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RESEARCH ARTICLE

GROUND WATER POTENTIAL ZONE MAPPING OF SEMI-ARID REGION OF KALABURAGI AND YADGIR DISTRICTS OF NORTH KARNATAKA: A GEOSPATIAL ANALYSIS APPROACH

[1,*]Biswajit Das and [2]Sunil Kumar Singh

[1]North Eastern Regional Institute of Science and Technology, Nirjuli, Itanagar, Arunachal Pradesh, India
[2]Central University of Karnataka, Kadaganchi, Kalaburagi, Karnataka, India

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ABSTRACT

Fresh water is a scare resource. During recent decades, each and every anthropogenic activities such as domestic, agriculture and industries require large amount of surface water and ground water. It has been seen that globally water resources face extraordinary challenges but these are at highly in the world's arid and semi-arid regions. In this region due to very little or no rainfall and lack of surface water, a ground water source becomes desired source for all activities. Identifying the potential region of ground water source become important for fulfilling the basic requirement of such region. In recent time the development of remote sensing approaches has helped in getting repetitive information of large area in short span of time. The satellite imageries of moderate to high resolution help scientist to delineate the ground water potential zone of the area with help of geospatial modeling approach. The present study employs the satellite imageries (Landsat Imageries, LISS III and Aster DEM) along with GIS technique to delineate the area having high potential of ground water source. The weighted overlay analysis is done using various thematic maps like, lineament density, geology, geomorphology, drainage density, Slope etc., to delineate the potential zones of ground water in water deficit district of Kalaburagi and Yadgir district of Karnataka.

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INTRODUCTION

The Arid and Semi-arid regions have limited natural water resources and precipitation and runoff have varied both spatially and temporally across the region. In these regions due to lack of surface water, ground water is the main source for both domestic and agricultural activity. It was estimated that these regions were inhabited by between 1.4 and 2.1 billion of people (Kundzewicz *et al*., 2007). And here it shows, groundwater increasing overexploited because of high population growth and extensive agricultural practices. The identification of the groundwater potential Zone depends on geomorphology, geology, drainage pattern of the region. And demarking of these are very tedious and time consuming. The recent trend in geospatial application enabled us to overcome in these difficulties due to its advantages over the spatial, spectral and temporal availability of data covering inaccessible area within short span of time. Therefore geospatial technology becomes the integral part of accessing, monitoring and managing the natural resources.

Ground water potential zonation of an area relies on the lithological unit and their structural deposits and geomorphic set up of that particular area. With recent development in geospatial technology accompanying with improvement in interpretation techniques, more focus has turned to this field. It is possible to identify various surface features such as geological structure (e.g. Karnkowski and Ozimkowoski, 1999; Adet Zen Bishta, 2010; Rao *et al*., 2009; Pour and Hasim, 2015, Pournamdari *et al*., 2014) geomorphology (e.g. Katla and saxena,2015; Jordan *et al*.,2005; Pareta and Pareta, 2015; Isal *et al*., 2014; Bolch *et al*., 2005; Martha *et al*., 2012; Tomar and Singh, 2015; Reddy and Maji, 2003; Bishop *et al*., 2012; Karwariya *et al*., 2013; Novak and Soulakellis, 2000), lineaments (e.g. Papadaki *et al*., 2011; Koike *et al*., 1998, Hasim *et al*., 2013; Raghavan *et al*.,1995; Abdullah, Akhir, J.M.Abdullah. I, 2010; A yassaghy, 2006; Marghany and Hasim, 2010) through geospatial technology, which are directly or indirectly related to the ground water occurrence of the particular area. The delineation of ground water potential zones in an area is achieve through weighted overlay analysis (Chi and Lee, 1994; Rao and Jugran, 2003Gopinath and Seralathan, 2004; Nag and Ghosh, 2012; Rashid *et al*., 2011; Pandian and Kumanan, 2013) of geospatial technology.

***Corresponding author: Biswajit Das,**
North Eastern Regional Institute of Science and Technology, Nirjuli, Itanagar, Arunachal Pradesh, India.

The present paper includes the applying of geospatial technologies to semi-arid region of Kalaburagi and Yadgir districts for delineating of ground water potential zones keeping in account of geomorphology, lithology, lineament, drainage and slope of the study area.

Background of Study Area

Kalaburagi district lies in northern part of Karnataka between 16^0 42' -$17^0$46'N latitude and $76^0$04'-77^0 46' E longitudes with geographical area of 10,950 Km^2. The district bounded by Bidar in north, Bijapur district in west, Yadgir district in south which is in between 16^0 11,-$16^0$50'latitude and 77^0 17'-77^0 28'longitude with an geographical area of 5234.4 Km^2. The district is bounded by Bijapur in west, raichur in south. Both the districts are sharing their eastern boundary with Telanganastate in the east.(Fig.1).

Different band combination of satellite data were used to generate a False Color Composite (FCC) for the interpretation of satellite data and onscreen mapping. In present study ASTER DEM was used to generate the profile, slope, hill shading, 3D scene fly through view, which helps in the visualizing landforms of the study area.

Geomorphology

The delineation of geomorphic features were interpreted based on key image elements such as shape, tone or colour, texture, pattern, shadow and association. Different band combinations of Landsat OLI, LISS-III were also examined for generating False Colour Composite (FCC) to map the geomorphic feature. The selection of best FCC for the mapping geomorphic feature was done interactively. ASTER DEM was used to generate the profile, slope, hill shading, contour, 3D fly through the view,

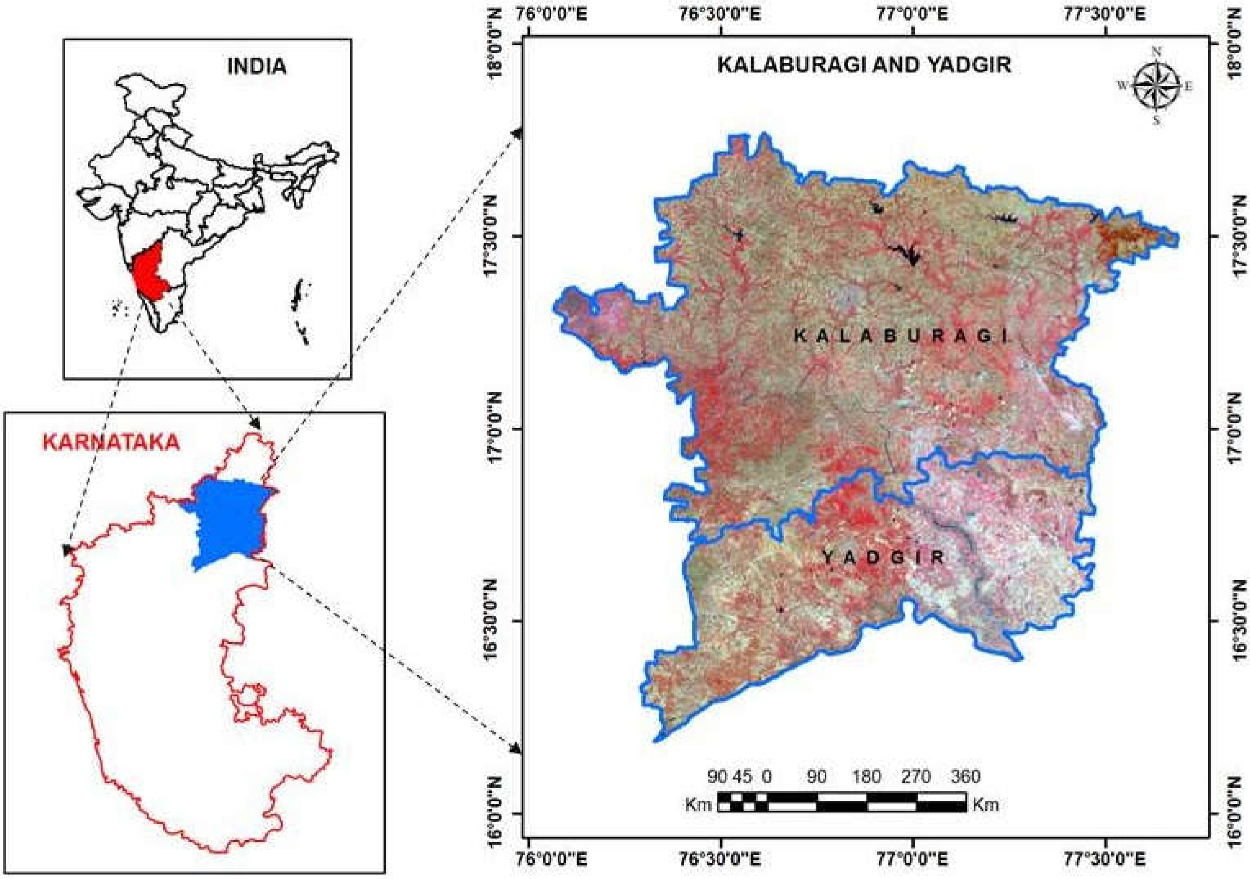

Fig. 1. Map Showing location of Kalaburagi and Yadgir district

MATERIALS AND METHODS

Database

Present study includes the Landsat Thematic Mapper (TM), Landsat Operational Land Imager (OLI), IRS -1D Linear image self-scanning (LISS)-III and ASTER DEM data for identification of various land surface feature with combination of ancillary data and some published literature. The geomorphic features were interpreted through the interpretation keys of the images i.e. size, shape, color, pattern, shadow, texture.

which help in the visualizing terrain elements of landform features. 3D flythrough created using ERDAS software helped in 3D perspective visualization and accurate demarcation of landforms. Geomorphologic map prepared and shown in (Fig.2). These are Denudational hills, Structural Hills, Water body, Anthropogenic Origin.

Denudational Hill

These are the hill formed due to differential erosion and weathering.

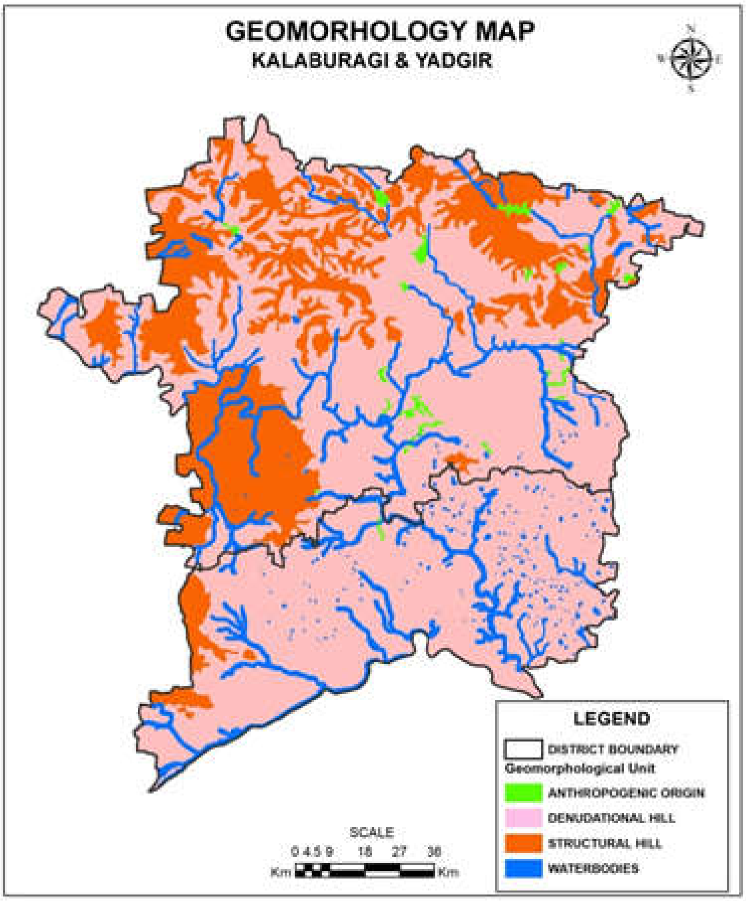

Figure 2. Geomorphology of the study area

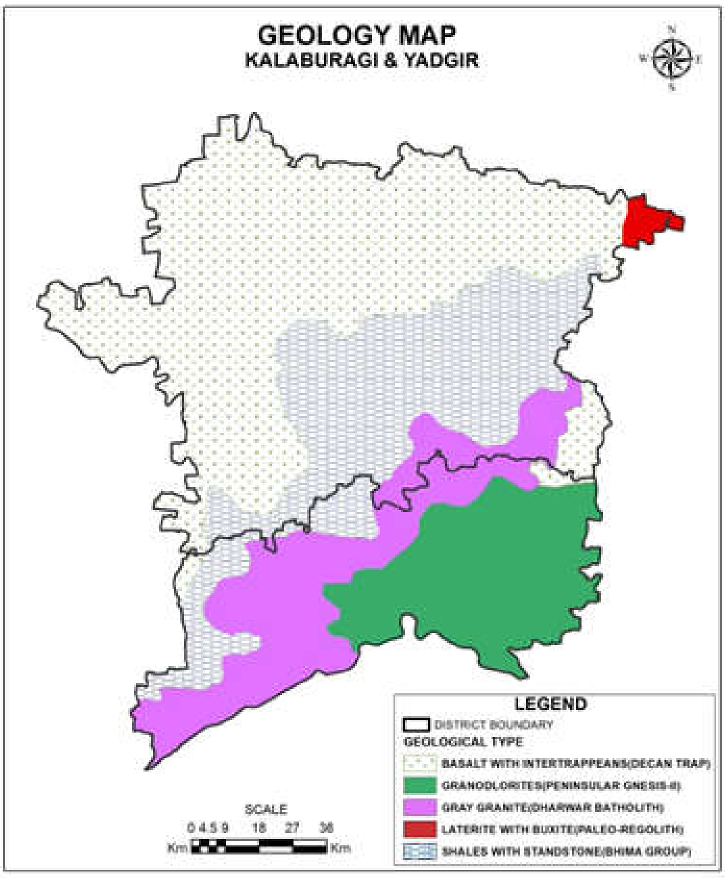

Figure 3. Geology of the study area

These occupied the largest area of the study area (covering an area of 10973.82 km^2). The ground water Prospect in this zone was poor as it acts as a runoff zone contributing very limited recharge to the narrow valley within the hills.

Structural Hills

These were linear to acute hills with narrow valleys showing definite trend lines. The ground water prospects were negligible. Moderate prospects were observed along the valleys.

Anthropogenic Origin

These were the artificial features on the surface feature of the study area having characteristics of shape and range in composition of unconsolidated earthy, organic, artificial material or rock. This is the result of human manipulation over a period. The ground water prospect in these areas were high.

Geology

The geology of study was derived from Landsat TM bands 7, 4, 2. Other band combination have also been examined (432, 452, 753, 742, 754 and 457), but 7-4-2 was found best. The image enhancement of the different band combination was also applied for the study area to derive the textures. The lithology types of the study area are identifies by the help of the lithology map of geological survey of India. All the rock formations in the study area were digitized as polygon Features. The southern part of the district comprises the Peninsular Gneiss and granites. Central, north-eastern and south-western part comprises of sedimentary formations viz. sandstone, quartzite, shale, slate, limestone and dolomite (Fig.3). Deccan Trap basalts cover northern and north-western parts which have cover the largest portion of the study area followed by the shales and sandstone of Bhima group. A small portion in the north-eastern part by laterite. Ground water prospect for the basalt is limited to moderate as these were hard rocks and acts as aquifuge. Shales and sandstones form good confines aquifers and favourable for recharge condition. The ground water prospect for the granite is moderate depending on the extent of weathering and fracture, and recharge. Laterites had very low prospect for groundwater and granodiorites have moderate to good prospects if ground water.

Drainage and Drainage density Map

Drainage of the study area was interpreted visually from the Landsat OLI, TM and LISS-III satellite image and digitized as line feature. Streams have the order from 1^{st} to 5^{th}order (Fig.4). Drainage density map was generated from drainage map by using line density in spatial analyst tools in ArcGIS. Drainage density was the ratio of length of stream to the total area. The drainage density map was prepared and it was divided into 5 classes. The northern part exhibit fine drainage density whereas the southern part shows coarse drainage density. Ground water potential was poor in areas with very high drainage density as major part of the rainfall is lost as surface runoff with little infiltration to recharge the ground water. On the other hand, areas with low drainage density allowed more infiltration to recharge the ground water and therefore have more potential for ground water (Fig.5).

Lineament and lineament density

Lineaments were very important from ground water point of view as they control the movement and storage of ground water. Both major and minor lineaments in the study area were delineated which include faults, fracture, cracks, etc. Present study used the ASTER DEM for generating shaded relief map of the study area. For identifying linear topographic feature from the DEM, eight shaded relief images were generated for the study area with light sources coming from eight different sources. The eight different illumination directions are 0^0, 45^0, 90^0, 135^0, 180^0, 225^0, 270^0 and 315^0. The other parameter was set to constant such as solar elevation at 30^0 and ambient light setting of 0.20 which yield good contrast. This whole process was done through ERDAS 9.1. Then four shaded relief image was combined to a single shaded relief image prepared by using GIS overlay technique. The first four shaded relief images were overlaid to produce one shaded relief image with different illumination of direction of 0^0, 45^0, 90^0 and 135^0 and the second overlay is to produce shaded relief image with illumination direction of 180^0, 225^0, 270^0 and 315^0.The resulted two shaded relief image were brought into PCI Geomatica 2012 for the algorithm of automatic lineament extraction technique (Abdullah *et al*., 2010). After the process of automatic lineament extraction it had found that lineament created from the 1^{st} shaded relief map of different illumination (0^0, 45^0, 90^0 and 135^0) showed the negative relation when it overlay on the drainage of the study area. And the lineament extracted from the 2^{nd} shaded relief map of different illumination (180^0, 225^0, 270^0 and 315^0) showed the positive relation. Hence for this study we include lineament extracted from the 2^{nd} shaded relief map (Fig.6) and the density of lineament was carried out through ArcGIS 10.1. The ground water prospects were high in the area comes under high lineament density and lower in low density area (Fig.7).

Slope Map

Slope plays an important role in ground water recharge. Areas having more than 20 % slopes had negligible ground water recharge. A slope map was prepared by using ASTER DEM. All part of the study area had very irregular slope which permit less runoff and have very good potential for ground water excluding very little part in North-East and South-East . Areas with steep slopes facilitated high runoff and have poor potential for ground water (Fig.8).

GIS analysis and Ground water prospect delineation

The present study involved weighted overlay method by integrating five thematic maps using spatial analysis tool in ArcGIS 10.1.The ranks had been given for each individual parameter of each thematic map. Based on the influence of the different parameter weightage was assigned to different thematic map. The weightage and rank had been taken considering works carried by the researchers such as (Krishnamurthy *et al*., 1996; Saraf and Choudhury 1998). All the thematic amps were converted in raster format and integrating these layers in weighted overlay analysis techniques which applies a common scale of values to create an integrated analysis using multi-criteria approach.

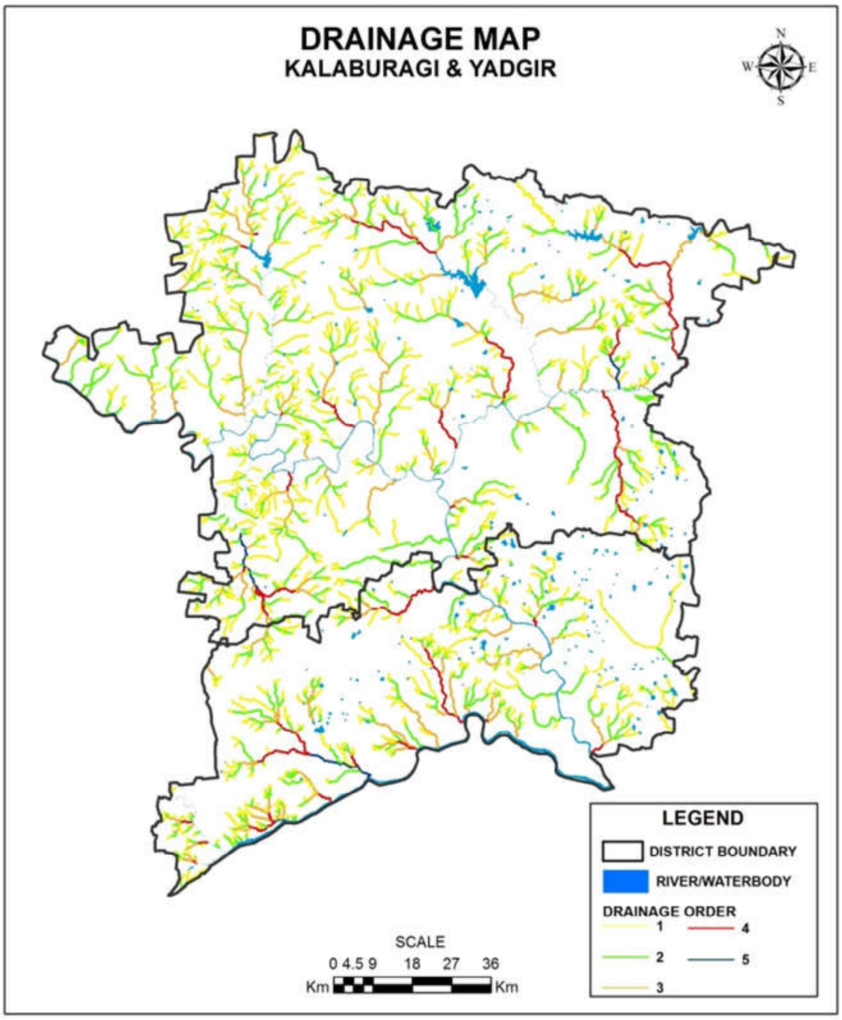

Figure 4. Drainage map of study area

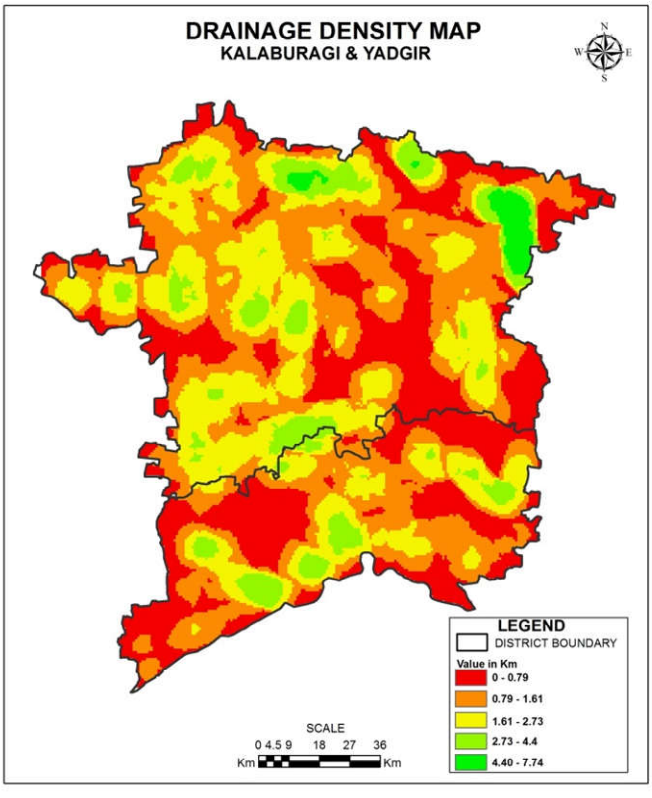

Figure 5. Drainage density map of study area

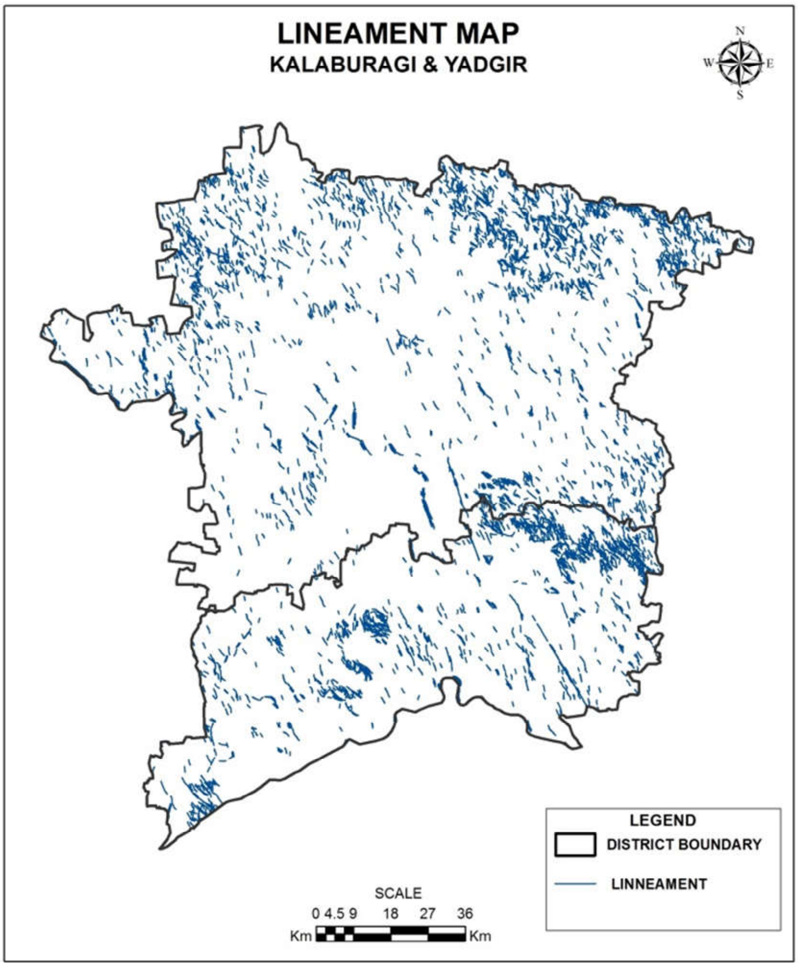

Figure 6. Lineament map of study Area

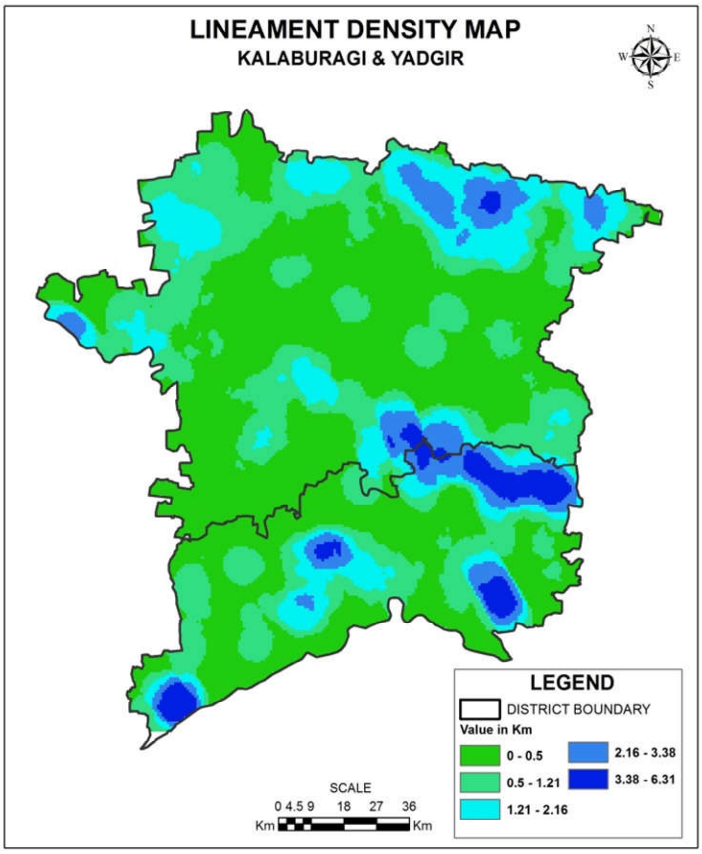

Figure 7. Lineament map of study Area

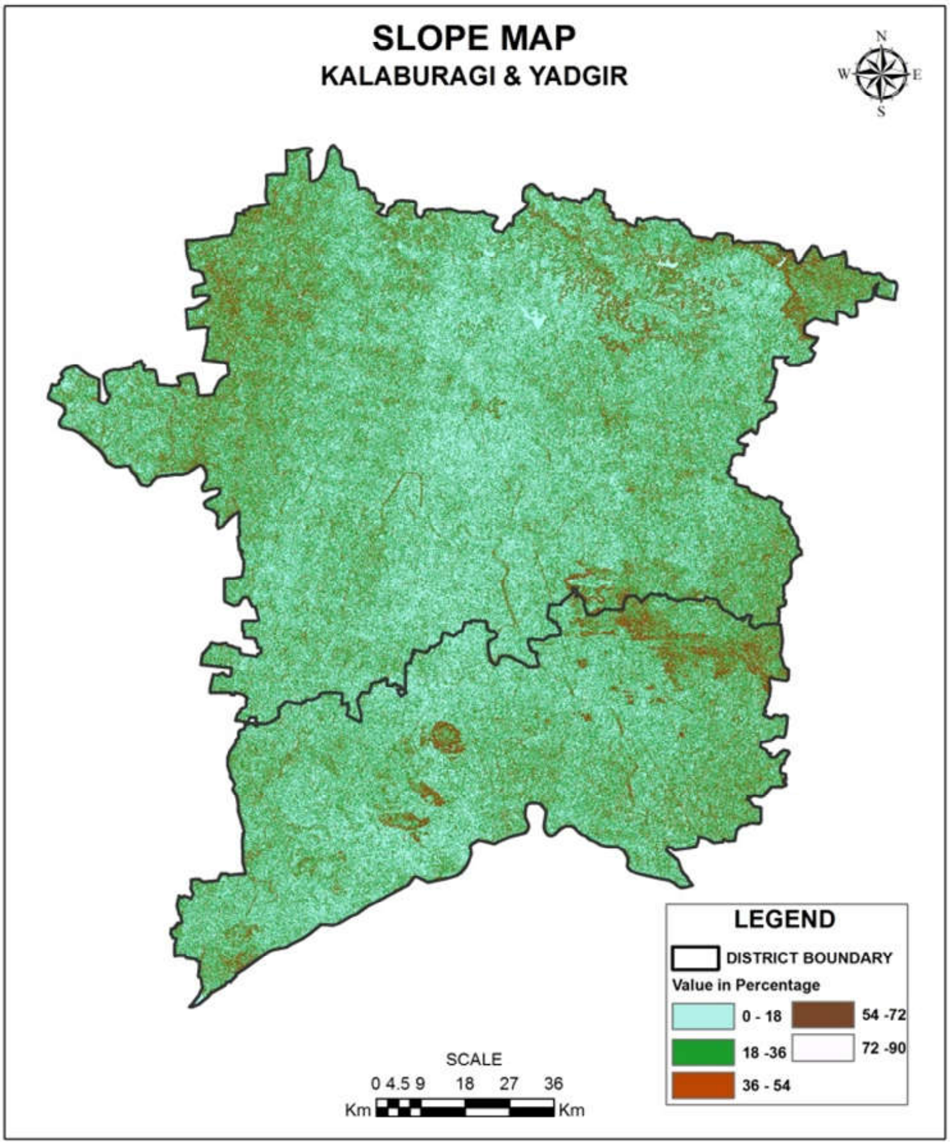

Figure 8. The slope of the study area

Table 1. Weightage and class rank of different parameter used for groundwater prospect

Parameter	Class	Weightage (%)	Ground water Prospect	Rank
Geomorphology	Denudational hill	30	Very Poor	2
	Structural hill		Poor	3
	Water bodies		Good	0
	Anthropogenic origin		Very good	9
Geology	Basalt with Inetertrappeans	25	Moderate	5
	Gray granites		Moderate	4
	Granodiorites		Moderate	4
	Shales and Sand stones		Very good	8
	Laterite with Buxite		Poor	2
Drainage density in (km/square km)	0-2.2	15	Very good	9
	2.2-4.4		Good	8
	4.4-6.6		Moderate	5
	6.6-8.8		Poor	2
	8.8-11.0		Very Poor	1
Lineament density (km/square km)	0-1.5	20	Very Poor	1
	1.5-3.0		Poor	2
	3.0-4.5		Moderate	5
	4.5-6.0		Good	8
	6.0-7.5		Very good	9
Slope (in percentage)	0-13	10	Very good	9
	13-26		Good	7
	26-39		Moderate	5
	39-52		Poor	2
	52-65		Poor	1

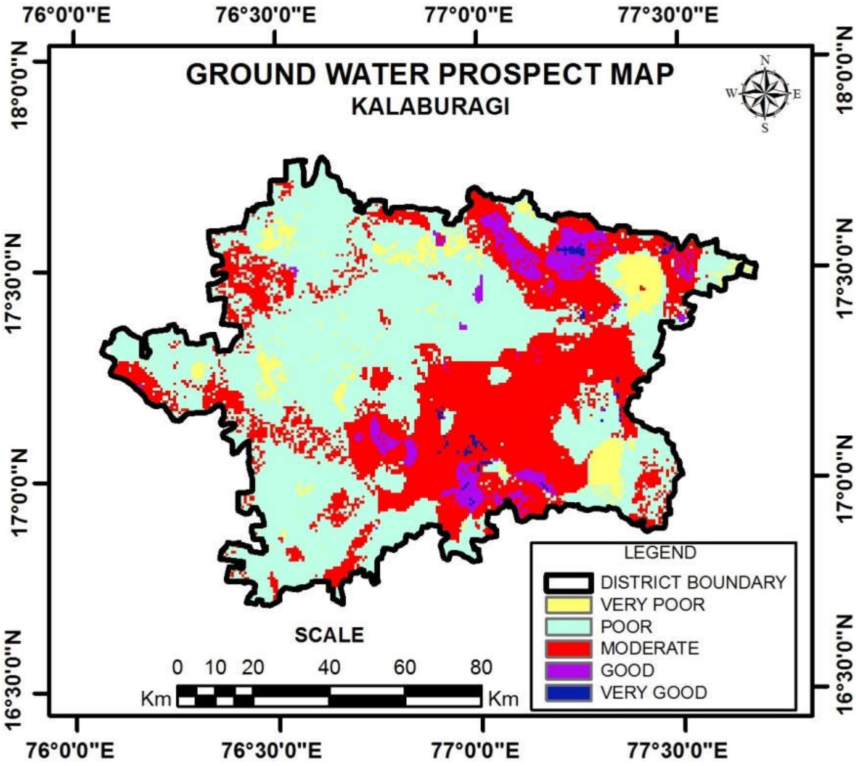

Figure.9: Ground water prospect map of Kalaburagi

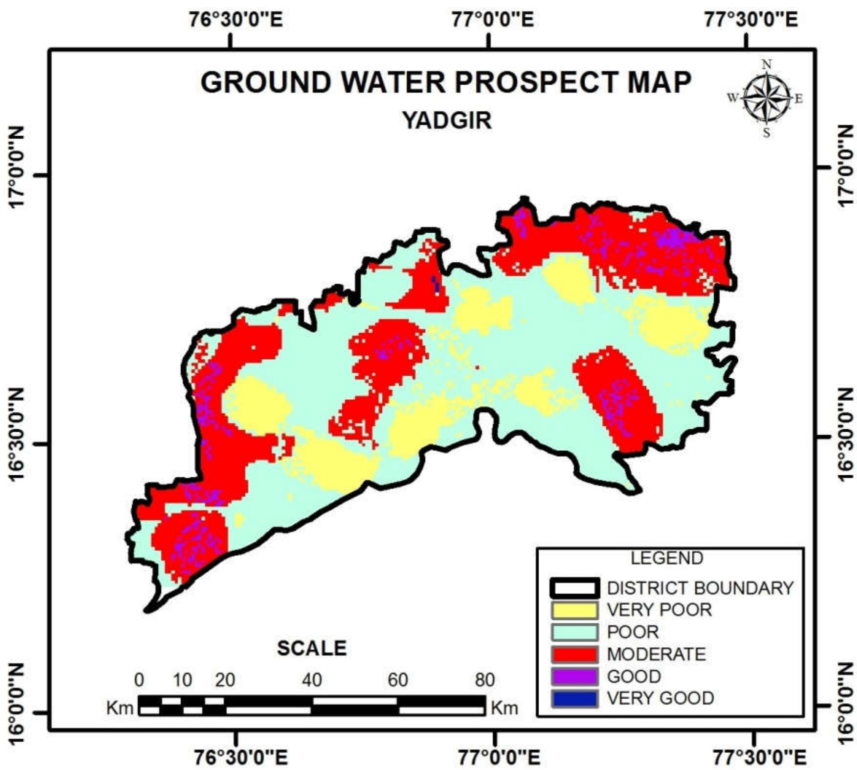

Figure.10: Ground water prospect map of Yadgir

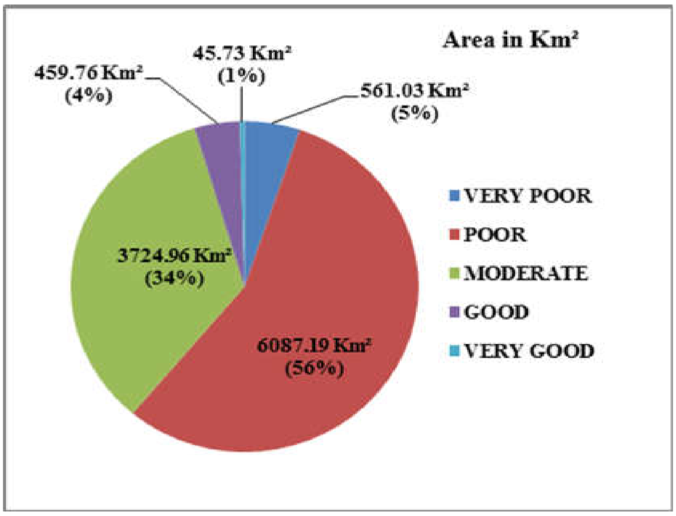

Figure 11. Distribution of potential zones in Kalaburagi

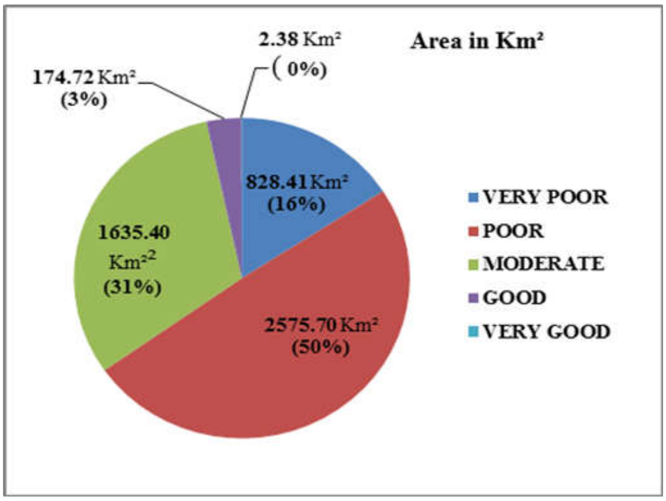

Figure 12. Distribution of potential zones in Yadgir

In this study higher weightage were given to the geomorphology and lineament density followed by the geology, slope and drainage density. The weightage and ranking assigned to each parameter of the thematic layer was given in Table.1.

RESULTS

The final map of ground water potential zones of the study area were grouped into five different group viz. Very good, Good, Moderate, Poor, and Very poor and reclassified to generate output map of both Kalaburagi district (Fig.9) and Yadgir district (Fig.10).The groundwater potential zones along with its area in km^2 and percentage of Kalaburagi were represented in (Fig.11) and of Yadgir in (Fig.12).

In Kalaburagi district the zone of very good occupied 45.73 km^2(i.e. 1%) and that of Yadgir district is 2.38 km^2 almost equal to 0% of the study area. Ground water prospect zone of good covered an area of 459.76 km^2 and 174.73 km^2 respectably (i.e. 4% and 3%). Moderate zone of ground water prospect in Kalaburagi district was 3724.96 km^2 (34%) and that of Yadgir was 1635.40(31%) of the respective total area of the district. The poor prospect for both districts were 6087.19 Km^2 (56%) and 2575.70Km^2 (50%). Very poor zone of ground water prospect in Kalaburagi was 561.03 Km^2 and that of Yadgir was 828.41 Km^2 (16%).

DISCUSSION AND CONCLUSION

The groundwater prospect zone in semi-arid areas depends on the spatio-temporal hydrological interaction and that also depends on the characteristics of the local climate, precipitation, surface and landform settings of that area. As precipitation in these area were very less, it may infiltrate directly to ground surface but due to undulation topography of surface precipitation flows as surface runoff through the flow channel. The most of geomorphic and lithology type present in the study had low porosity and permeability. Because of this our study area showed the very little good or very good ground water potential zone. The identification of ground water potential zone in semi-arid region by traditional methodology is not time and cost -effective. For this, geospatial analysis can play important role and identify the ground water potential zones in a cost effective and targeted manner. High potential zones of ground water were found along the lineaments, and along the slope less than 5%. The geomorphic unit like denudational hills and structural hills showed the poor to moderate potential zones in the study area. The low potential zones are located along the slope more than 25% and in the area of denudational hills and structural hills. The implication of geospatial analysis approach in were identification and mapping of ground water prospect zones in semi-arid region is economically viable and it will helps decision maker to sustainable management of groundwater resources in the these area.

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