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Application of Remote Sensing and GIS in Groundwater Prospect Mapping

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***Abstract*— Groundwater is considered as the preferred source of water for meeting domestic, industrial & agricultural requirements, due to its longer residence time in the ground, low level of contamination, wide distribution, & availability within the reach of the consumer. Remote sensing & Geographical information system technology have opened new paths in groundwater studies. The concept of integrated remote sensing & geographical information system has proved to be an efficient tool in integrating urban planning & ground water studies. The groundwater prospect map is a systematic effort & has been prepared considering major controlling factors, such as geology, geomorphology, drainage pattern, water body, settlement, slopes, etc. which influence the occurrence, movement, depth & yield of groundwater The present study is an attempt to generate groundwater prospect map of Kharun Basin, Chhattisgarh, India using integrated approach of Remote Sensing & Geographic Information System techniques.**

***Keywords*— GIS, Groundwater prospect mapping, Geomorphology, Lithology.**

I. Introduction

Groundwater is one of the most important natural resource of the earth which is mostly required for drinking, irrigation and industrialization. Ground water is attracting an ever increasing interest due to scarcity of good quality sub-surface 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. Efficient management and planning of groundwater in these areas is of the utmost importance. The rate of withdrawal of groundwater is increasing continuously due to rapid growth of population accompanied by agricultural and industrial development. The occurrence and movement of groundwater in an area is governed by several factors such as topography, lithology, geological structure, depth of weathering, slope, land use/land cover and interrelationship between these factors. Artificial recharge systems are engineered systems where surface water is put on or in the ground for infiltration and subsequent movement to aqui-fers to augment groundwater resources. Where these are not available, trenches or shafts in the unsaturated zone can be used, or water can be directly injected into aquifers through wells. Remote sensing and GIS technology have opened new paths in groundwater studies. In the present study, an attempt has been made to identify the Ground Water Prospect sites in the Kharun basin Division of Chhattisgarh based on remote sensing and GIS techniques. The objective is to prepare the ground water prospects maps corresponding to survey of India topographic sheet covering all the habitation.

II. Study Area

The area under study, Kharun river basin, is bounded with Chhattisgarh Plain region province in Chhattisgarh region. The origin point is located in Kharun river, near Petechua village with its latitude 20°33’30” N to 21°33’38” N and longitude 81°17’51” E to 81°55’25” E. It has area of 4191sq.km lying upstream to the point where the river merges with Seonath River. It is covered by the survey of India sheet topographic no. 64G6, 64G7, 64G8, 64G10, 64G11, 64G12, 64G14, 64G15, 64G16, 64H5, 64H6, 64H9, 64H10 and bounded by four districts of the Chhattisgarh. Namely Dhamtari, Durg, Kanker and Raipur out of these districts major area is covered by Durg district. The average annual rainfall of the state is 140 cm. The monsoon brings over 80% of the annual rainfall between the months of June to October, with the highest precipitation occurring in July & August. The area has maximum and minimum tempera-tures of 32.6ºC and 21.0ºC respectively. Groundwater is the major source and is being exploited mainly through dug wells & bore wells under moderate & shallow depth for drinking & irrigation purposes. Location map of Kharun River basin is shown in the *Fig. 1* Brief details of the basin are given in Table I.

TABLE I
DETAILS OF KHARUN RIVER BASIN

S.No.	Particulars	Values
1.	Area of the Kharun basin	4191 sq. km
2.	Perimeter of the Kharun basin	321 km
3.	Maximum height of the Kharun basin	411m
4.	Minimum height of the Kharun basin	269 m
5.	Length of the Kharun basin	2336 km
6.	Width of the Kharun basin	562 km

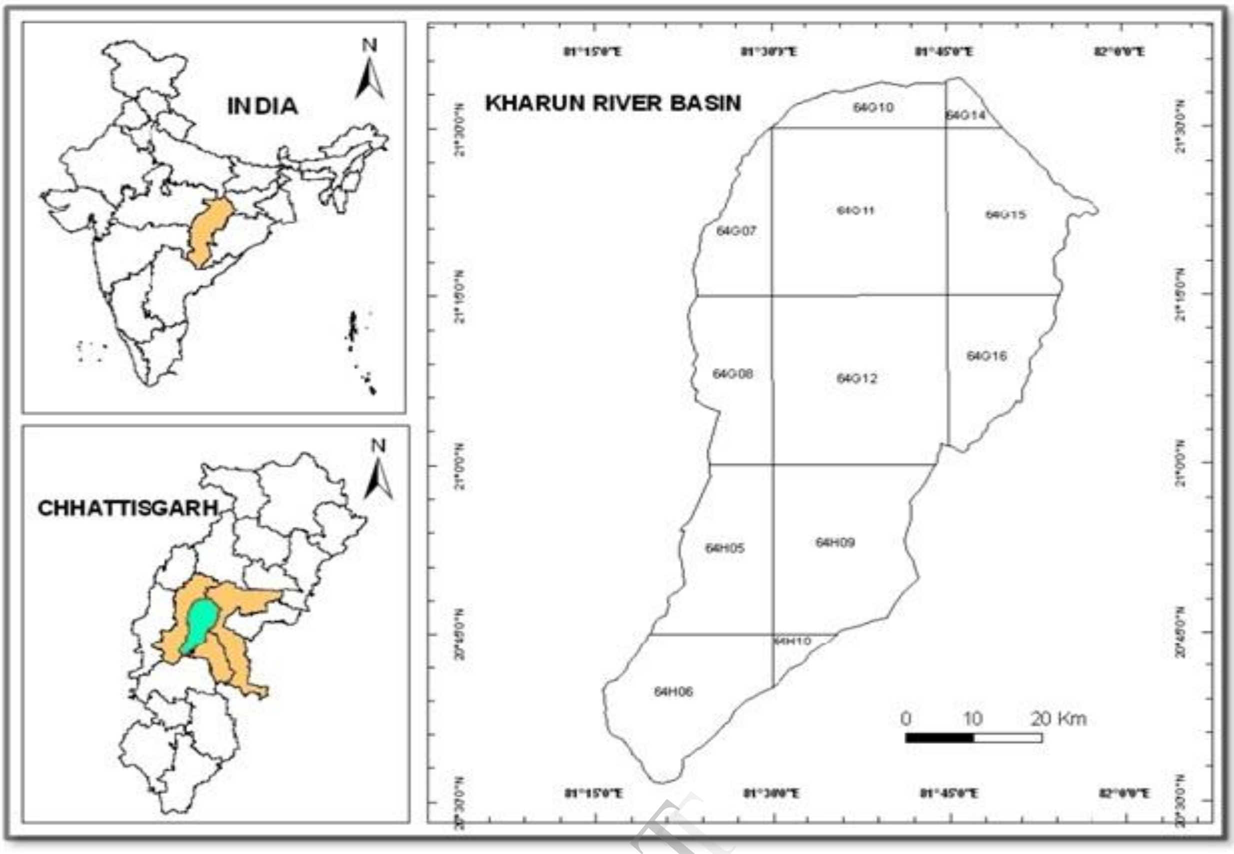

Figure 1. Location map of the study area

III. DATA USED AND METHODOLOGY

A. Data used

LISS-IV sensor data of Indian remote Sensing Satellite IRS-P6 were acquired. A number of published map and reports were used for the purpose of thematic layers generation as input. There are topographical maps at 1:50,000 scale from Survey of India. District Resource Map of the area on 1:250,000 scale. For the study area a 90M resolution Digital elevation model (DEM) is downloaded from Shuttle Radar Topographic mission (SRTM). Location of raingauge station with rainfall of the study area. Well location with water yield data under the study area. Field data were collected for landuse/landcover, aquifer parameters, water level details were also collected through field surveys.

B. Methodology adopted

The methodology adopted for the present study is shown in *Fig. 2*. In order to demarcate the groundwater potential zones of study area different thematic maps on 1:50,000 scales were prepared from remote sensing data, topographic maps, geological maps & field data. Drainage map was prepared from Survey of India topographic sheets and updated from the satellite data. Geological map of the area was prepared from District resource Map of the area published by Geological Survey of India. The slope map was prepared from SRTM DEM. All primary input (hydrogeomorphology, lineament, slope, drainage, water body, etc.) were digitized using Arc GIS 9.3 software. The different polygons final thematic layer were qualitatively visualized into one of the categories like (i) Excellent, (ii) Very Good, (iii) Good, (iv) Average (v) Poor (vi) Very Poor in terms of their importance with respect to the groundwater zones.

IV. THMETIC LAYER GENERATION

A. Administrative Map

Administrative map give an overall view of the area covered by the districts under Kharun river basin with their railway network to reach the destination and also the base of map the road network with different type like cart track, unmetalled and metalled road. In this map various features which are being shown in *Fig. 3* are road network, railway lines and district boundary where each layer is being digitized form toposheet under the Kharun river basin boundary as a polyline layer in 1:50,000 scale.

B. Drainage Map

Drainage is one of the most important and base of the basin boundary layer to be created. From topographic sheet the various drainage pattern is digitized as a polyline layer which are directly meet with the river flow where attributed as first drainage D1 after that the branches attached in D1 where attributed as D2 and rest are being attributed as D3. Durg district covers the major area of drainage whereas Dhamtari has very less drainage lines. Drainage map is shown in *Fig. 4*.

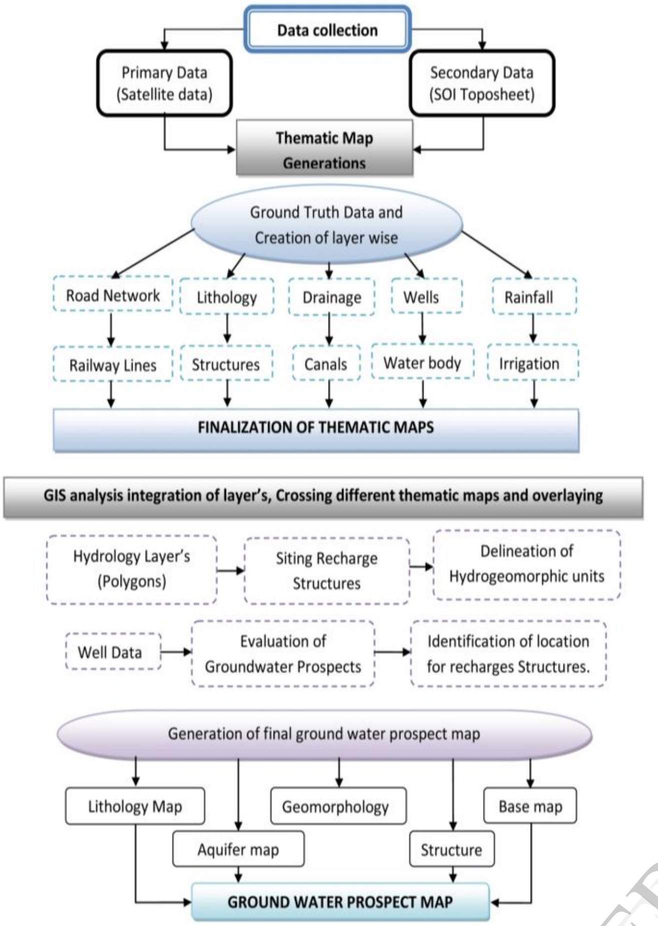

Figure 2. Methodology used

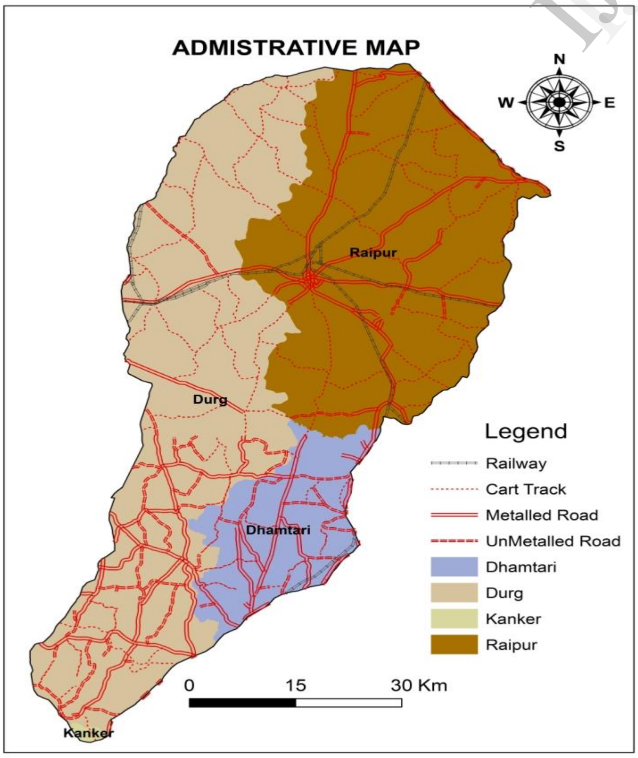

Figure 3. Administrative Map

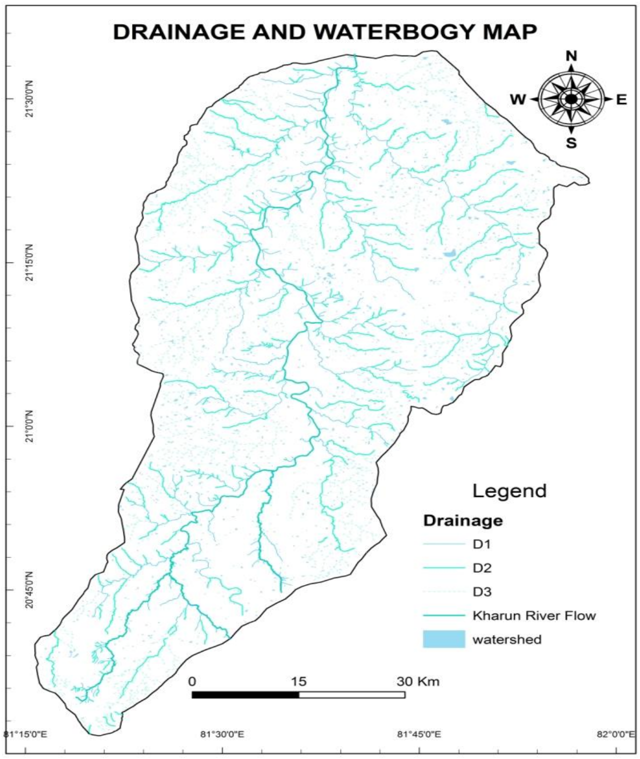

Figure 4. Drainage and Water body Map

C. Geomorphology Map

Geomorphology is defined as the science of landforms with an emphasis on their origin, evolution, form, and distribution across the physical landscape. An understanding of geomorphology and its processes is therefore essential to the understanding of geography which is shown in *Fig. 5*. Geomorphology is the science of studying the external expression/and architecture of the area. Various geomorphic parameters like landforms, slopes, drainage and lineaments played very important role for ground water prospects. Geomorphological process is generally complex and reflect interrelationship among the variables such as climate, geology, soil and vegetation. The major geomorphic units identified in this area are given in Table II and graphical representation is shown in *Fig. 6*.

TABLE II
Geomorphology in the Study area

S. No .	Alpha _Code	Full Name	Area in sq.km	% of total area
1.	APM	Alluvium plain-Moderate	139	3.32
2.	APS	Alluvium plain-Shallow	38	0.91
3.	BPM	Burried Pediplain-Moderate	98	2.33
4.	BPS	Burried Pediplain-Shallow	62	1.48
5.	CB	Canal Bar	3	0.072
6.	FPS	Flood Plain-Sallow	11	.26
7.	MS	Meander Scar	1	.023
8.	PD	Pediment	143	3.41

9.	PLM	Plateau Moderately Dissected	19	.045
10.	PLS	Plateau Slightly Dissected	99	2.36
11.	VFM	Valley Fill-Moderate	14	.33
12.	VFS	Valley Fill-Shallow	26	.62
13.	PPD	Weathered Pediplain Deep	336	8.02
14.	PPM	Weathered Pediplain-Moderated	1736	41.42
15.	PPS	Weathered Pediplain-Shallow	1463	34.91

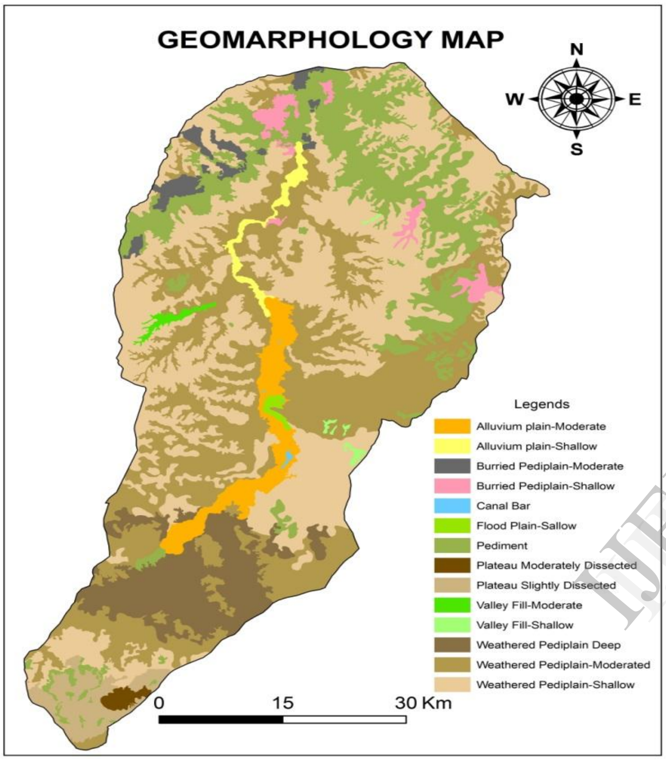

Figure 5. Geomorphology Map

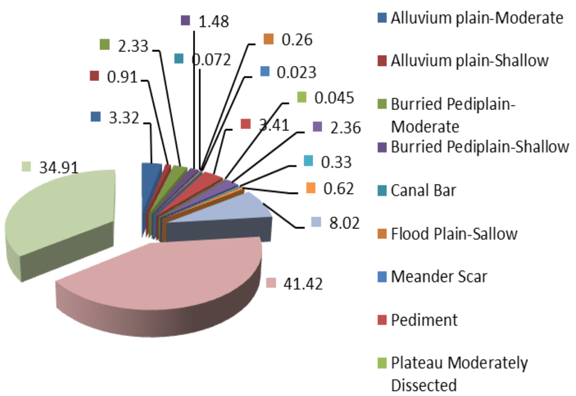

Figure 6. Percentage of Geomorphology

D. *Landuse/Landcover Map*

The landuse and land cover relates to the type of feature present on the surface of the earth whereas landuse refers to the human activity associated with the specific piece of land initially, Survey Of India (SOI) topographical sheet and Satellite data used for information of various land use and land cover information in the study area. The study area is classified into a number of land use and land cover based on different spectral signatures of the surface features in the imagery. Although supervised classification served as a very good helping tool for the interpretation of landuse classes, the thematic map was generated by satellite imagery and digital data which is shown as map in *Fig. 7*. Total geo-graphical area is shown in Table III and graphical representation is shown in *Fig. 8*. Thus it can be concluded that agricultural area covers maximum area where as tree clad and water bodies cover very less or minimum area.

TABLE III
Landuse/Landcover in the Study area

S.No.	LULC	AREA in sq.km	%of total area
1.	Agriculture land	3215	76.71
2.	Built up	428	10.21
3.	Forest	195	4.65
4.	Tree Clad	2	0.06
5.	Waste land	257	6.13
6.	Water bodies	94	2.24
Total Area		4191	

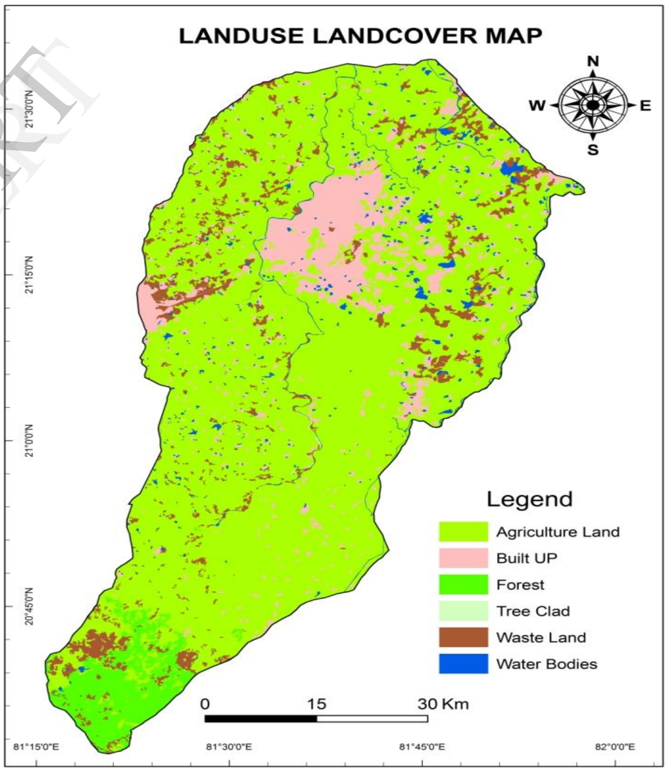

Figure 7. Landuse/Landcover Map

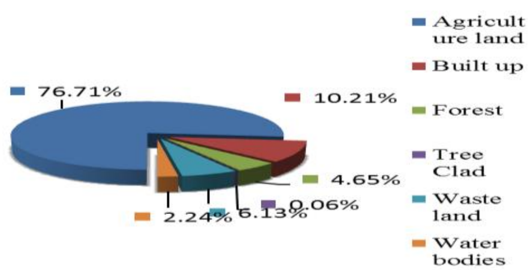

Figure 8. Percentage of Landuse/Landcover

E. Lithological Map

Lithological area in Kharun basin is 4191sq.km in which Stromatolitic Sandstone having alpha code 9 with total area 2106.47 km2 i.e. 50.26% area is being covered whereas Kurud & Pindraon tank having alpha code T which have minimum area of 6.070 sq.km i.e. 0.14 % area, where as the other feature are being shown in Table IV. The features where generated in Arc Info with help of editor tool as digitization of mapping is being done and map is shown in *Fig. 9*. To generate lithology map district resource map is required which is being provided by Chhattisgarh Council of Science and Technology, Raipur. With district resource map the various lithological feature are describe in its graphically shown in *Fig.10*.

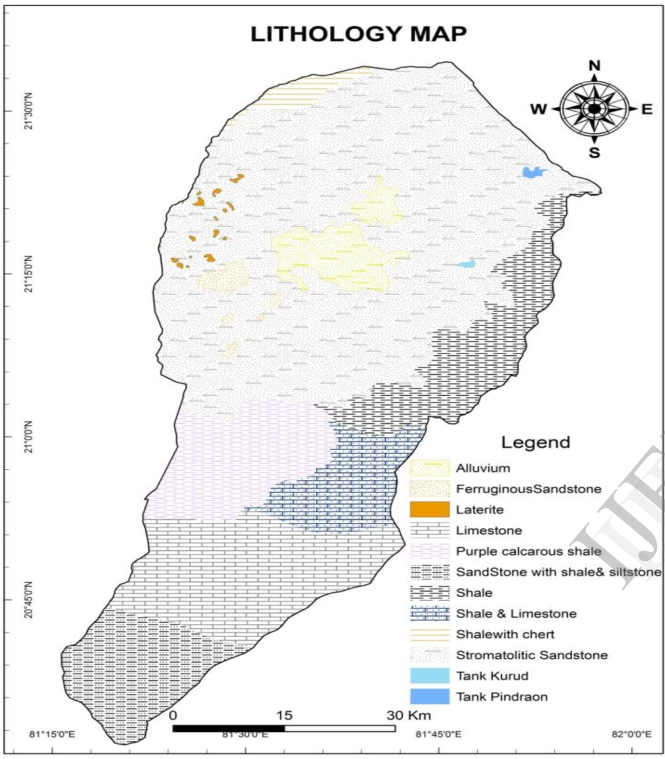

Figure 9. Lithology Map of the study area

TABLE IV
Lithology in the Study area

S.No.	Lithology	Alpha Code	Total Area (sq.km)	% of total area
1.	Alluvium	37a	154.375	3.68
2.	Ferruginous Sandstone	10	36.177	0.86
3.	Laterite	14	15.334	0.36
4.	Limestone	7	554.359	13.23
5.	Purple calcarous shale	8	355.189	8.48
6.	Sandstone with shale& siltstone	6	303.708	7.25
7.	Shale	36	369.336	8.81
8.	Shale & Limestone	5	235.954	5.63
9.	Shale with chert	11	54.027	1.3
10.	Stromatolitic Sandstone	9	2106.47	50.26
11.	Tank Kurud & Pindraon	T	6.070	0.14

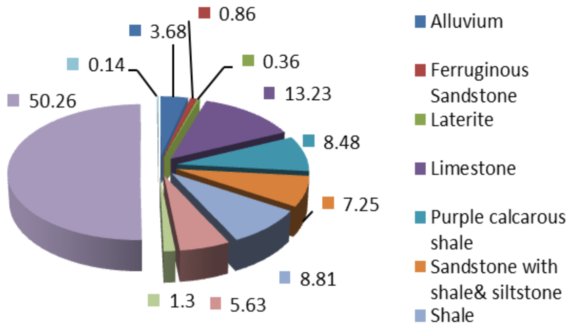

Figure 10. Percentage of Lithology

F. Settlement Map

From olden time habitation occurs near the riverbank for basic need as time cross that habitation increases and peoples get settled there. The settlements are identified with the help of topographic sheet under Kharun river basin. The settlement areas are digitized as a point layer as shown in *Fig. 11*.

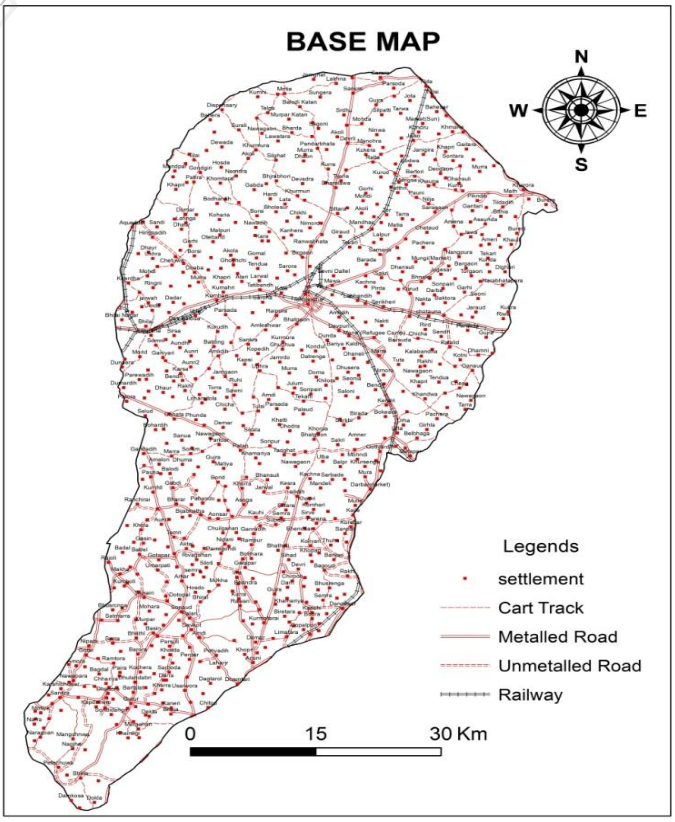

Figure 11. Settlement Map

V. Result

The occurrence and movement of groundwater is mainly controlled by various factors such as landforms, lithology, geological structures, soil, land use/landcover, rainfall etc. This mapping exercise takes into account a variety of satellite derived parameters on geomorphology, geology, structure, drainage, surface, water bodies and integrates with the data on canal, roads, settlements especially drinking water scarcity villages, hydrological data and nature of aquifer. The database thus generated identifies groundwater potential & groundwater recharge areas for suitable site location. After integrating all thematic maps using ArcGIS software, groundwater prospects map is generated for the study area. On the basis of well yield shown in Table V the groundwater prospective zone are differenced as Very poor, Poor, Average, Good, Very Good and Excellent as shown in *Fig. 12*. The groundwater prospective zone map is shown in *Fig. 13*.

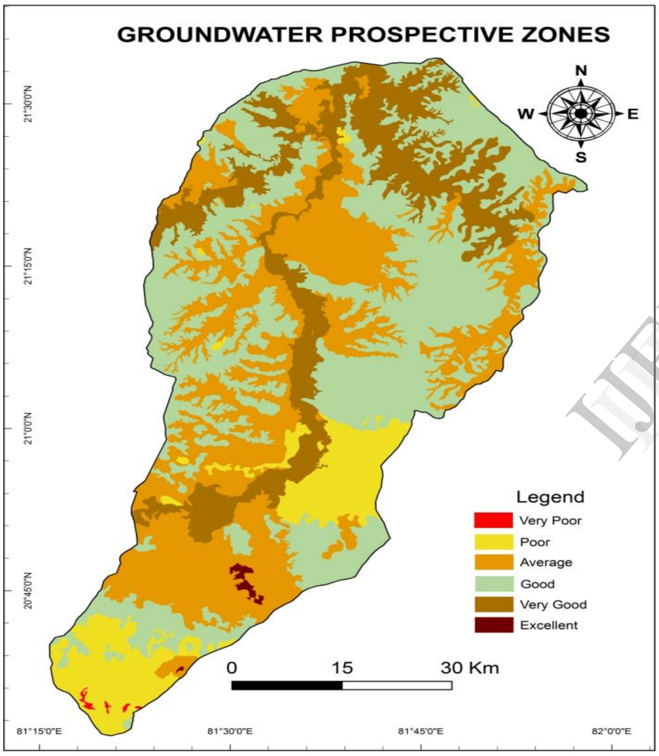

Figure 13. Percentage of different GWP zones

TABLE V
Different GWP Zones in the Study area

S.No.	Well Yield	Type	No. of Well	% different GWP zones
1.	<10	Very Poor	1	0.66
2.	10-50	Poor	27	17.88
3.	50-100	Average	48	31.79
4.	100-200	Good	44	29.14
5.	200-400	Very Good	29	19.21
6.	400-800	Excellent	2	1.33

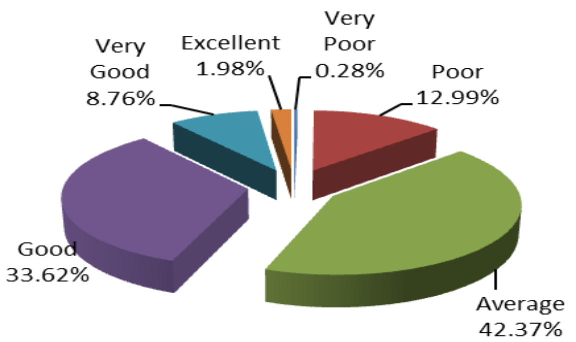

Figure 12. Groundwater Prospective Zones of Kharun Basin

VI. Concusions

The study has shown a systematic planning of groundwater development Modern techniques is used for the proper utilization and management of this precious but shrinking natural resource. Groundwater resources potential has been evaluated in Kharun river basin in Chhattisgarh using remote sensing and geographical information system techniques. Various thematic maps like drainage map, base map, lithology map, geomorphology map, slope map, water body map and land use/land cover map of the study area have been prepared using Arc GIS software. These thematic maps have been integrated and appropriate weightages have been assigned to various factors controlling occurrence of groundwater. The results show that there are six categories of groundwater prospect zones ranging from excellent to very poor. The results are in general agreement with the acquired yield data of the existing dug wells and bore wells. This depicts the favorable prospect zones in the study area for evaluation of groundwater resources. Kharun river Basin has been classified into six different groundwater prospect zones namely 'excellent', 'very good', 'good', 'average', 'poor' and 'very poor' covering different percentages of the study area. Since the major portion of the study area exhibits 'good' to 'average' groundwater prospect, it can be inferred that the groundwater resource is adequately available in the study area. The categorization of groundwater potential zones are in general agreement with the acquired yield data of the 354 existing dug wells and bore wells. This depicts the favorable prospective zones in the study area for evaluation of groundwater potential. Further, the results of this study demonstrated that the integrated remote sensing and geographical information system based approach is a powerful tool for assessing groundwater potential based on which suitable locations for groundwater withdrawals could be identified.

- Quickly identify the prospective groundwater zones for conducting site specific investigation work.
- The groundwater prospects maps will serve the field geologists to plan recharges structures for improving sustainability of drinking water sources, wherever required. The process of groundwater development and management become more efficient and easier.

ACKNOWLEDGMENT

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