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Identification of Groundwater Potential Zones Using Remote Sensing and GIS for Gautam Buddha Nagar

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Abstract:** With an escalatory growth of human population in the 21st century there has been a significant increase in demand of water for human survival. With the limitation of Surface water sources now ground water that contributes to the total annual supply of water consumption and outshines as one of the major sources. The objective of this paper is to review and analyze the area of Gautam Buddh Nagar, Uttar Pradesh using remote sensing and Geographic Information System for identification of groundwater potential zones. There is various expertise which are used for different water zones for its mapping and its analysis. Parameters like density, soil, land use\cover, geology, drainage, rainfall, contour and terrain are used for controlling groundwater zones. These Groundwater mapping methods are explained and extracted from data sources of satellite images. These techniques include methods which are advance and conventional. For identification and mapping of groundwater potential analysis the thematic layers are used. The significance of each layer is discussed for the location groundwater potential zones using the conditions present. For effective exploration and identification of appropriate locations for water extraction this groundwater potential information will be helpful. For analysis exploration and study of a location remote sensing data is a fast, cost-effective and economical way of doing it. With the Integration of these data for the exploration of groundwater resources has been seen as a breakthrough in the field of its research, and plays a significant role for providing assistance in monitoring, accessing, and preservation of groundwater resources. In the present paper, the assessment of groundwater availability in Gautam Buddha Nagar, Uttar Pradesh, India have been conducted using these techniques. Various maps were prepared like base map, DEM, drainage density map, contour map, land use map, lineament density map and groundwater potential zones using the data of remote sensing and the existing maps. Raster data was transformed from base map and DEM using feature to raster converter tool in ArcGIS 10.3 version.

I. INTRODUCTION

Water is one of the most important and essential commodities for humankind and animal species and fresh water lays in the form of groundwater constitutes as one of the largest resources of it [1-3]. It is one of those natural resources which has highest significance and which support both human needs and economic needs of growth and prosperity of human societies. Exponential rise in the fields of agricultural, domestic and industrial activities in recent decades has increased the demand for groundwater [4-7]. The presence of groundwater at any place on the earth is not something related to luck or chance but a consequence of the interaction of the geological, weather, physiographical, geographical and ecological factor [8-11]. The transportation of groundwater is managed mainly by geological factors like permeability and porosity of the upper soil layer of the earth and underlying lithology. The changes in ground water potential is caused due to different geomorphic formations which have different porosity and permeability for the same lithology [12-15]. This is also valid for similar geomorphic units with varying lithology. The hydrological features of surface like geomorphological, topographical and eater bodies of surface and drainage, etc. play significant role in rejuvenation and revilement of ground water [16-19]. High reliefs and slopes which are steep provides higher runoff while depression in terrain supports increase in infiltration of water. A region which has a high drainage density helps in providing a higher potential of surface runoff if compared with an area with low drainage density [20]. Water bodies present on the surface land like rivers, lakes, ponds, etc. can act as recharging and zones of enhancement of ground water potential of the area. Hence for generation of groundwater potential zone of a regional area identification and approximation of such features are useful and important [21].

There were some studies that were conducted to identify the Groundwater Potential Zone with the use of geological and hydro geological techniques. With an Integration of Geographic Information System (GIS) and remote sensing resulted in providence of a superior access to a larger coverage, even in areas with difficult access [22].

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These techniques have minimal processing time limit and are economical tools in producing important helpful data on geomorphological and geological parameters and the data generated plays a major role in finding of groundwater potential zones [23]. A technical approach of remote sensing and Geographic Information System (GIS) for identification and exploration of recharge sites for artificial rejuvenation for ground water was used by Goyal et al. (1999) and Saraf and Choudhary (1998). For evaluation of resources for various aspects GIS has also been considered. A hydro-geomorphological mapping using these techniques for management of water resources around palaeo channels was conducted by Aslam et al. (2003). Rokade et al. (2007) used Geographic Information System for analysis model of groundwater potential modelling. Recently, GIS and remote sensing was used over regional scale for delineation of potential areas by Rao (2006); Ettazarini (2007); Vijth (2007), Mills and Shata (2009) and Elewa and Qaddah (2010). The main objective of this study is to find out Groundwater Potential Zone in a form of map based multi-criteria approach and on parameters which affect it directly and indirectly like hydrological and geological parameters and factors like slope, contour. These parameters include parameters like fractures, drainage network, relief, topographic slope and convergence index which are directly or indirectly associated with groundwater accumulation in Gautam Buddha Nagar.

II. STUDY AREA

The name of the study area is known as Gautam Buddha Nagar, which comes under the western region of Uttar Pradesh. The latitude of Gautam Buddha Nagar, Uttar Pradesh, India is 28.358982, and the longitude is 77.550758(Figure 1). The topography of the study area is plain with the elevation which varies from 195 m above mean sea level to 200 m above mean sea level. The climatic conditions of the study area are that the area experiences similar climate to Delhi: mostly dry all year around with very hot and dry during summer, humid during monsoons, pleasant and dry during spring and autumn, and cold during winters. May-June are the hottest months and December-January is the coolest months. The minimum temperatures recorded ranges from 3°C to 4°C in December and January and the maximum temperature ranges from 23ºC to 46ºC. Most of the precipitation of the area is experienced during monsoon which the area experiences between June and September with 80 % of the total rainfall is received during monsoon period. The major water bodies in the study area are Hindon River, Yamuna River and many seasonal nalas.

Due to limited water resources availability, water scarcity exists in the study region. It is proposed to have groundwater potential map in the study area to fulfill the regular water requirements and to fulfill the water requirements proposed installation of beneficiation plant.

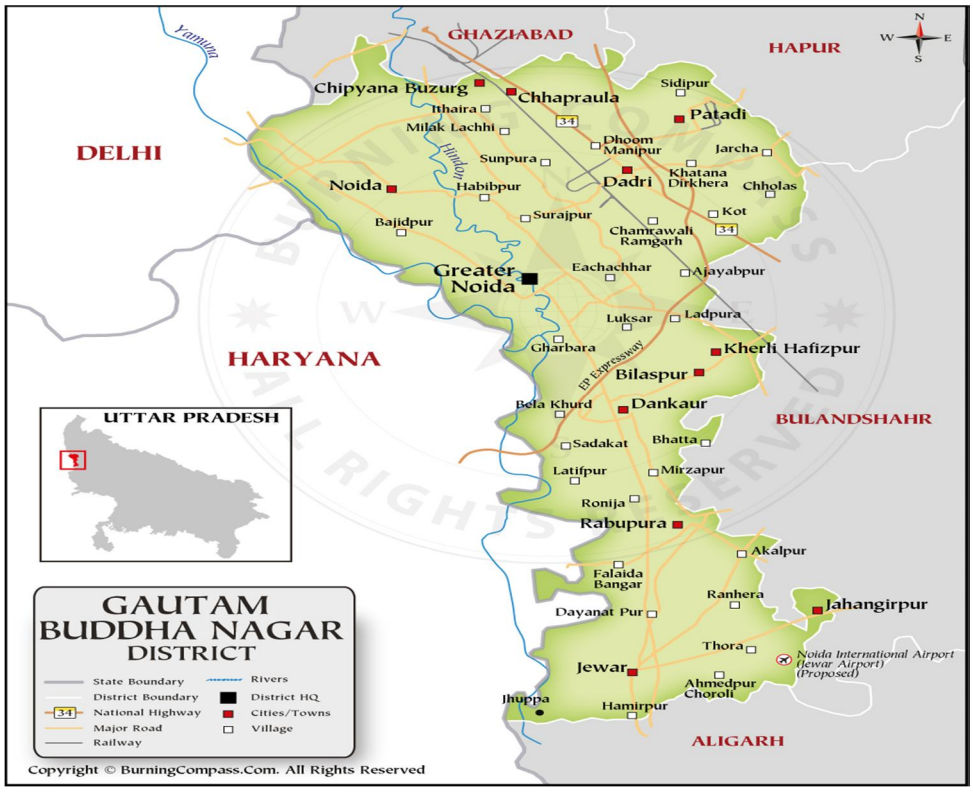


Figure 1: the study area Gautam Buddha Nagar

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III. MATERIALS AND METHOD

Data Collection: Cartosat-1 (DEM) data was used which was taken from the USGS site a data source which is open for academic research for development of the Satellite images of the study area from where the data was downloaded. The groundwater map and its and the recent data associated with it has been downloaded from government data generated and present on Central Groundwater Board, Northern region sites. For the individual layers and mapping and analysis Arc view, Arc GIS, and Arc map were used. Satellite Data Analysis: Resourcesat-1 (DEM) was processed using the multiple images satellite of the study area of different band sets and map was developed using the FCC (false color composite) technique; where colors were assigned to different band sets of images for generating the map using raster tool in Arc GIS 10.2 software as shown in Figure 2.

A. Topographical Data Analysis

A topographical map was obtained from the Bhuvan, Nation Remote Sensing Center the geoportal of ISRO.
In this study, software used was ARCGIS where we used its 10.3 version to create following maps:

1) Contour map
2) Digital elevation map
3) Drainage density map
4) Lineament density map

For the study area ARCGIS 10.3 version was used for GIS analysis.

IV. METHODOLOGY

System integration, which involves the integration of computer software (ArcGIS 10.3) and hardware, imagery processing, information extraction and analysis formed the basic scanner at building capable expert system to extract geo-referenced information from the acquired data.
For study area, ground elevation contour map – Gautam Buddha Nagar toposheet on 1:150000 scale
Digital elevation model (DEM) – was prepared using ArcGIS 10.3 version software Mapsscanned and digitized – ArcGIS 10.3 version software

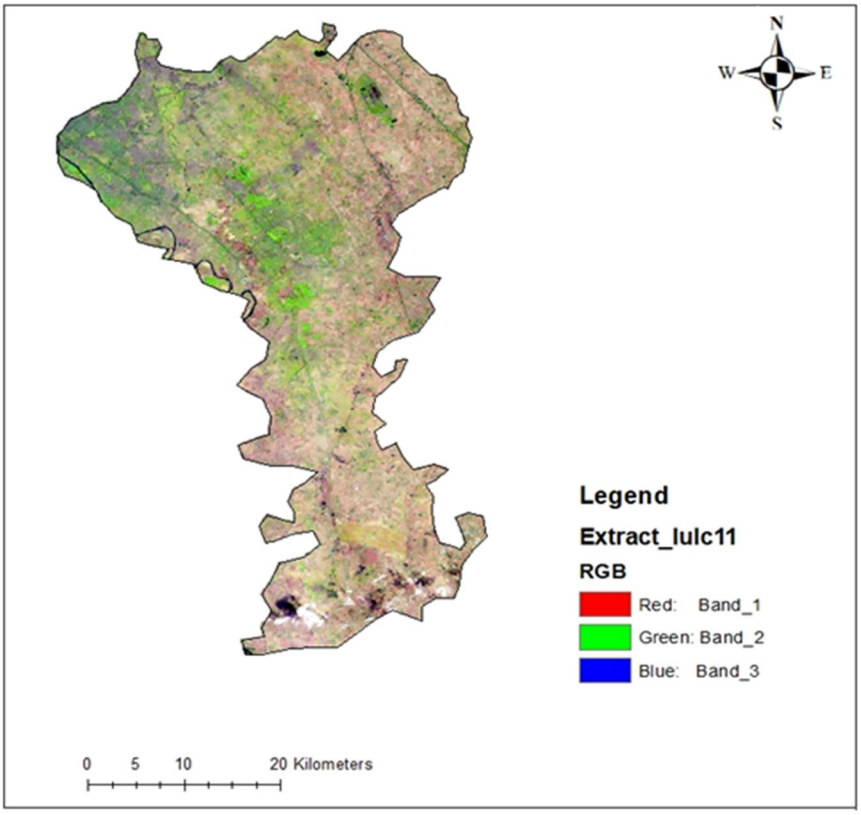


Figure 2: Satellite Image of study Area, 2022

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V. RESULT AND DISCUSSION

Generation of Thematic Maps & Image: Primarily IRS (Resource sat data) was used for resulting the satellite image of the study area. DEM was prepared from the different tile map; the boundaries of which were prepared manually from the by tracing the boundary line and geo-referencing

Contour map: For the preparation of Contour map, Contour map and other information of the study region were created in softcopy as tiff and layer files. These maps were delineated separately for different features in Arc-GIS software to generate various maps. The toposheet was first scanned and it was done Geo referencing of the scanned Raster (TIFF) filesand then the tracing of contours line was done by the contour tool in spatial analyst toolbox in Arc Gis, selecting the sketch tool keepingthe contour interval of 5m as shown in Figure 3.

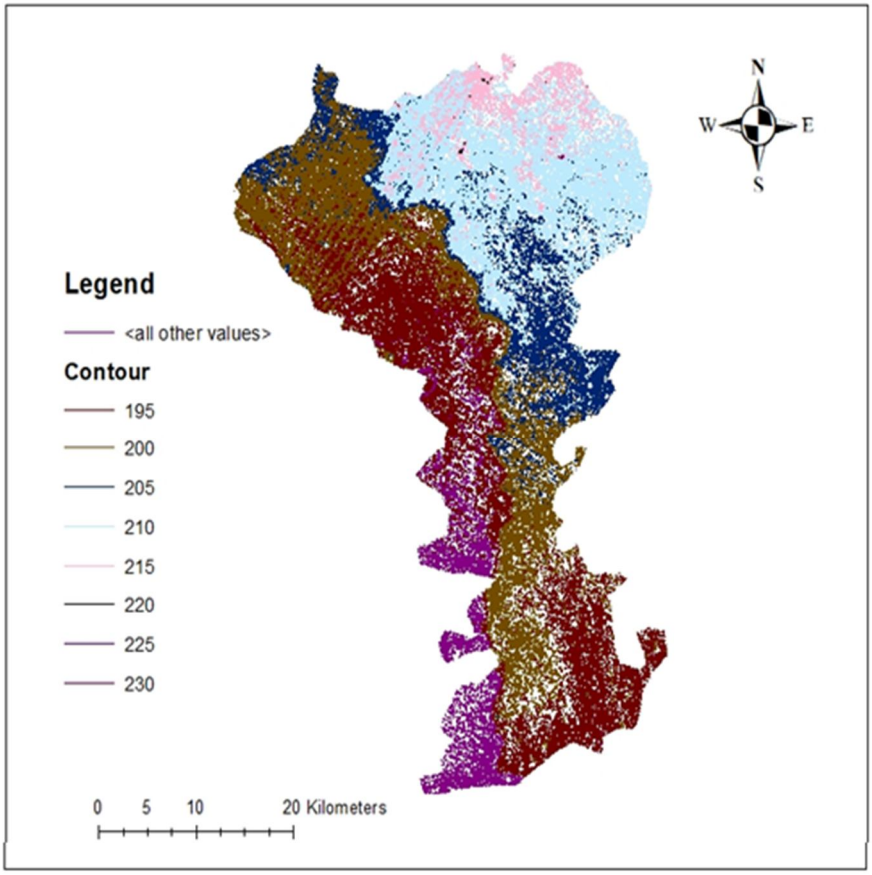


Figure 3: contour map

DEM (Digital Elevation Models): It is a terrain surface's digital model representation created from the data of terrain elevation. The surface of the earth and including all objects present on it is represented as digital surface model. The representation of gird of squares also known as height map can be also represented in a Digital Elevation Model which represents elevation or as a triangular irregular network (TIN) which is vector based. The initial DEM represents the TIN DEM dataset, whereas the computed DEM represents the raster DEM. For the creation of digital elevation model remote sensing techniques data are used, but they may also be created from the surveying land data obtained. Digital Elevated Model are the most common basis for relief maps which are digitally produced and are used often in geographic information systems.

DEM was created as shown in Figure 4.

Drainage Density Map: Drainage density is defined as the spaces present in the closeness of stream channels; since Nala(river) were also located was also present in the study area i.e. Hindon River. Drainage density is the measurement of the total distance of the stream of all channel segment in present orders of streams per unit area. The drainage density has an inversely proportional relation with permeability. A rock with less permeability will have lesser rainfall infiltration, which results in concentration in surface runoff.

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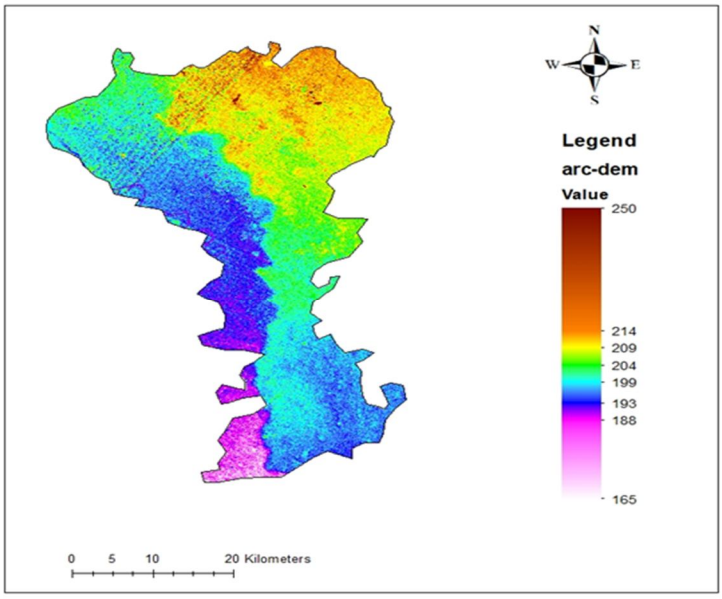


Figure 4: Digital Elevation Model (DEM)

Drainage density of the study area is generated using spatial analyst tool in which line density analysis is a sub-tool present in Arc Toolbox in ArcGIS software. Line Density too is used for calculation of the magnitude of features that are linear in the neighborhood of each output raster cell. The study area has been divided into group of five classes. These classes were assigned as 'very high', 'high' 'moderate', 'low' and 'very low' respectively. Very Low drainage density is recorded in the study area (Fig. 5). The suitable region for groundwater potential zones has an indirect relation with drainage density because it is related with surface water runoff and permeability as shown in Figure 5.

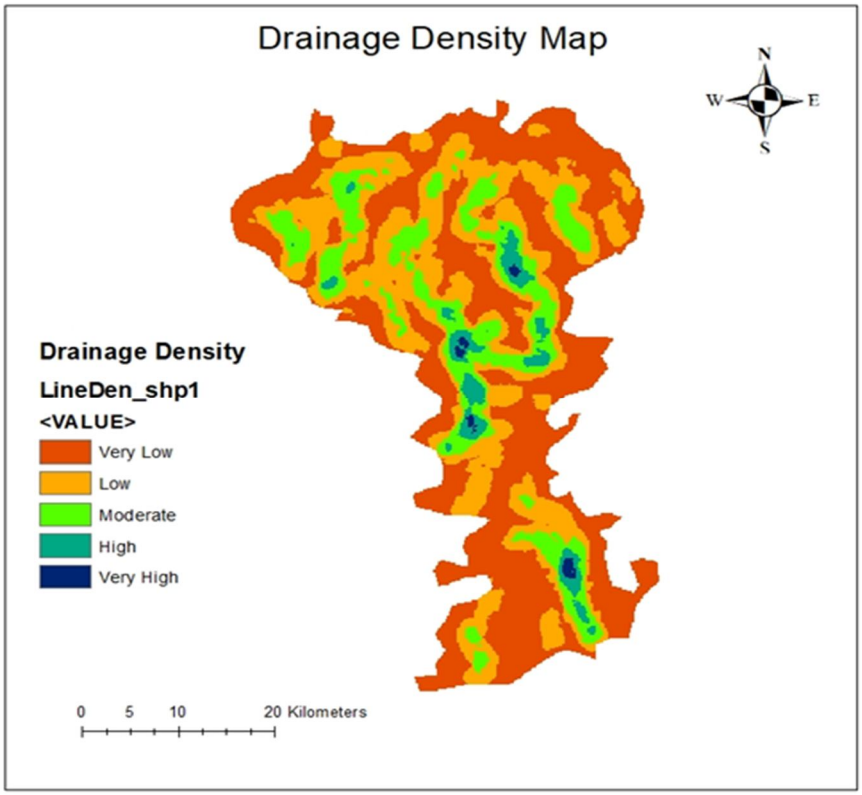


Figure 5: Drainage Density Map

Lineament Density Map: Lineaments are features that are curvilinear, which are identified by their relatively linear alignments from the satellite images. The underlying structural features of the surface topography are expressed by these features. Lineaments represent the zones of faulting and zones of fracturing which results in increase in the secondary permeability and porosity. These factors play a very important role from a hydro-geological perspective as they represent the way of direction for groundwater movement. The potential of groundwater present in the area can be revealed indirectly with the help of lineament density, since lineaments presence usually represents a zone of permeability. Areas which have higher lineament density are favorable for groundwater potential zones. The study area has been divided into group of five classes. These classes were assigned as 'very high', 'high' 'moderate', 'low' and 'very low' respectively. The lineament density map Gautam Buddha Nagar as shown below Figure 6.

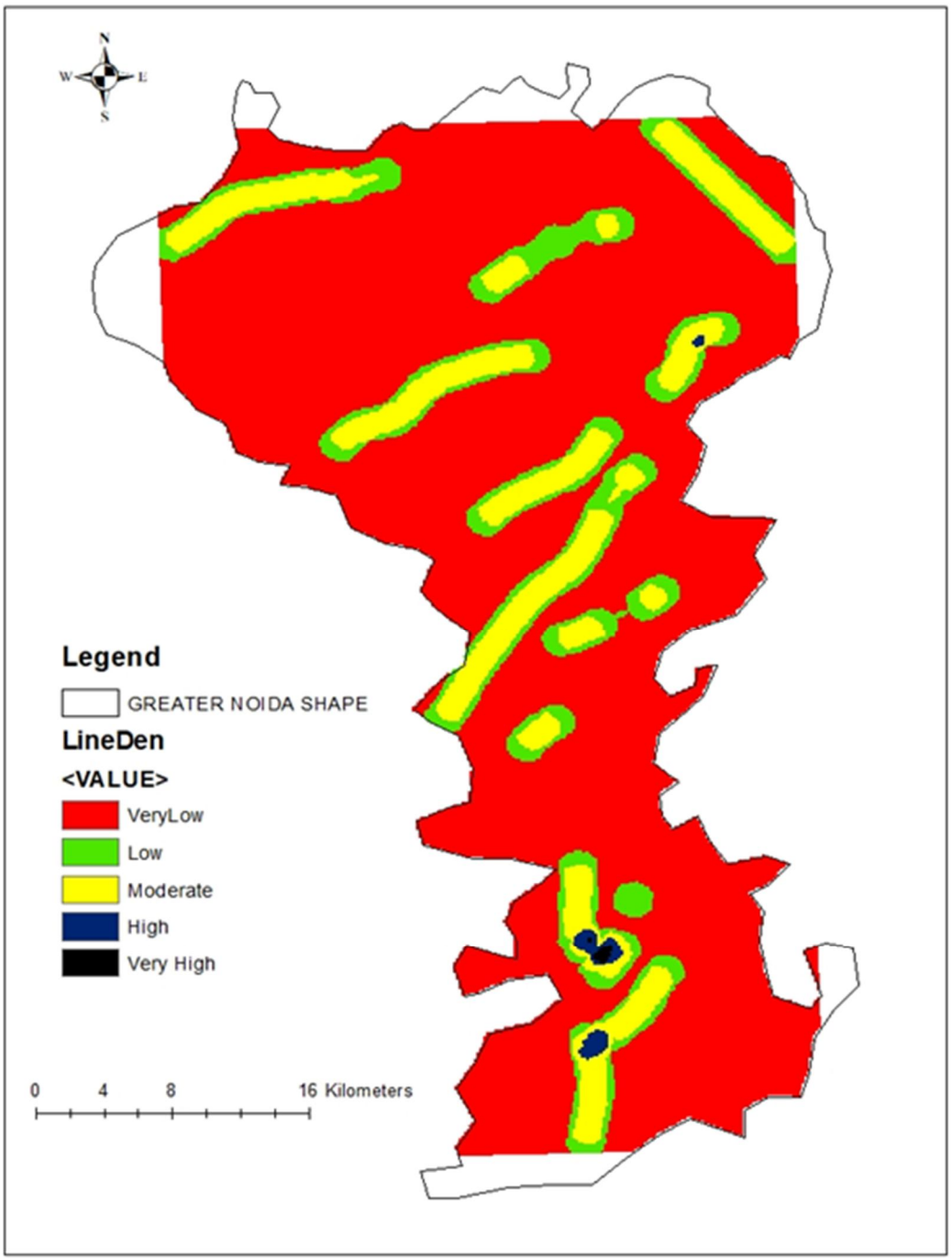
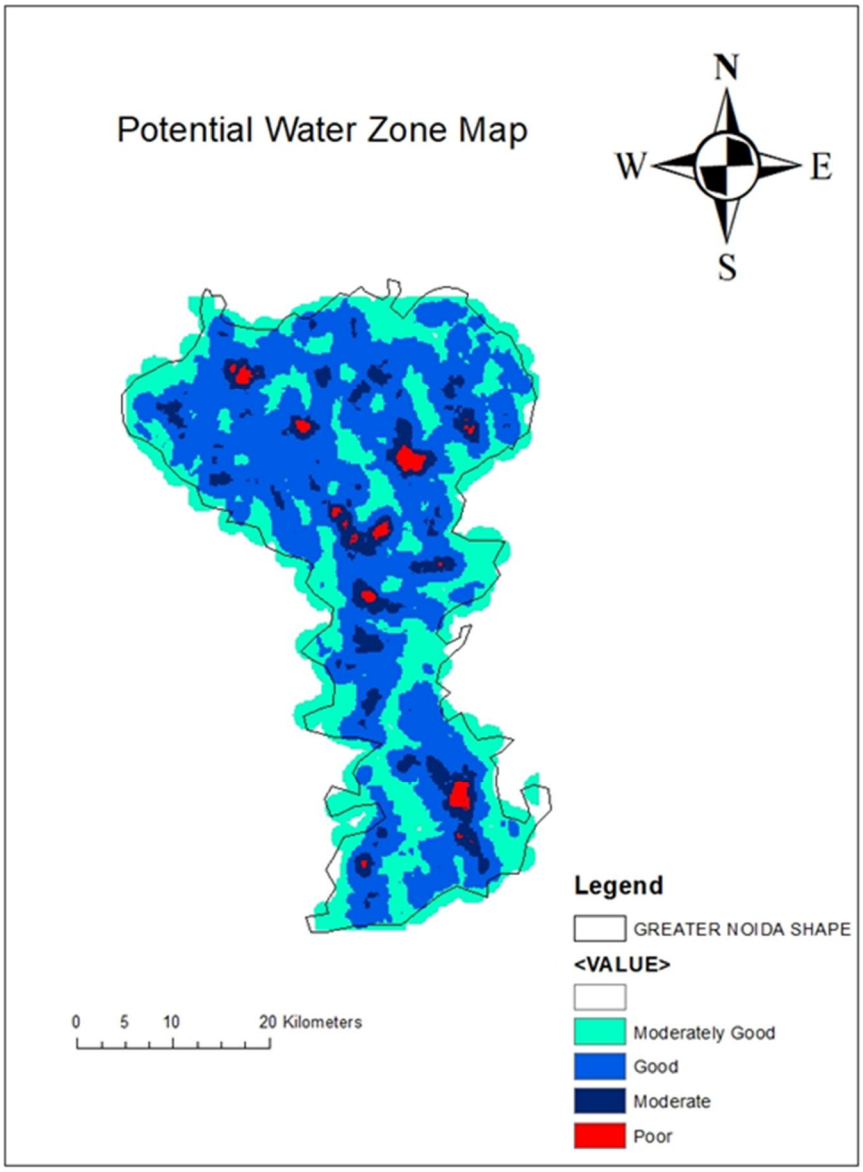


Figure 6: Lineament Density Map

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Figures 7: groundwater potential zone in the study area Gautam Buddha Nagar

VI. CONCLUSION

From the above study and by use of various maps which were created; we could successfully conclude that GIS and remote sensing provides a useful platform for detailed analysis for groundwater studies. The above techniques have been implemented for successful evaluation of groundwater potentiality of the area it has shown a successful demonstration and thus, the groundwater potential zones which was obtained as shown in the above figures 8 encircled with different colors with different zones which represents different potential water zones which are divided into four classes

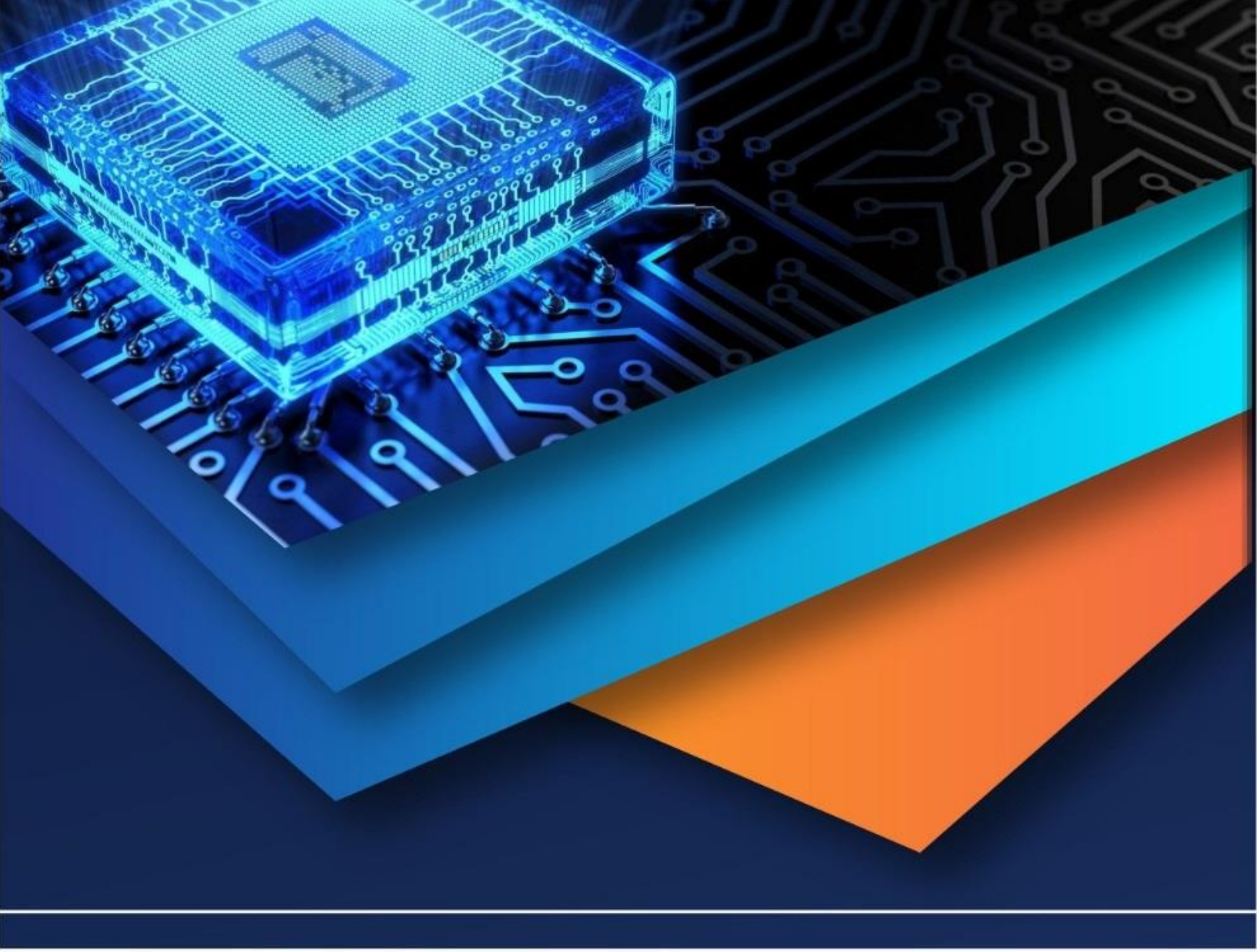
1) Moderately good
2) Good
3) Moderate
4) Poor

The groundwater potential zones for the study area is depicted for the study area which can be helpful in better resource allocation city planning and water management of groundwater resources for future uses and references.

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