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Delineate Ground Water Prospect Regions for the Proposed Study Area for Preparation of Thematic Layers of Tumakuru Taluk, Karnataka, India

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Abstract: In present study, the digital elevation model from Advanced Spaceborne Thermal Emission and Reflection Radiometer - Global Digital Elevation Model (ASTER GDEM) of 30 m resolution is used to carry out the automatic extraction of stream network at the threshold of 0.05 km2.

ASTER GDEM was processed using ArcGIS Hydrology tool by adopting Deterministic Eight-node (D8) method to derive the stream (drainage) network map of Tumakuru sub-basin in Karnataka State of India. The delineation and extraction of stream network has helped in calculating the length of streams under different stream orders as follows: 1st order has a total length of 782.96 km, 2nd order 391.31 km, 3rd order 174.55 km, 4th order 118.82 km and 5th order 40.69 km covering 51%, 25%, 12%, 9% and 3% of the study area respectively.

The automatic drainage network extracted from ASTER GDEM after sinks filled with the threshold value >500 for the flow accumulation was subjected to ground truth analysis based on GPS survey. There is a good match between the random check points generated on the map and the ground truth measurements. The accuracy of the stream order map generated from ASTER GDEM is found to be 87%.

Keywords: Stream network, TOPO Sheet, Satellite data, ERDAS IMAGINE 2010, ArcGIS 10.2.2

I. INTRODUCTION

Accurate delineation of drainage network is a prerequisite for many natural resource management issues (Paik, 2008; Liu and Zhang, 2011)6 Digital Elevation Model (DEM) refers to a quantitative model of a part of the Earth's surface in a digital form (Burrough and McDonnell, 1998)2. Several radar satellite based DEMs like Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) with 30 m resolution and Shuttle Radar Topographic Mapping (SRTM) with 30 m resolution are available for the public use. The availability of satellite based new topographic datasets have opened new venues for hydrologic and geomorphologic studies including analysis of surface morphology (Staley et al., 2006; Frankel and Dolan, 2007; Patel et al., 2016) and channel network structure (Lashermes et al., 2007).

To process raster DEMs automatically, many steps are followed to measure their properties and extract drainage networks (O'Calaghan and Mack, 1896; Tarboton et al., 1992) Martz and Garbracht, 1988; Al-Fugera et al., 2014). Studies have shown that the fast and easy way to determine flow direction of a river basin is using different procedure to extract the information from DEM automatically. Different algorithms are generally used.

D8 method, the easiest and simplest method for specifying flow direction, was proposed by O' Callaghan and Mark (1984)9 and has been widely used at present. This method enables to assign flow from each pixel to one of its eight neighbours by identifying the direction with steepest downward slope.

The quantitative analysis of drainage pattern is one of the important aspects in characterization of watersheds (Starahler, 1964)14. GIS based methods are being used increasingly to delineate channels automatically for use in hydrologic models. However, care needs to be exercised to ensure that networks are extracted from DEMs at an appropriate scale. Using GIS techniques in determining the quantitative description of the basin geometry, various researchers have attempted to analyze the drainage characteristics of the basins (Reddy et al., 1999; Biswas et al., 2000; Vijitha, 2003 and Sathish, 2006; Katimani and Prashad, 2015). In present study, the digital elevation model from ASTER GDEM of 30 m resolution is used to carry out the automatic extraction of stream network at the threshold of 0.05 km2. ASTER GDEM was processed using ArcGIS Hydrology tool by adopting Deterministic Eight-node (D8) method to derive the stream (drainage) network map of Tumakuru sub-basin in Karnataka State of India.

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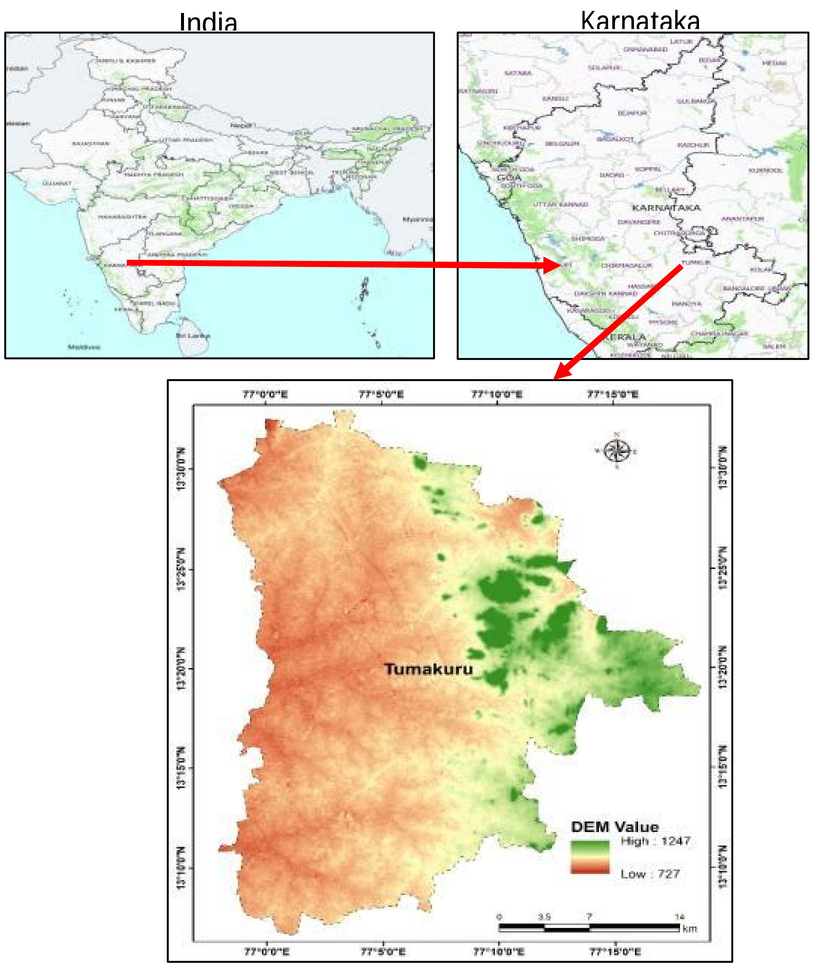
II. STUDY AREA

The study area, Tumakuru taluk, falls under Tumakuru district of Karnataka State, India. Tumakuru is an industrial city situated at a distance of 70 km northeast of Bengaluru, the capital of Karnataka. The Tumakuru taluk lies between 13.11° & 13.55° N Latitudes and 76.96° & 77.32° E Longitudes. The altitude of the study area ranges from 727 to 1247 meters. The average annual rainfall of the study area is 540.7 mm and annual potential evapotranspiration is over 1800mm with monthly rates less than 100 mm during December and January months and over 250 mm during May month (Directorate of Economics & Statistics, Karnataka). As the area is under semi-arid climatic condition the temperature start rising from January and reaches its peak value in May with a maximum temperature of around 40°C.



Study Area

III.DATA AND PRE-PROCESSING

A. Data Used

Multi parametric datasets that were utilized to obtain groundwater zones and the points of interest of the primary and secondary information are presented in the following sub sections.

B. Primary Data

1) *Toposheet:* Survey of India topographic maps of 1975 were considered for the mapping of base map, contour map and Drainage Map. Table below gives the toposheets considered in the study.

Details of toposheet (Sources: SOI, Bangalore)

Toposheet No	Scale
57c,D43Q, 14.15,16,,57G,B43R,2,3,4,7	1:50,000

2) *Satellite Data:* The satellite data taken into account for this investigation is "multispectral Linear Imaging Self Scanning-IV (LISS-IV), RESOURCESAT (IRS-P6)" sensor information is obtained on 15th November 2016. The details are furnished in Table below.

Information of Satellite Data (NRSC, Hyderabad)

Satellite Identity	**RESOURCESAT – 2 (IRS – P6)**
Sensor Type	L4FMX
Path/Row Details	
Date of Data Acquisition	15/11/2016

C. Secondary Data

The secondary data considered for the investigation are geology and geomorphology maps (1:250000) that are used to map Lithological and Lineament features.

Existing Map	Scale	Source
Geology	1:250000	Geological Survey of India (GSI)
Geomorphology	1:250000	Geomorphology Atlas of India
Geo-hydrological	1:500000	CGWB, Bengaluru.
Soil	1:500000	National Bureau of soil Survey & Land use

IV. SOFTWARE USED

The investigation carried out by the software in this study comprises of

A. ERDAS Imagine 2010
B. ArcGIS 10.2.2

V. STEPS INVOLVED

A. Georeferencing

This technique is used to assign location coordinates to image data. The image data pre-existing on the desired plane, may not be related to proper coordinate system. Rectification by description includes georeferencing, by directing all projection frameworks and aligning them with proper location coordinates. Image to image enrollment contains georeferencing just in case where the reference picture is contemporarily georeferenced. Georeferencing, independent from anyone else, includes changing the map coordinate in order to the image.

B. Mosaicking

Image taken at distinct times and lighting condition can be manipulated to attain a seamless mosaic from various images. Over the frequently cloud covered areas, it is possible to obtain numerous images at different time and selectively use only the portion of

C. Resampling

Resampling is a process of undulation of the distorted image with a moving window function, as in spatial filtering. However between the original pixels, the resample output values are computed. In this way, the resampling weight is featured as a continuous function, instead of the discrete array.

D. Registration

In most of the cases, images that are gathered from different sources of one area must be handled together. In order to resolve distinct images through each pixel, the pixel grids of each image must follow to the other images in the information base individually. The conversion of disparate images of same coordinate system is done with the help of rectifying image data tools.

To extract boundary first image to be georeferenced and then it is digitized using GIS tool. After boundary extraction it is easy to show the location based on latitude and longitude.

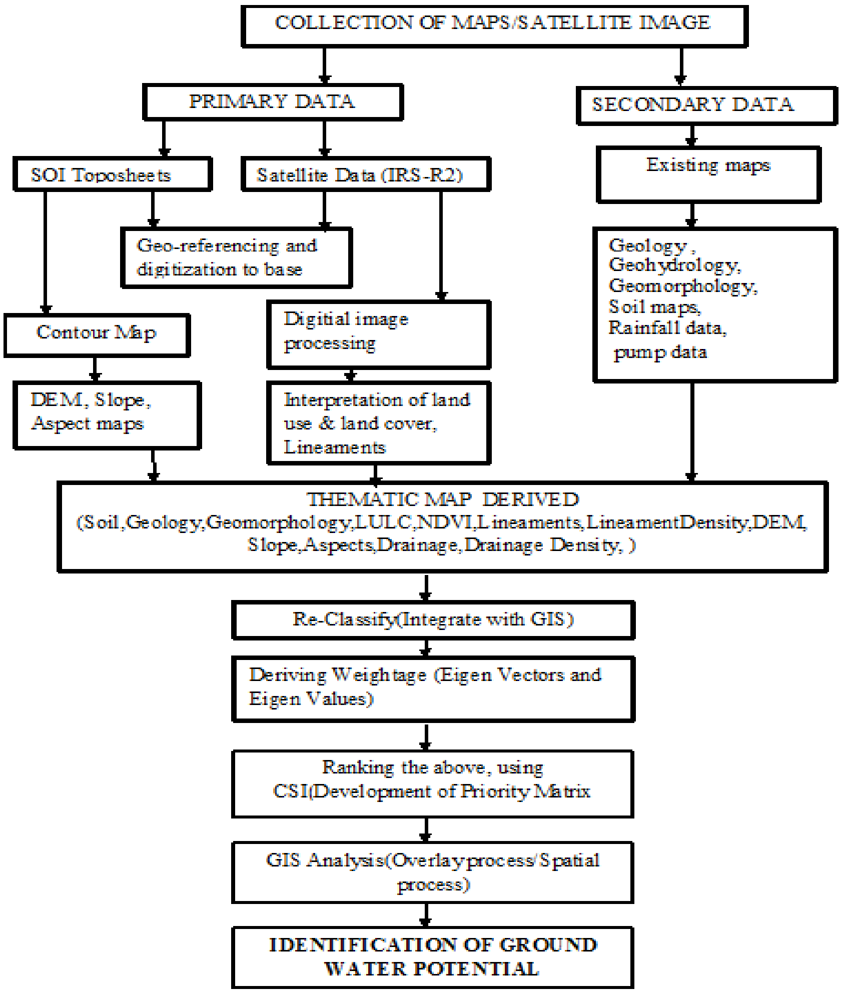
E. Boundary Extraction

To extract boundary from the JPG Image the georeferenced image or shape file is required.

F. Image Enhancement And Feature Extraction

Image improvement is the process to count the image over several parameters or functions that are utilized on the original image. It can be scrutinized as conversion of the image. Generally image amplification is used for image analysis in the form of an image output, whereas feature abstraction is used for automated classification or quantitative analysis.

VI. METHODOLOGY



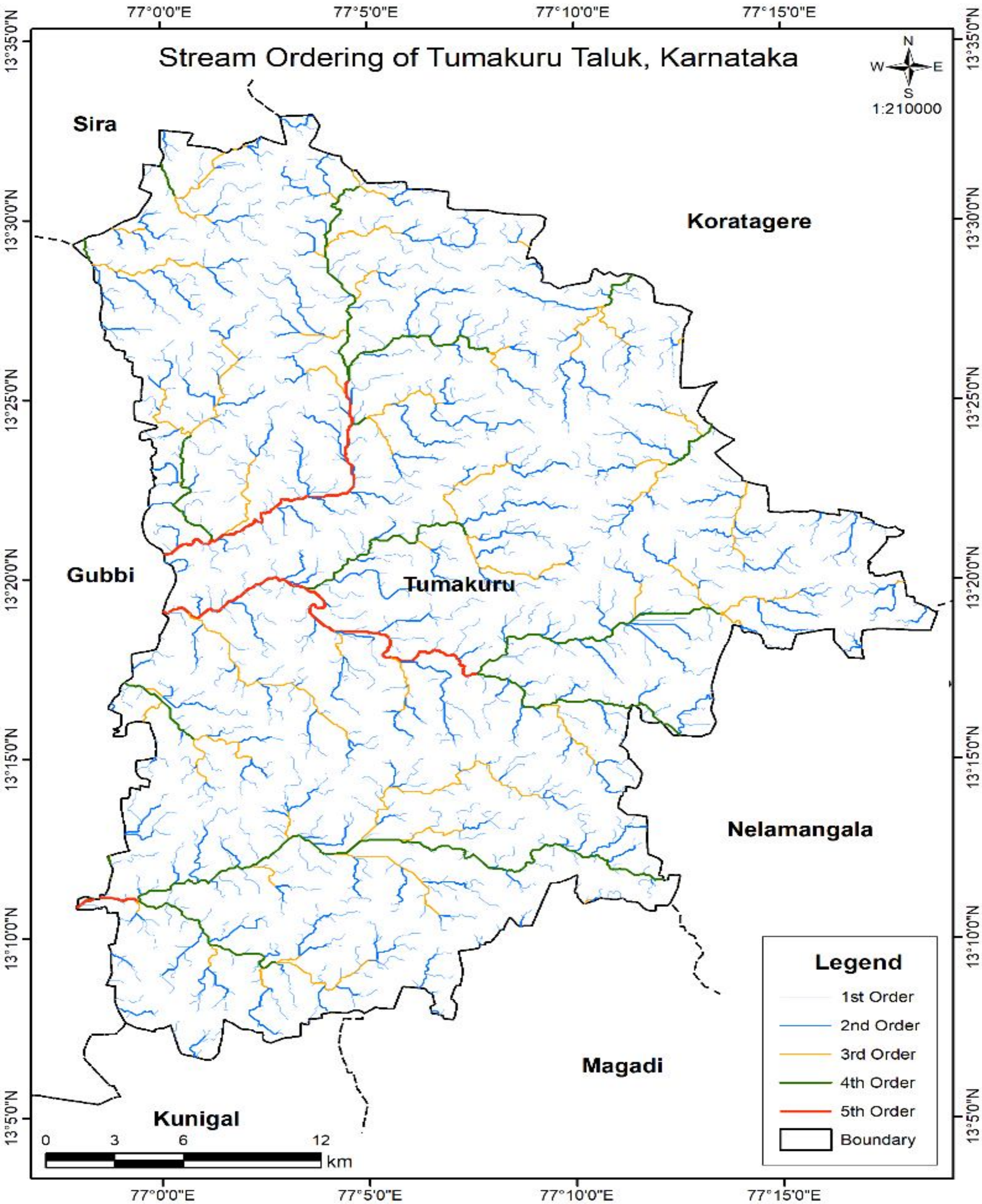
The toposheets used in the investigation area were skimmed, registered and mosaicked by means of ERDAS Imagine 9.1. Satellite information that is obtained was pre-processed and geo-corrected corresponding to registered toposheets. Digitalization of forms from Toposheet were done and a 'Digital Elevation Model (DEM)' for the analysis zone was created. Thematic layers of "geology, geomorphology, geohydrology, slope, aspect, drainage, lineament density, NDVI, Land use/land cover" were generated and weight of each themes and distinct features and its consequent normalized weights were obtained according to Composite Suitability Index (CSI). These thematic layers were finally compiled together and ground water prospective regions of the investigation area were drafted.

VII. PREPARATION OF THEMATIC LAYERS

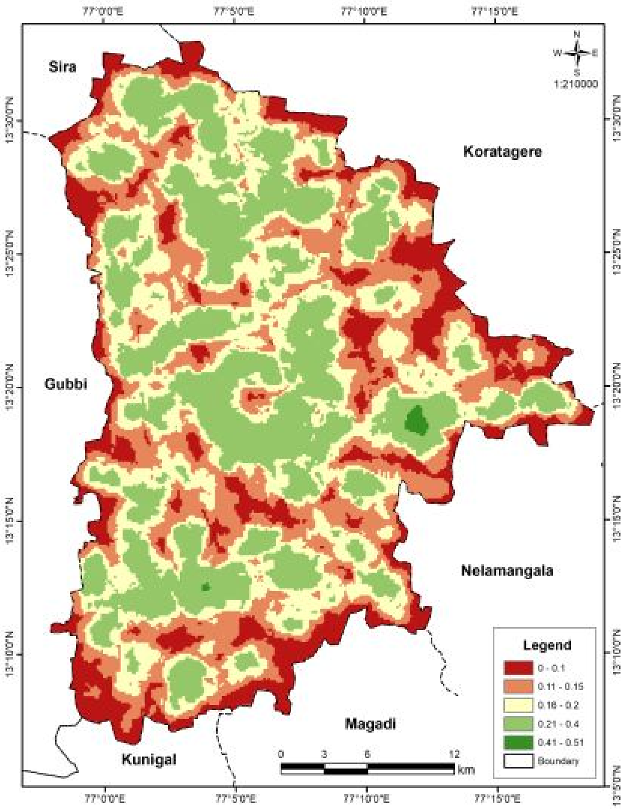
In this investigation, Remote Sensing, GIS and Composite Suitability Index method have been used for assessment of groundwater potential zone. Clearly, this sort of investigation always has an additional influence over predictable survey. The integration of multiple layers such as "geomorphology, land use, geology, lineament density, drainage density and depth to ground water" gives smaller suitability units as a combined layer. The inter layer and intra layer weight ages further accrues the interpolation. The polygons were grouped into classes suitable for development of groundwater recharge structures with respect to their standard deviation.

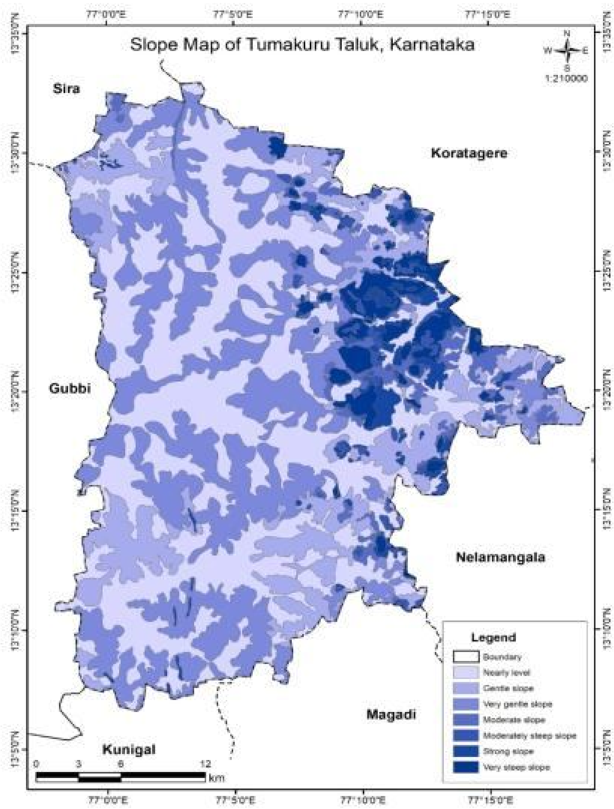
A. Drainage Density

It is the proximity of spacing off low conduit. The investigation area has been grouped into five classes "0 - 1 km; 1.1 – 1.5 km; 1.6 – 2.0 km; 2.1 – 4.0 km; 4.1 – 5.1 km". These classes have been assigned as good, good to moderate, moderate, poor and very poor. The appropriateness of groundwater prospective zones is basically interdependent to drainage density as a result of surface run off and permeability. It is defined as the contiguity of spacing of stream channels. It is the real measure of entire length of the stream portion of all orders taken per unit area respectively. It is inversely proportional to permeability i.e., Lower the permeability of a rock, lower will be its rainfall infiltration rate, which results in higher surface runoff.



Drainage Map with Stream Ordering

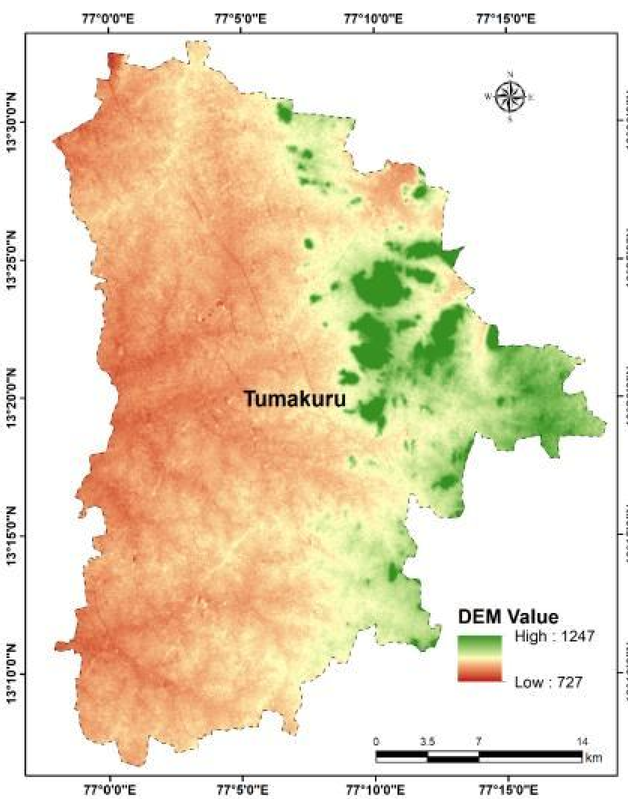


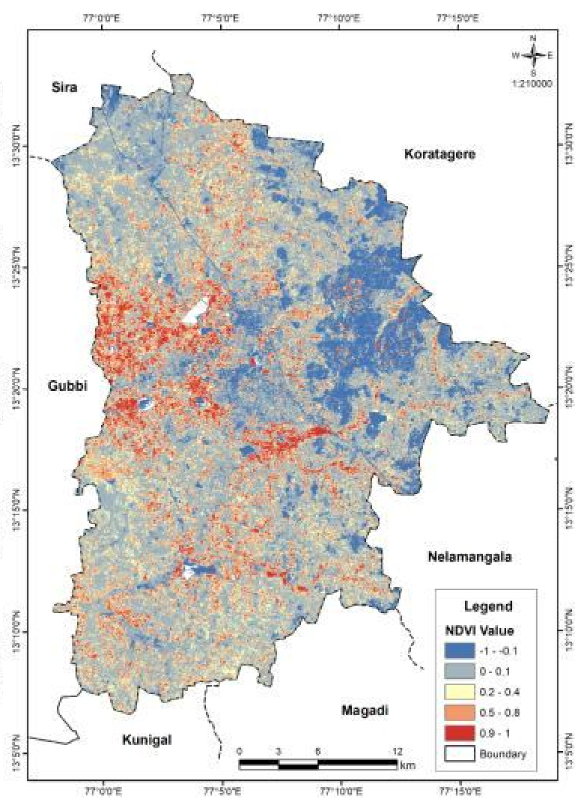


Feature and Slope Class

Slope Map

B. DEM (Digital Elevation Modeling)





NDVI Maps

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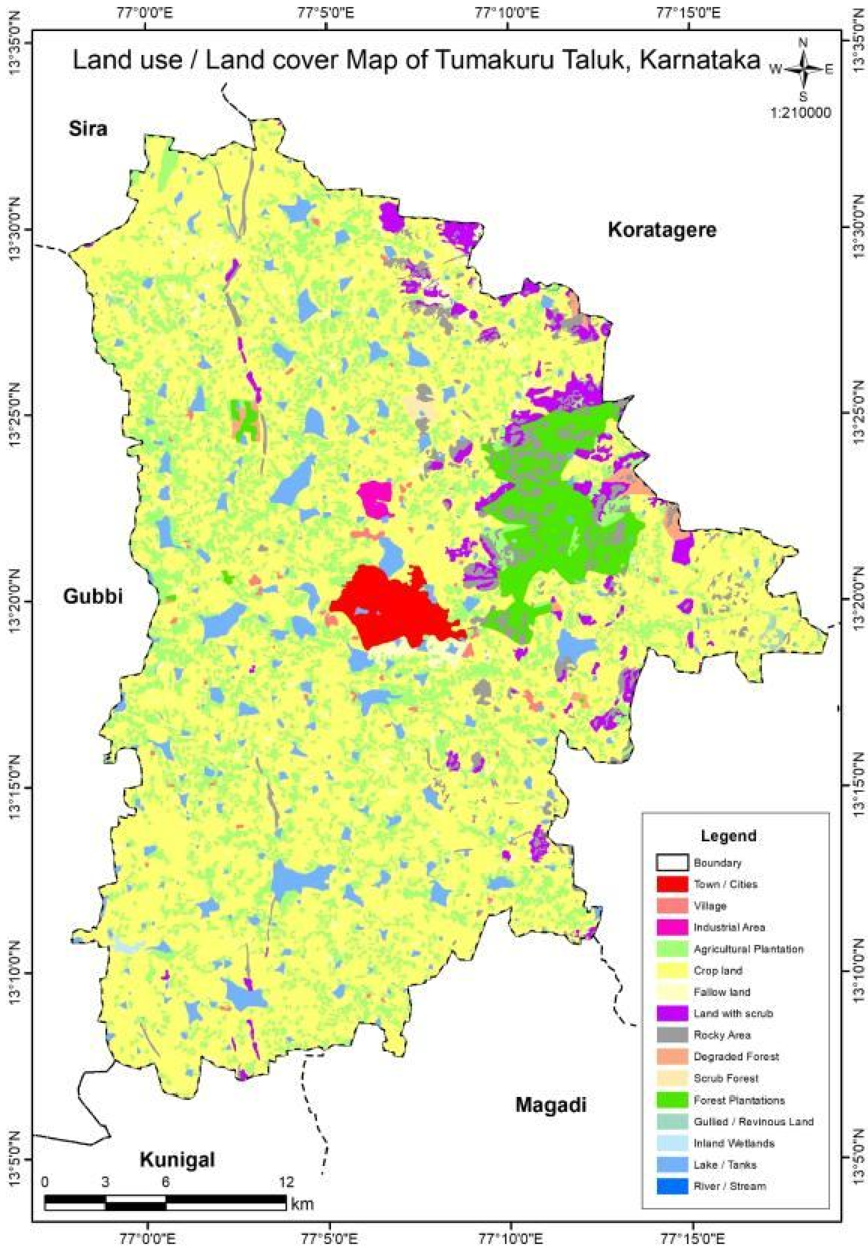
NDVI Value	Description
-1	Non-vegetation
-0.1 to 0.1	Water Body
0.2 to 0.4	Fallow Land
0.5 to 0.8	Medium Vegetation
0.9 to 1	Dense Vegetation

C. Land Use/Land Cover

Land use/land cover plays an important role is considered for the "geo-hydrological study because the land use pattern of any ground is a reflection of the complex physical processes" prevalent upon the earth's surface. Some of the processes are the geologic and topographic conditions on the distribution of soils, vegetation, occurrence of water and the impact of climate. So it is significant for future development and management to have timely and reliable information on environmental status through land use studies. The major land-use type in this investigation area is composed of settlements and built-up area. These land use classes are drafted from LISS-IV satellite data.



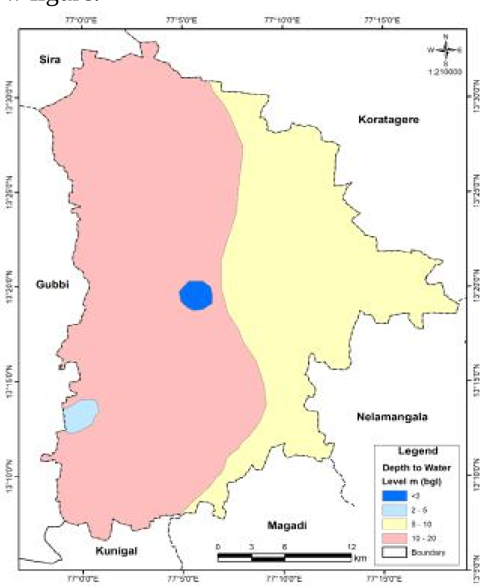
Land use / Land cover Map

Aerial Extent of Land use / Land cover

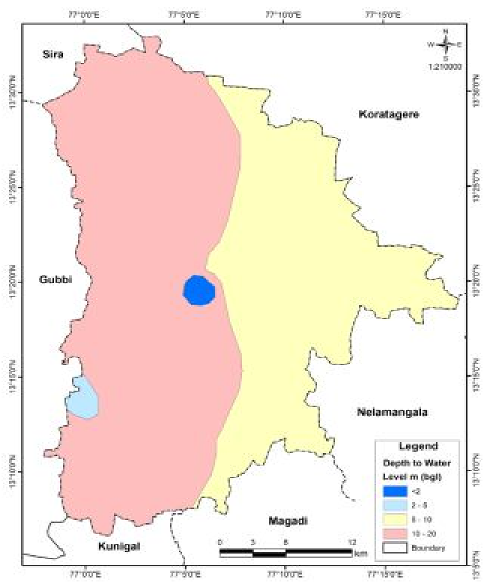
LU/LC	Area covered in Km^2	% of area covered
Town / Cities	16	1.6
Village	5	0.4
Industrial Area	2	0.2
Agricultural Plantation	191	18.5
Crop Land	634	61.6
Fallow Land	15	1.5
Land with Scrub	27	2.7
Rocky Area	36	3.5
Degraded Forest	5	0.5
Scrub Forest	2	0.2
Forest Plantations	37	3.6
Gullied / Revinous Land	2	0.2
Inland Wetlands	1	0.1
Lake / Tanks	57	5.5
River / Stream	0.1	0.01
Total		100

D. Depth to Water Level

The depth to water level in the central area of Tumakuru Taluk has the shallowest water level which is less than 2 m. Majority of the stations situated in the outskirts of area have deeper water level in the range of 10m – 20m. In general pre-monsoon depth to water level of the piezometer varies from 2 to 20 m. Similarly, the post-monsoon depth to water level of the piezometer varies from 2 to 20 m as shown in below figure.



Monsoon Map



Post-Monsoon Map

E. Conclusions

In this investigation, Remote Sensing, GIS and Composite Suitability Index method have been used for assessment of groundwater potential zone. Clearly, this sort of investigation always has an additional influence over predictable survey. The integration of multiple layers such as “geomorphology, land use, geology, lineament density, drainage density and depth to ground water” gives smaller suitability units as a combined layer. The inter layer and intra layer weight ages further accrues the interpolation. The polygons were grouped into classes suitable for development of groundwater recharge structures with respect to their standard deviation.

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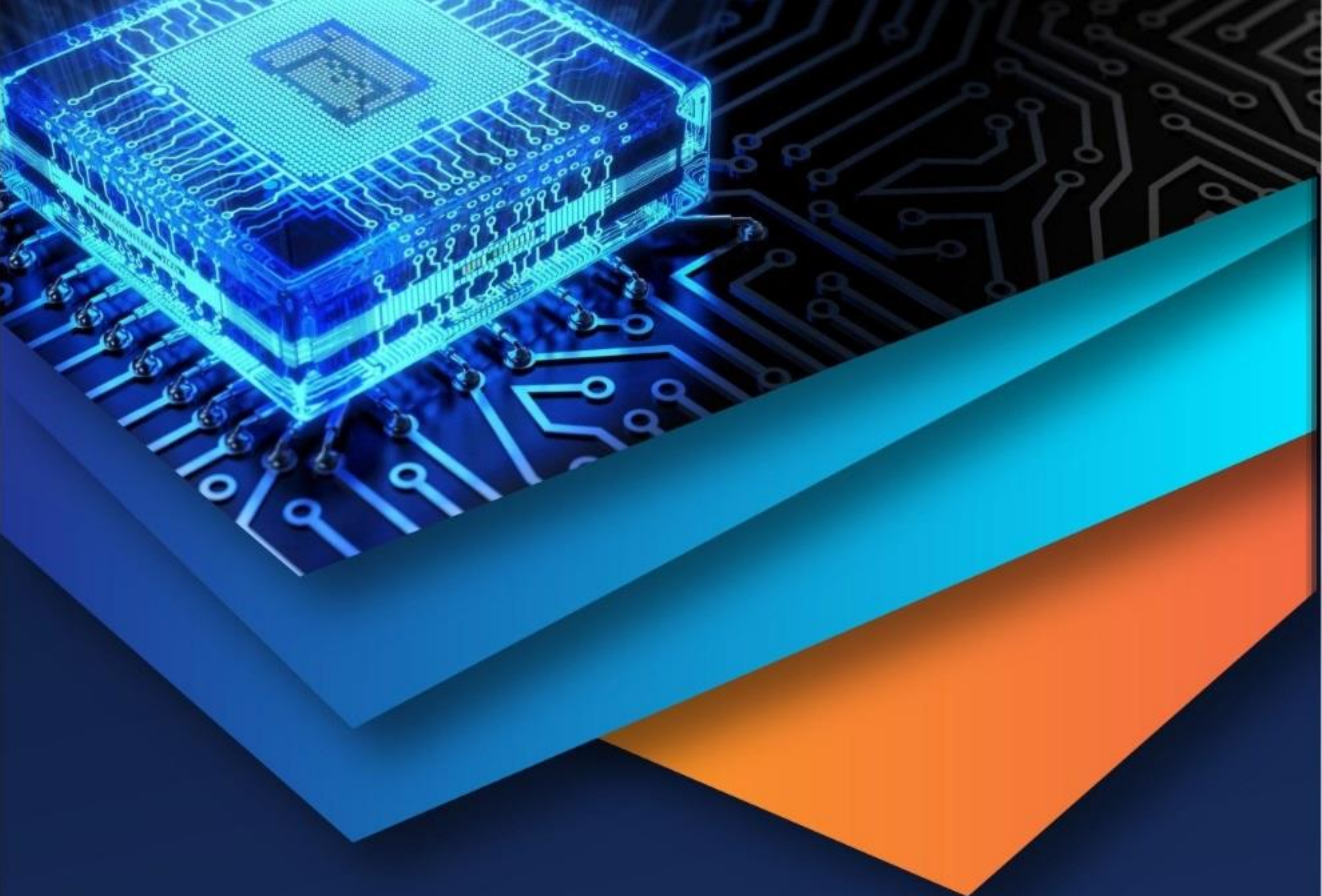

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