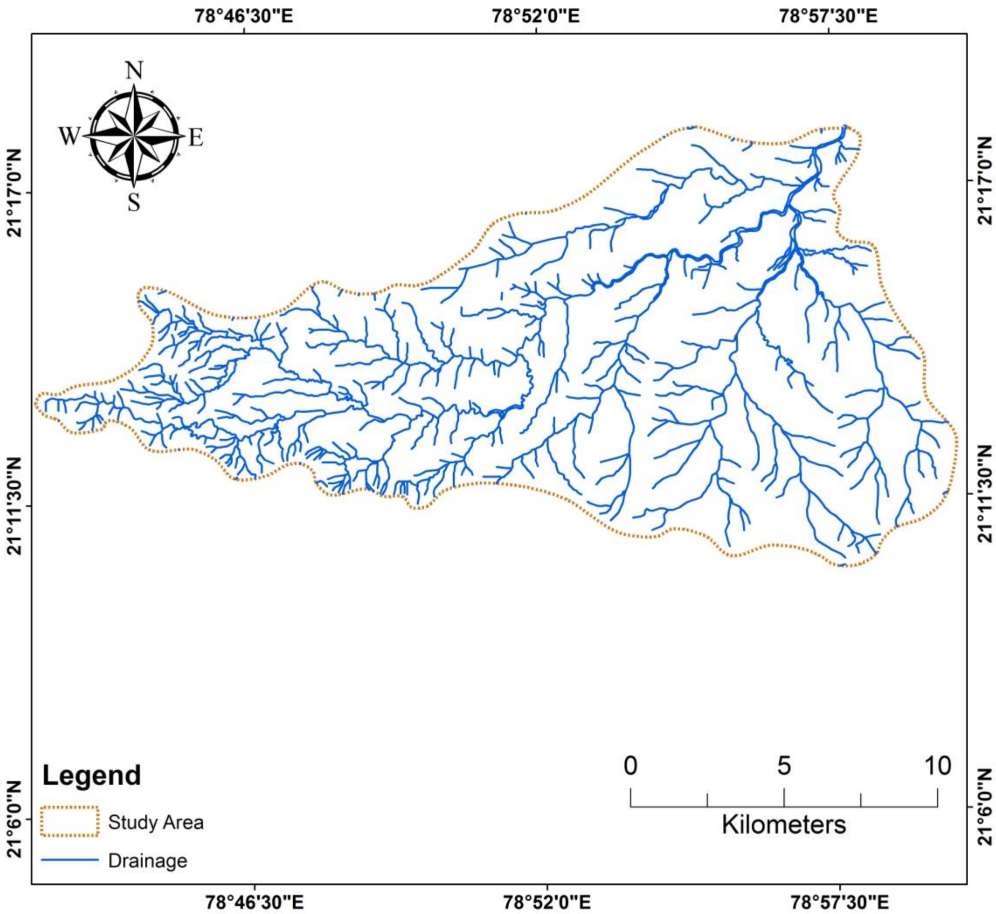

Fig. 5 : Drainage map of the study area

Slope mapping

The slope of a surface refers to the maximum rate of change in height across a region of the surface. Slope is an important terrain parameter and it affects the land stability. The slope map has been prepared from SRTM DEM (Fig.6) . The slopes in the study area have been categorized into seven classes as per the IMSD Guidelines (NRSA, 1995). The study area shows the slope category 00 to 30 0 and majority of the falls into 0-1% i.e. nearly level and 1-3%. High slope is observed in the north east part, estern part and southwestern part of the study area (Fig. 7).

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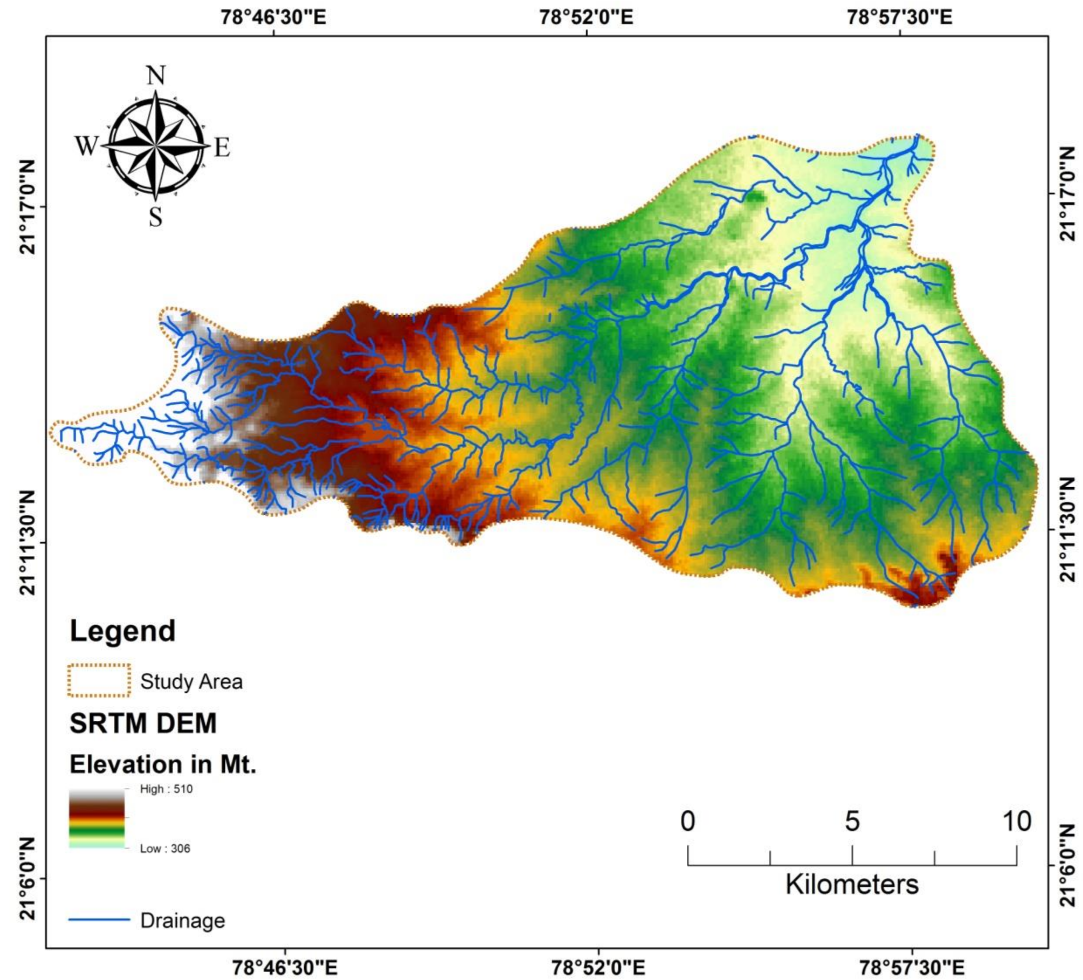

Fig.6: SRTM DEM (30 mt. spatial resolution) map of the study area

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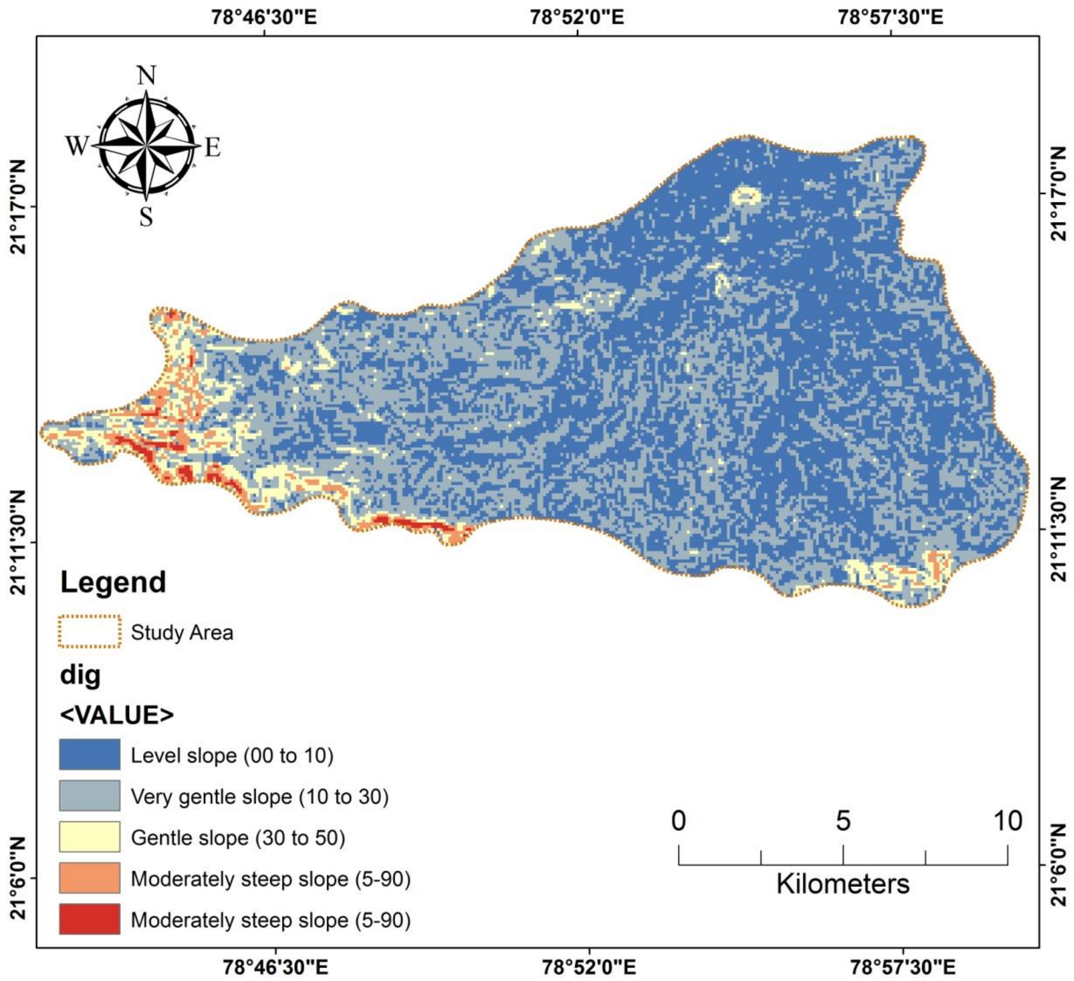

Fig.7: Slope map of the study area

Land Use/Land Cover Mapping

From the land use and land cover mapping the agriculture land shows the maximum area next to this waste land, forest land, Built-up Area and water body respectively.

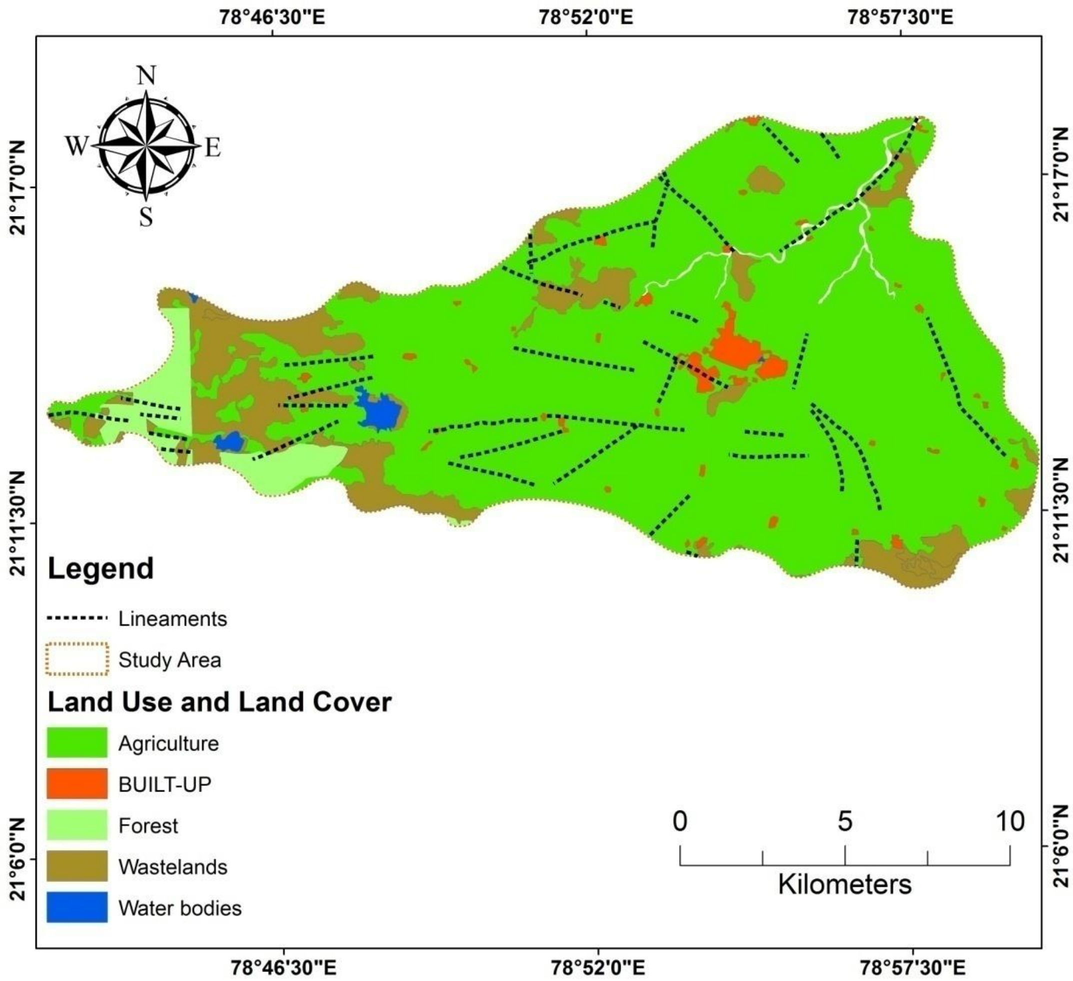

Fig.8 Landuse landcover map of the study area

Table 3 : Area wise distribution various Land use/Land cover categories of the study Area

Sr.No.	Landuse Landcover	Area in sq,km	%
1	Agriculture	187.82	80.61
2	Built-up Area	4.82	2.08
3	Forest Area	9.33	4.02
4	Waste land	29.44	12.67
5	Waterbody	1.46	0.64
	Total	232.98	

Lineaments/Fracture

Lineaments are linear or curvilinear structures on the earth surface; it depicts the weaker zone of bed rocks and is considered as secondary aquifer in hard rock regions. These lineaments are mapped with the help of satellite data and be correlated with fractures, faults, joints, bedding planes, lithological contacts and Unconformities. The study area is found to have a number of crossed lineaments. The joining of lineaments is considered as good occurrence of groundwater potential zones. Lineaments are linear features caused by the linear alignment of regional morphological features such as escarpments, streams and mountain ranges and tonal features that in many areas are the surface expressions of fractures or fault zones (Lillesand, T.M., and Kiefer, R.W., 1994).Lineament analysis of remote sensing data constitutes an important part of studies related to engineering, tectonics, geomorphology and in the exploration of natural resources such as groundwater, petroleum and minerals (Koopmans 1986, Kar, 1994, and Philip 1996).Mapping of lineaments from various remote sensing imagery is a commonly used step in groundwater exploration. In relation to groundwater exploration, since lineaments are the results of fractures and faults they infer that they are the zone of increased porosity and permeability, which in turn has greater significance in groundwater studies occurrence and distribution. Structural features can be interpreted from satellite imagery. In such imagery they are identification the basis of break of slope, truncation of terraces, abrupt change in stream course, lithology, texture, vegetation, drainage density etc.

Mapping of lineaments in the study was done by visual interpretation of various digitally enhanced single band and multi band images that involves standard band combinations, principal component analysis and directional filtering. The lineaments were identified by visual interpretation and interactive digitization in the images (Fig.9).

Hydrogeomorphological Setup of the Study Area

The hydrogeomorphological map was prepared following the guidelines of Ground Water Prospect Mapping under Rajiv Gandhi National Drinking Water Mission by NRSC, Hyderabad (2007). In order to delineate the aquifers the lithological, geomorphological and structural map overlays are subjected to overlay analysis by superimposing the layers one over the other in the GIS environment. During the process of integration, the geomorphic units and rock types are made coterminous by adjusting the boundaries.

These integrated lithological, and structural geomorphic units are treated as homogenous areas with respect to hydrogeological properties. In the study area the hydrogeomorphological map shows the synoptic view of the study area and helps to identify the ground water potential prospecting the study area (Fig.4).In hydrogeomorphological map aspects, which are essential as basis for planning and execution of groundwater exploration. Because of high potential zone suitable surface and subsurface conditions like occurrence of lineaments, permeable aquifers and nearness to streams create conducive environment for higher water yield as well as favorable discharge. Low potential zones include rocky area, which act as runoff zones. The aquifers are deep and yield is very poor.

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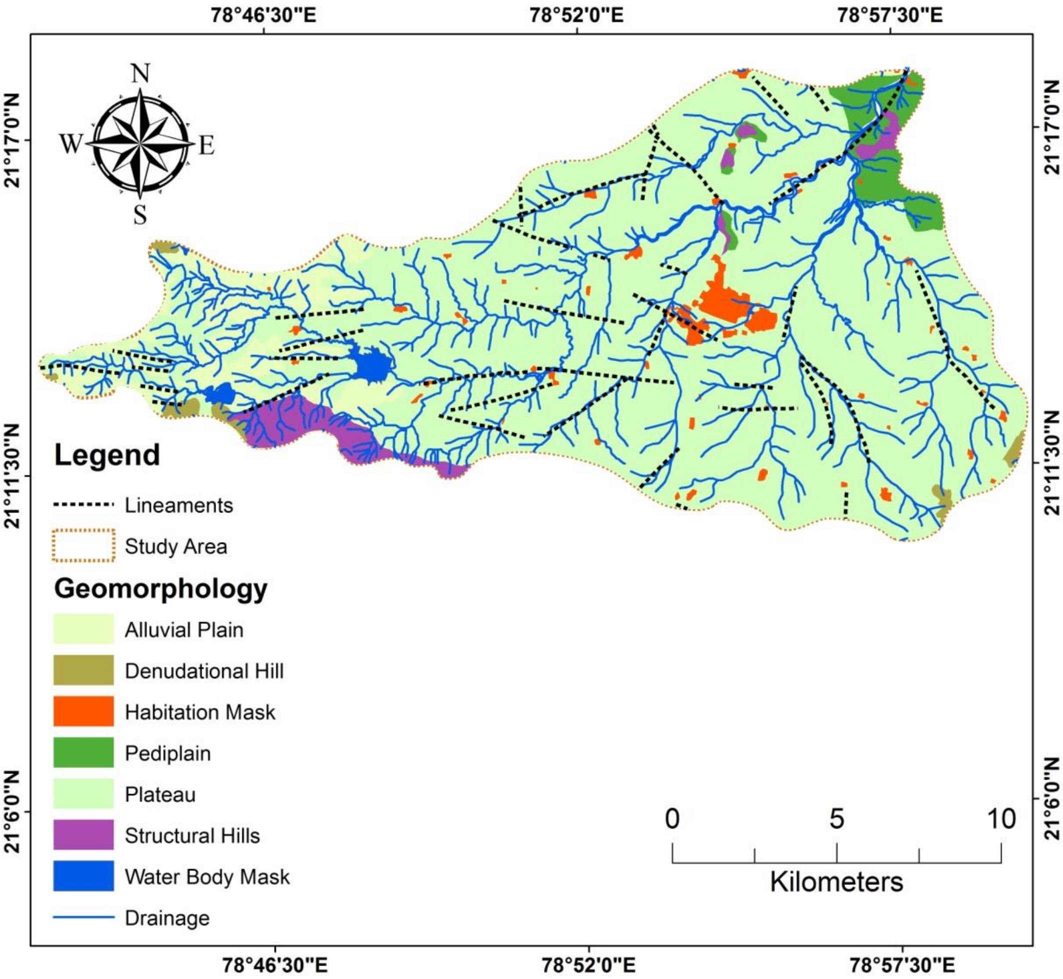

Fig.9 : Hydrogeomorphological map of the study area

Ground Water Prospect Mapping

Satellite images from IRS-1C, LISS-III sensor, on a scale of 1:50,000 which have been used for the delineation of thematic layers facilitate the preparation of lithological, structural, and geomorphological maps, especially at a regional and small scale according to the resolution of the images. These thematic layers were converted into a raster format before they were brought into GIS environment. The groundwater potential zones were obtained by overlaying all the thematic maps in terms of weighed overlay analysis. There are certain multi influencing factors, such as lithology, slope, lineament and drainage.

All are interrelated and each relationship is weighted according to its strength. The representative weight of a factor of the potential zone is the sum of all weight value shows a larger impact and a factor with a lower weight value shows a smaller impact on groundwater potential zones. Integration of these factors with their potential weights is computed through weighted overlay analysis in Arc GIS. The methodology adopted can be used as a rapid assessment tool in groundwater exploration and is helpful in predictive groundwater resource management. By taking the weightage of different geomorphic and lithological units on ground water condition seven groundwater prospect zones (i) poor to nil, (ii) poor, (iii) moderate to poor, (iv)

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moderate to good and (v) good, vi) good to moderate and vii)Very good have been prepared (Fig.10). The area statistics of different ground water prospect zones are given in Table4 .

From the calculated ground water potential map which shows the potentially the area out of 232.98 sq. km., 89.91^2 km, Moderate 35.64, Good to moderate 35.64, Moderate to poor 18.17, Poor 11.77, Poor to nil 2.85and Very good 50.97 square kilometer (Table 4).

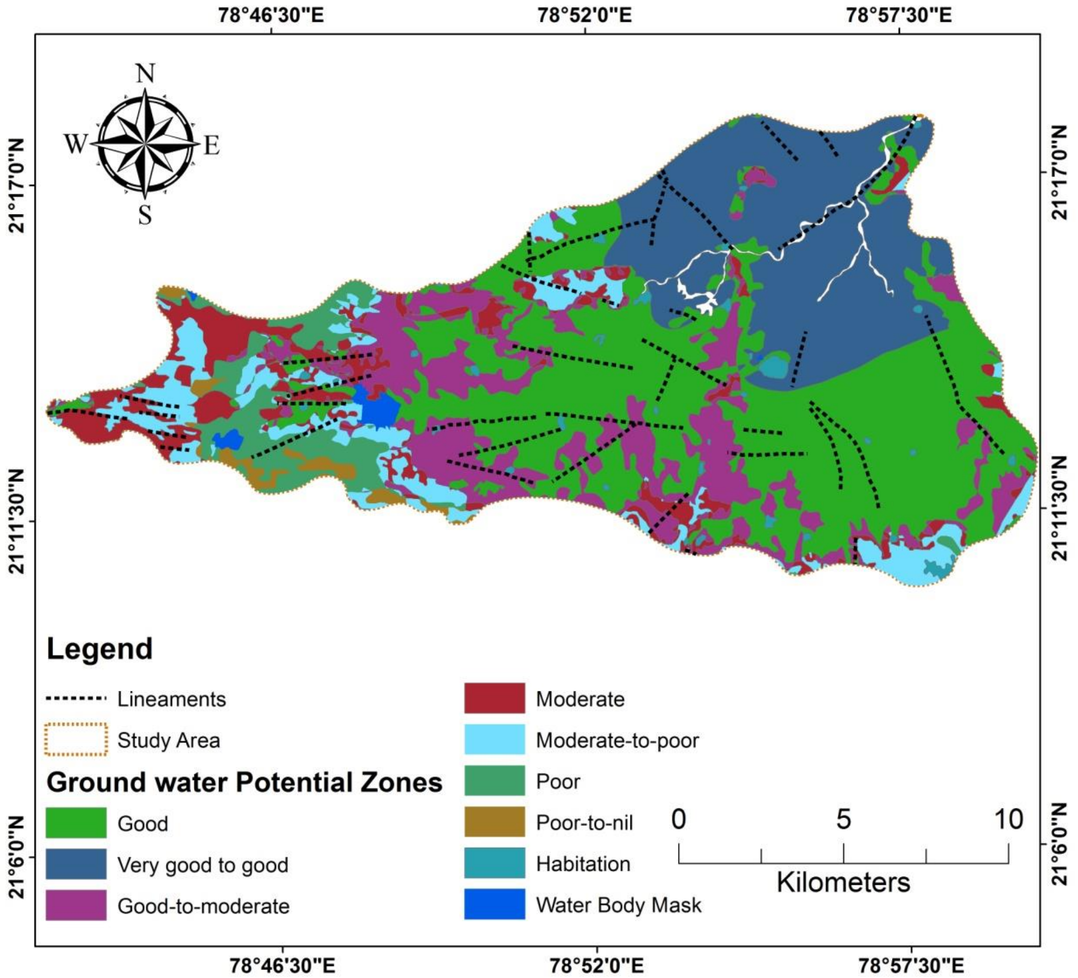

Fig.10: Ground water potential zone map of the study area

Table 4: Statistical distribution of different ground water prospect zonesin the study area.

Sr.No.	Ground water potential zone	Area in sq,km	%
1	Good	89.91	38.67
2	Good to moderate	35.64	15.34
3	Moderate	19.27	8.29
4	Moderate to Poor	18.17	7.81
5	Poor	11.77	5.06
6	Poor to nil	2.85	1.22
7	Very good to good	50.97	21.93
8	Habitation	2.36	1.01

9	Water body mask	1.55	0.68
8	Total Area	231.98	

III.CONCLUSION

In the given study area of groundwater is primarily controlled by structures, hard basaltic rock type and landforms and to a lesser expanse soil, slope and drainage. Geology, geomorphology, slope and lineament were taken as the principal factors for the distribution and occurrence of groundwater in the given study area. Structure, drainage and Land cover or use and incorporated in characteristic expressions of geomorphologic and lithology. Geologically the study area comprises the basaltic lava flows which show the secondary porosity and hence the identification of groundwater potential zones map is very necessary. The integration of all the thematic maps e.g. lithology, structure, geomorphology, hydrology, land use land cover and lineaments with further analysis of data for ground water potential zones were delineated and classified. From the total 232.98 ^{2} km area the good ground water prospect zone is 89.91^{2} km, Moderate 35.64, Good to moderate 35.64, Moderate to poor 18.17, Poor 11.77, Poor to nil 2.85and Very good 50.97 square kilometer. The majority of the Chandrabhaga sub watersheds area shows the good to moderate ground water potential zone. In hydrogeomorphological map features, which are necessary as basis for execution of groundwater exploration and planning. In hydrogeomorphological map aspects, which are essential as basis for planning and execution of groundwater exploration. Because of high potential zone suitable surface and subsurface conditions like occurrence of lineaments, permeable aquifers and nearness to streams create conducive environment for higher water yield as well as favorable discharge. In the study are use of remote sensing and GIS played a vital role in delineation in the groundwater potential zones map.

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