Geospatial distribution of groundwater potential zone using Remote sensing, GIS and analytic hierarchy process (AHP) approach: a case study of Raipur district, Chhattisgarh, India

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Abstract

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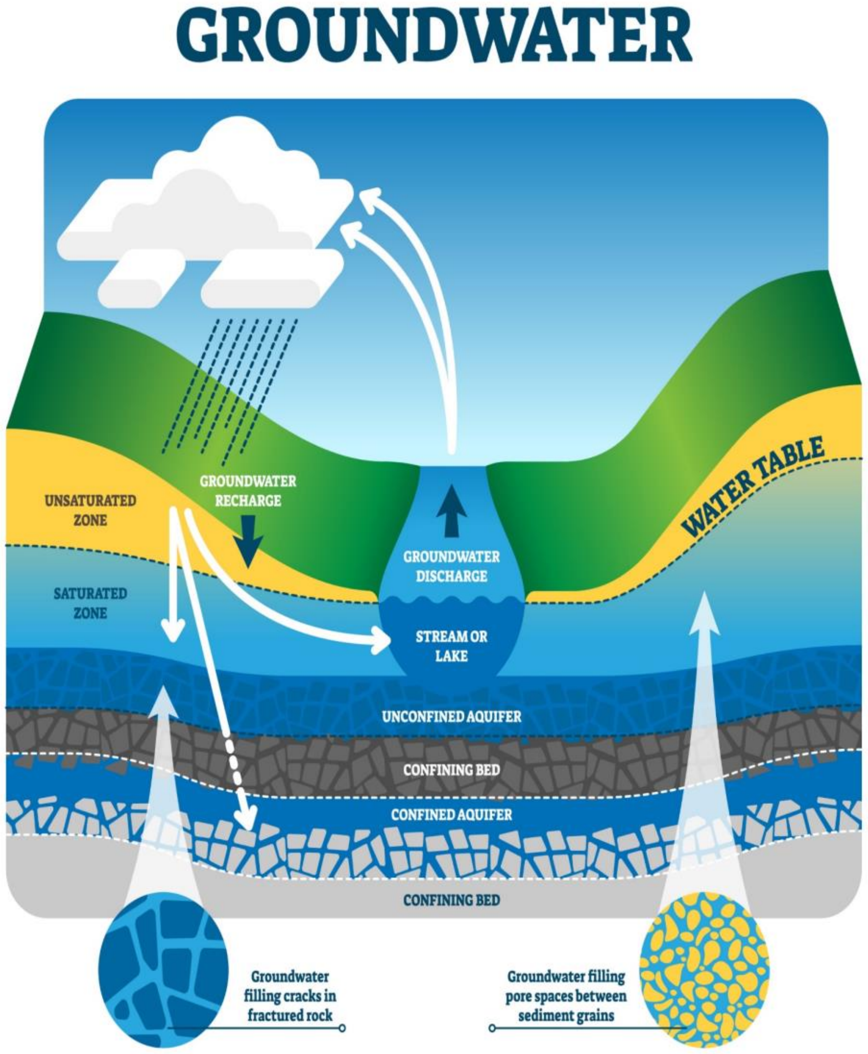
Introduction

- Groundwater is one of the most important and vital natural resource which is stored in the subsurface geological formation of earth's crust.
- In Ancient times, surface water was the primary source of water for various uses in India.
- With increasing population and variation in climatic condition, dependency on ground water has increased.
- Occurrence and distribution of groundwater mainly depends on various natural and anthropogenic factors.
- India is the largest groundwater user in the world, with an annual withdrawal of 230 km^3 for irrigation.



Reference: https://lwvc.org/managing-water-under-our-feet-groundwater

Groundwater Potential Zone

- A Groundwater potential zone refers to an area where the conditions are conducive for the occurrence and movement of groundwater.
- Delineated Groundwater zone map can also be used to decide a location for drilled and dug wells for domestic and irrigation purposes.
- Various Factors affecting GWPZ-

1. Geology
2. Lineament density
3. LULC
4. Drainage density
5. Soil type
6. Slope
7. Rainfall

Raipur District

1. Raipur is the capital city of Chhattisgarh State.
2. The Raipur district is located on the Mahanadi river basin.
3. Raipur districts mostly have two types of soils, i.e., Sandy loam and sandy clay loam.
4. The Raipur districts Extends from latitude 21°23″ to longitude 81° 65″.
5. The total coverage area of Raipur district is 2,892 km²

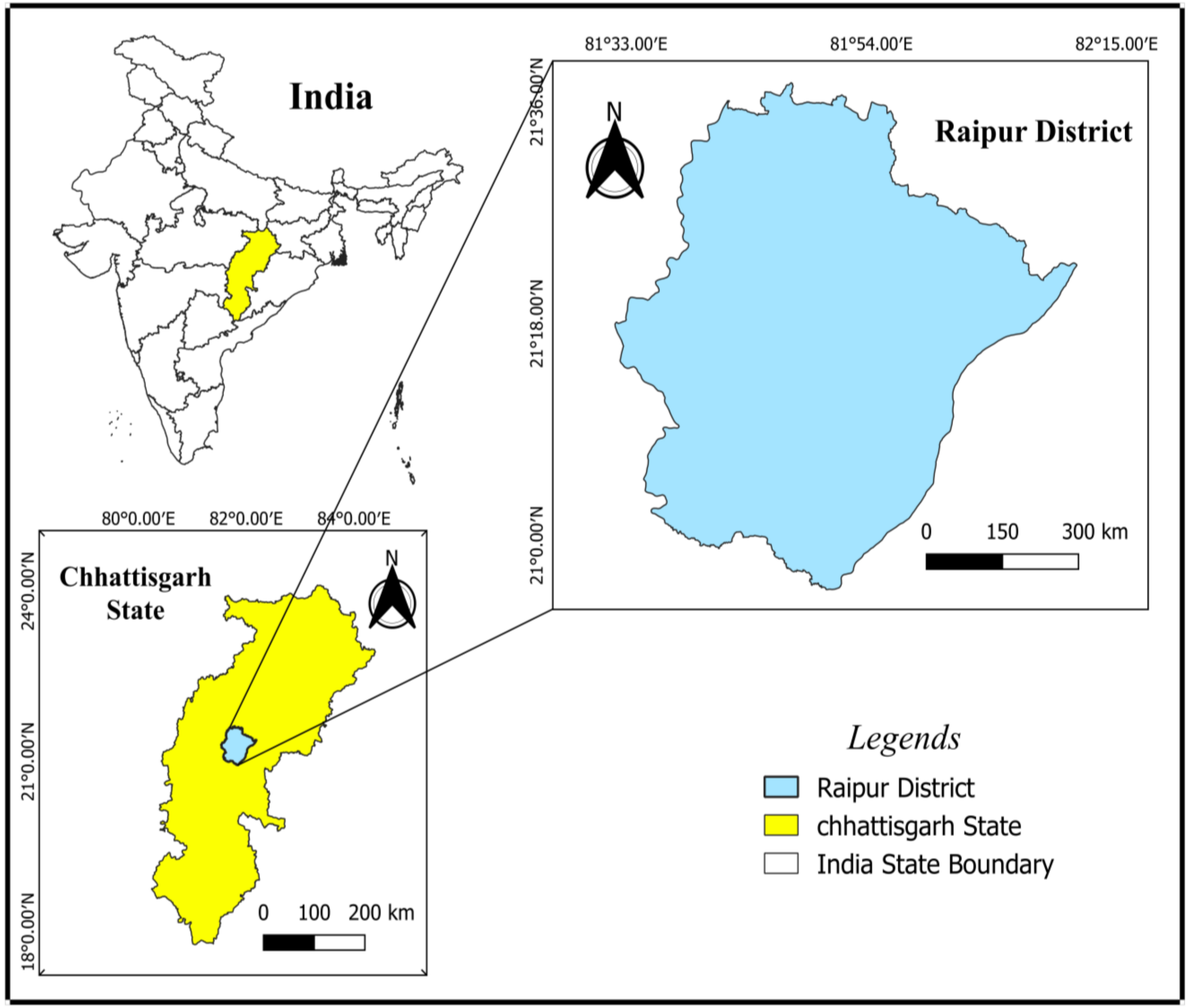


Figure 1: Boundary area of Raipur District

Data Collection

Introduction
Study Area
Methodology
Results
Conclusions

S.No.	Data Required	Resolution	Source
1.	Digital Elevation Model(DEM)	30 x 30 m	BHUVAN https://bhuvan.nrsc.gov.in/home/index.php
2.	Satellite Images(for LULC)	30 x 30 m	USGS and GEE https://earthexplorer.usgs.gov/
3.	Meteorological Data	12 x 12 km	IMDAA https://www.ncmrwf.gov.in/data/
4.	Soil Data	1 km	FAO https://www.fao.org/soils-portal/data-hub/soil-maps-and-databases/faounesco-soil-map-of-the-world/en/
5.	Lithological Data	2 m	BHUKOSH https://bhukosh.gsi.gov.in/Bhukosh/Public
6	Groundwater level Data	Station wise	CGWB

Methodology

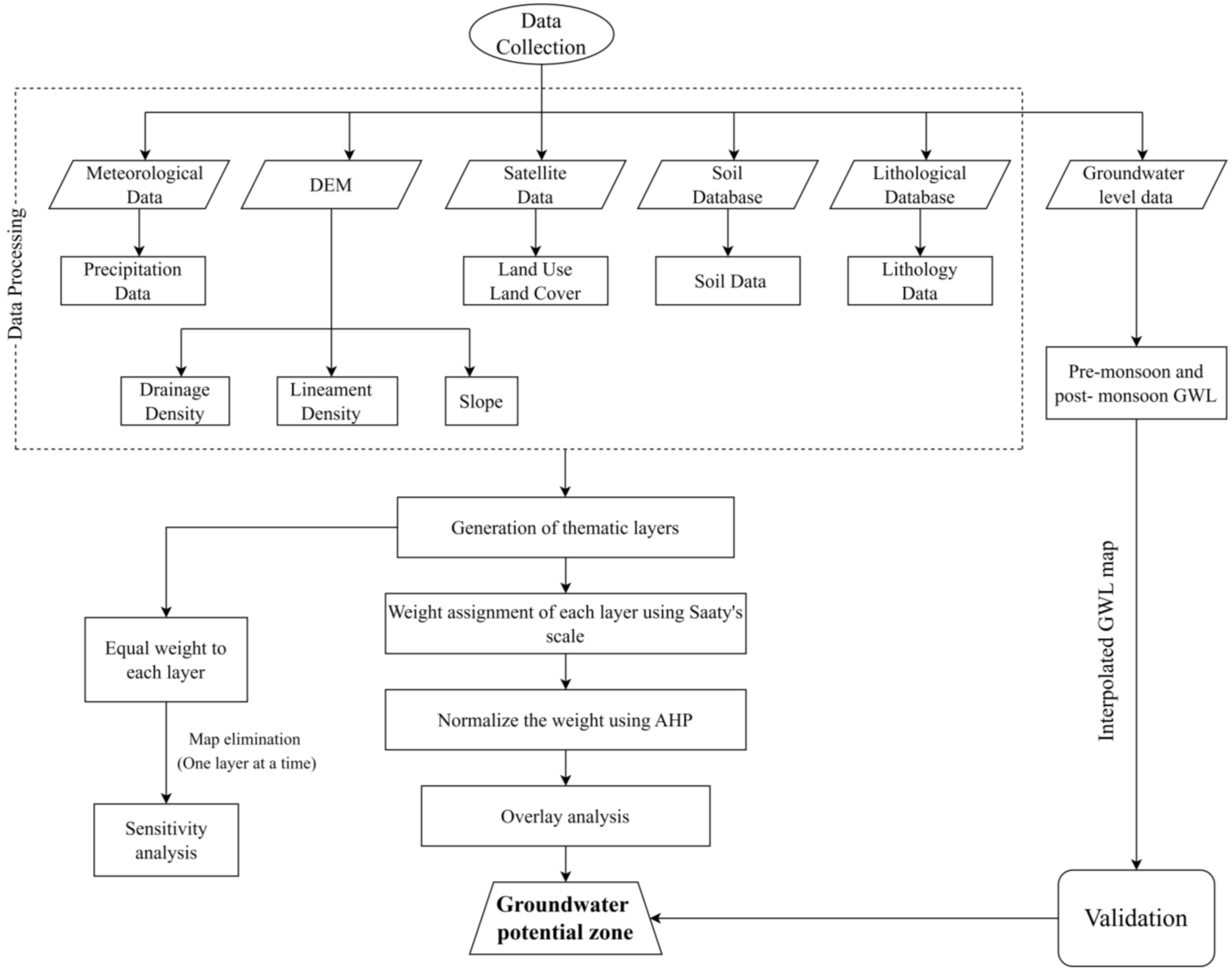


Figure 2: Methodology adopted for this study

Weightage Calculation

	Lithology	Slope	Soil	LULC	Lineament Density	Drainage Density	Rainfall	Weight
Lithology	1	2	3	4	5	6	7	0.3503
Slope	1\2	1	2	3	4	5	6	0.2375
Soil	1\3	1\2	1	2	3	4	5	0.1589
LULC	1\4	1\3	1\2	1	2	3	4	0.1056
Lineament Density	1\5	1\4	1\3	1\2	1	2	3	0.0696
Drainage Density	1\6	1\5	1\4	1\3	1\2	1	2	0.0461
Rainfall	1\7	1\6	1\5	1\4	1\3	1\2	1	0.0318
Total								1

Consistency Ratio (CR) = 0.0246

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Thematic Layers

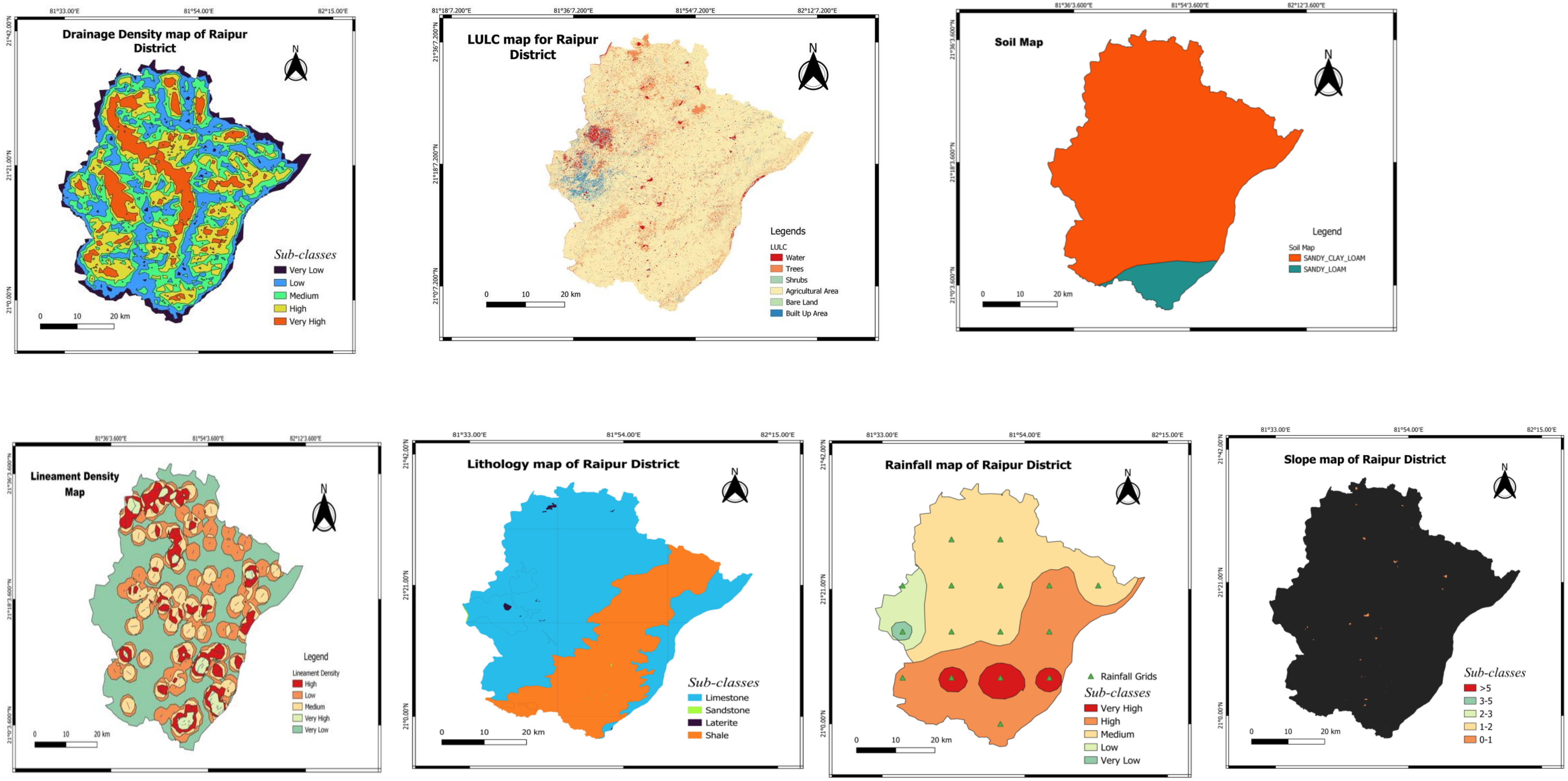
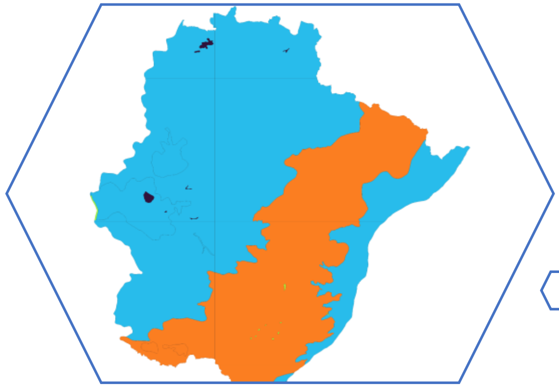
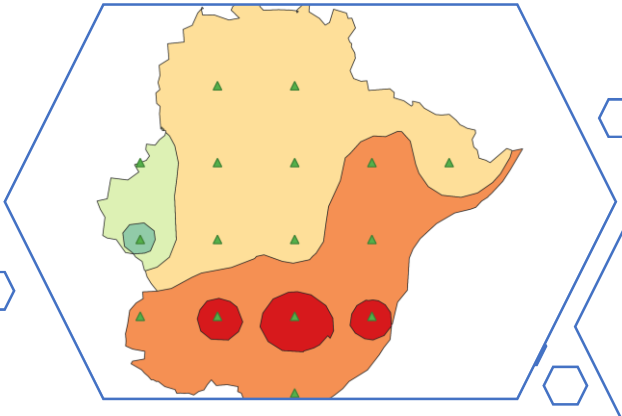
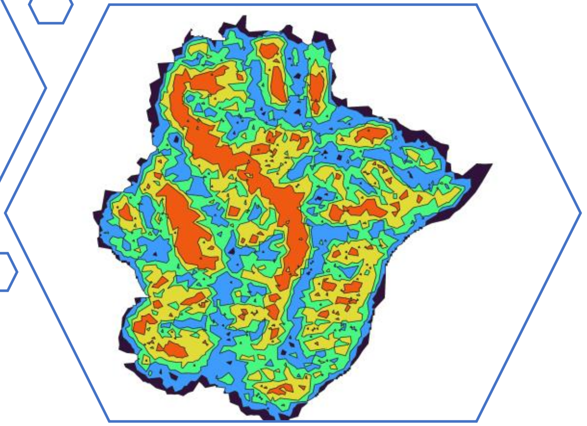


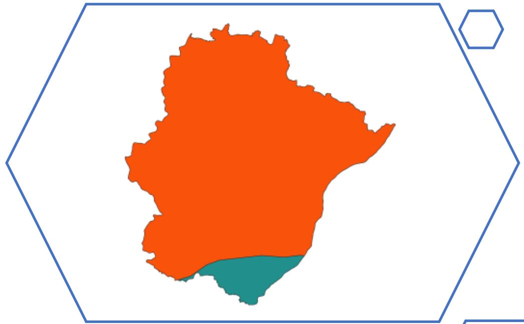
Figure 3: Thematic Layers (DD, LULC , Soil, Lineament Density, Lithology, Rainfall, Slope)

Overlay Analysis









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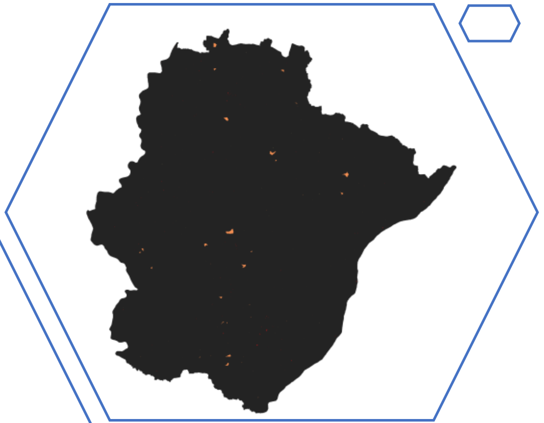

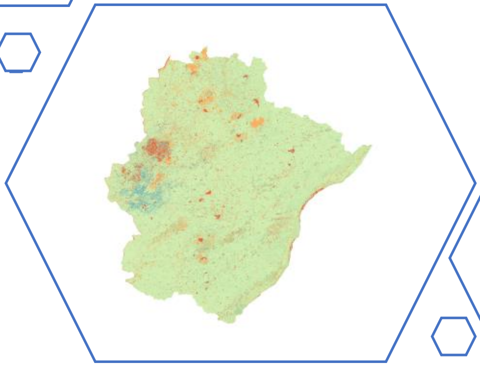

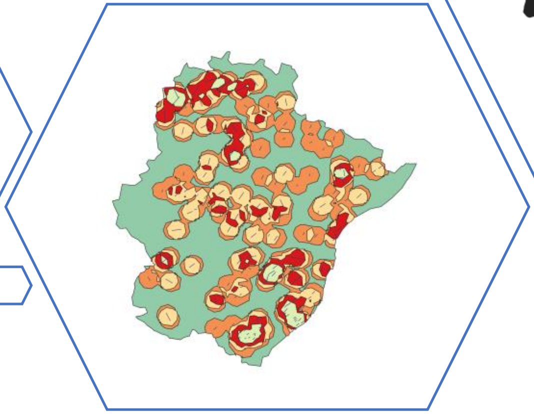

Groundwater Potential Zone

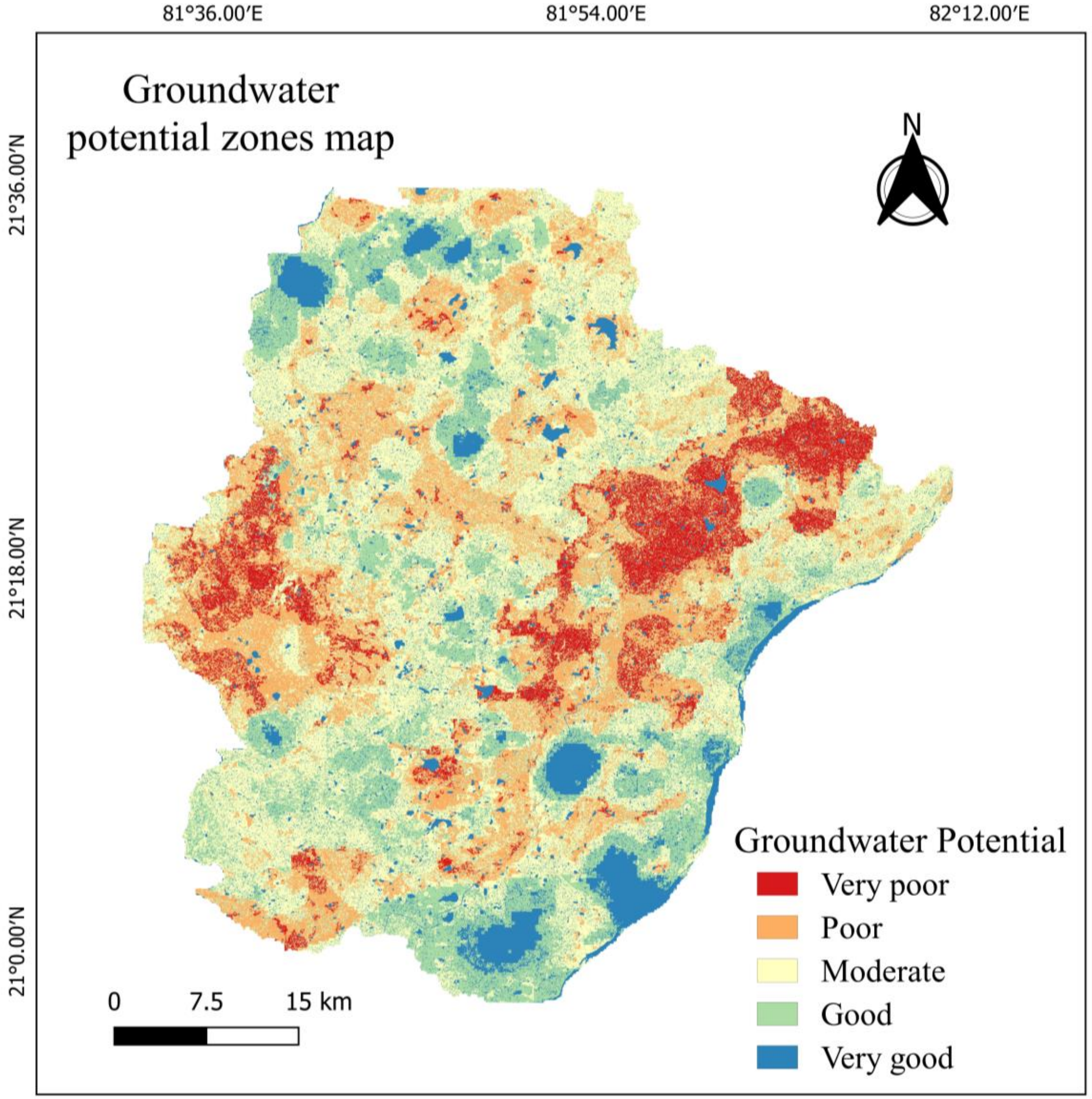

Figure 4: Final Groundwater Potential Zone Map

Sr. No.	Ground Water Potential Zone	Area in sq. km	Area coverage (%)
1.	Very Good	311.908	10.92
2.	Good	609.773	21.34
3.	Moderate	1080.615	37.82
4.	Poor	630.314	22.06
5.	Very poor	224.779	7.87
	Total	**2857.389**	**100**

Analysis

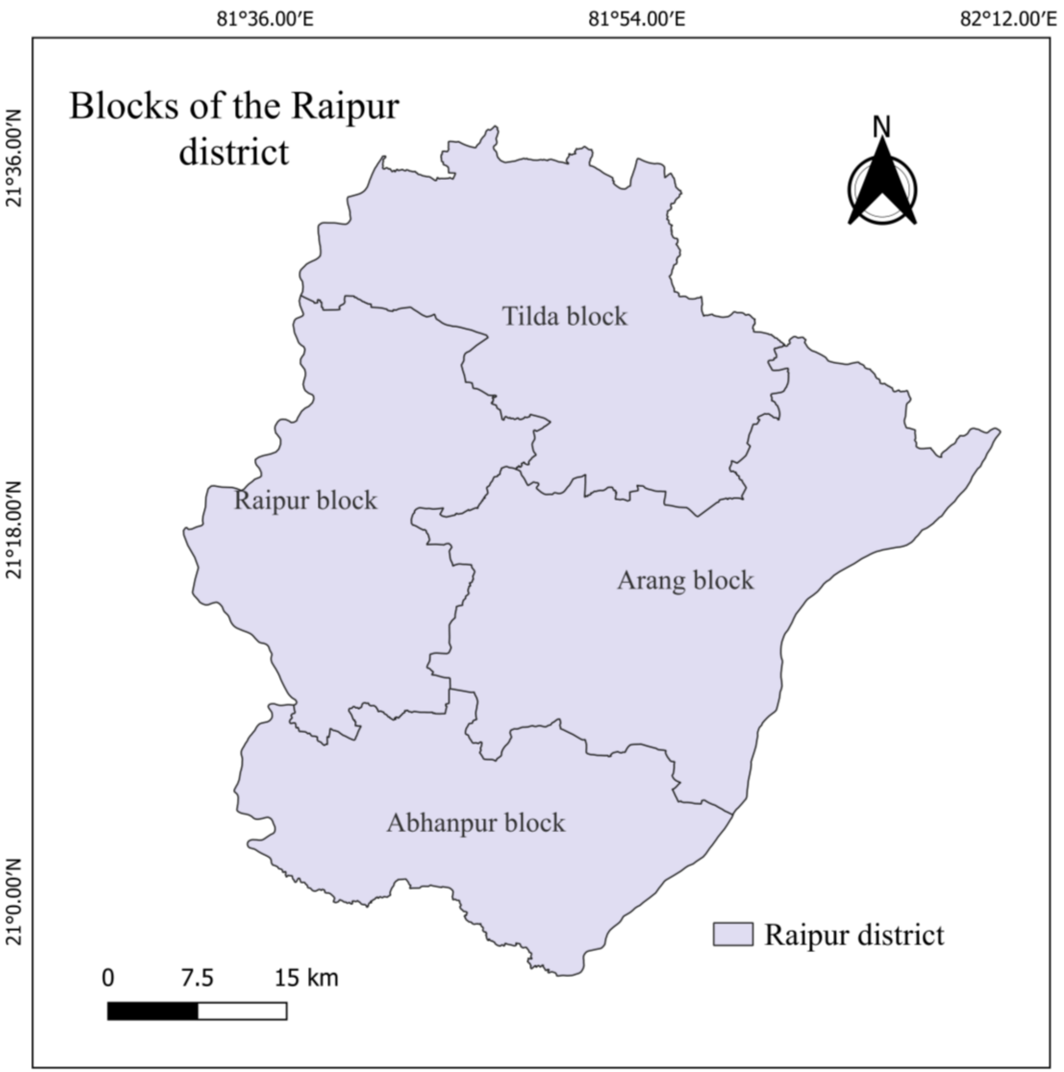

Figure 5: Blocks of Raipur District

1. The Arang block shows a low groundwater potential zone due to the presence of impervious rock i.e., shale while the Raipur block is a highly urbanized area in the district leading to an impervious area hence the occurrence of a low groundwater potential zone.
2. The upper side of the Raipur district consists of Limestone which is highly permeable and shows a Good GW potential zone.

validation

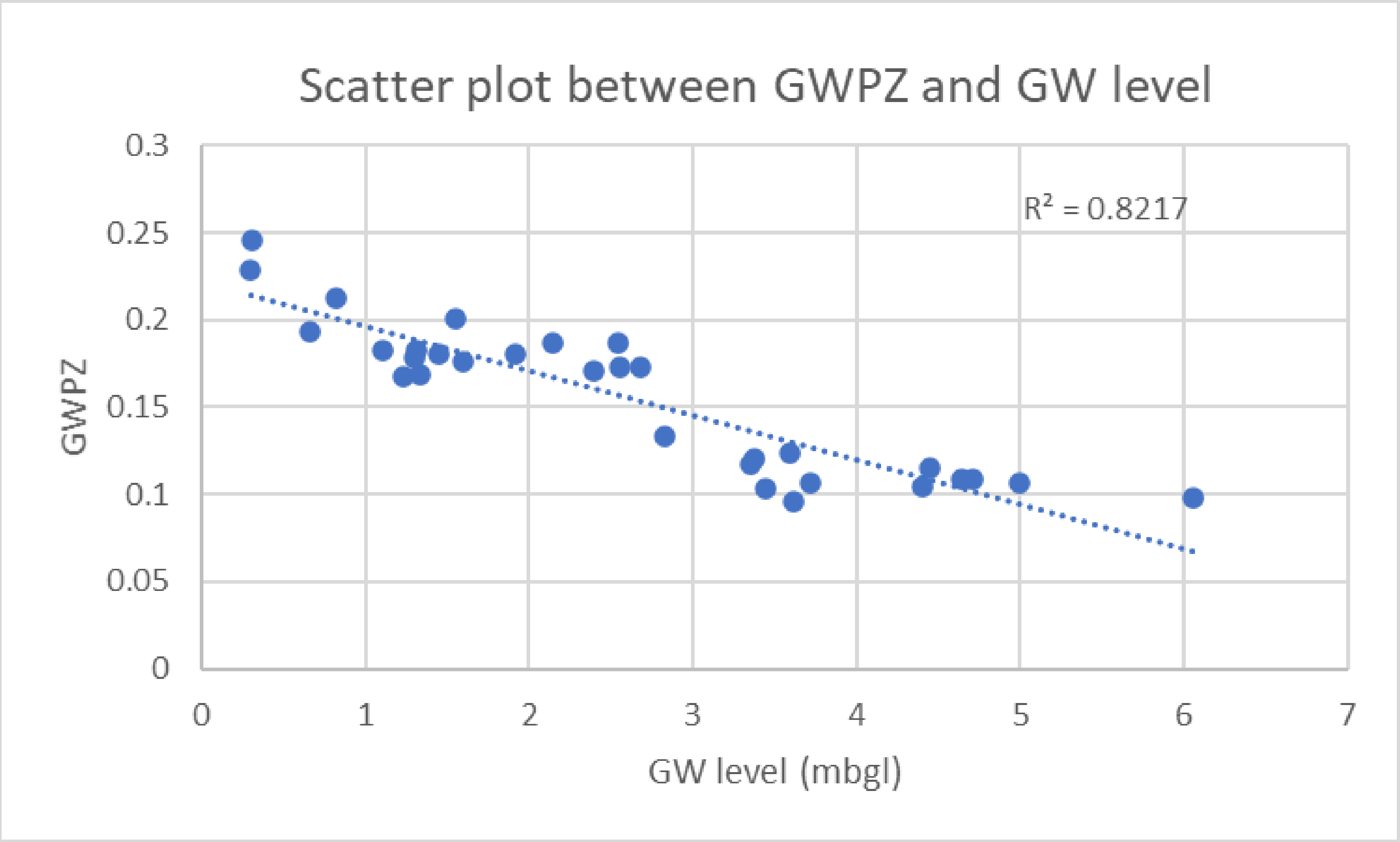

Figure 6: Scatter plot between GWPZ and GW level

Sensitivity analysis

Sr. No.	Removed Parameter	The variability of sensitivity index (%)				
		Min.	Max.	Mean	Median	SD
1	LULC	6.34	1.43	4.37	8.15	3.58
2	Lithology	6.17	1.13	4.20	8.22	3.59
3	Lineament	5.61	2.02	3.69	7.52	2.99
4	Slope	2.11	1.94	2.17	4.04	5.96
5	Rainfall	1.95	0.99	2.12	4.45	1.58
6	DD	3.88	2.02	1.47	5.17	2.14
7	Soil	1.40	0.97	0.79	3.04	0.21

Figure 7: Statistical result of sensitivity analysis

Conclusions

- Groundwater potential zone, determined and identified by direct checking of hand drilling, is a costly and time-consuming activity hence RS and GIS an effective tools for efficiently mapping groundwater potential zones which is efficient and also time-saving.
- The poor potential zones are mainly distributed in the areas having high drainage density. Hence, the groundwater potential in these areas could not be sufficient for irrigation and other livelihood requirements.
- Results indicated that the southern and eastern part of the study area falls under a poor GWP zone due to the presence of unfavorable conditions for groundwater occurrence and needs for proper groundwater management and planning in these areas is needed to improve the groundwater level.

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Thank You!