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GIS-BASED MAPPING OF GROUNDWATER POTENTIAL ZONES USING AHP FOR UJJAIN DISTRICT, MADHYA PRADESH, INDIA

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OUTLINE

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INTRODUCTION

- Water is an elixir of life and the most vital substance in an ecosystem. It is a valuable natural gift for all plants, animals, and other living beings, as well as a crucial component for human survival (Ajaykumar et al., 2016).

- India is significantly reliant on groundwater for a variety of reasons. Groundwater is the world's greatest source of freshwater (Pal et al., 2020).

- In rural regions, groundwater supplies 80–90 percent of residential water. Groundwater is also used to provide 50 percent of urban and industrial demand. It also supplies water to more than half of the irrigated land (Ground Water Board, 2019).

- Groundwater demand has been steadily rising across the world due to massive demands for residential, agricultural, industrial, economic, and ecological needs (Jasrotia et al., 2013).

- Groundwater is the most widely distributed treasure and asset on the planet, and unlike other mineral assets, it is replenished annually by precipitation (Lakshmi & Reddy, 2018).

- The availability of groundwater resources has become a dynamic concern worldwide as a result of fast population expansion and increased levels of human activity (M. Qadir et al., 2020).

- Furthermore, unsustainable population increase and rapid urban development have led to the resource's overexploitation, which has resulted in a massive drop in groundwater level (Kanta et al., 2018).

- Groundwater is a dynamic resource that is influenced by a variety of factors including lithology, slope, geomorphology, soil, topographic changes, moisture availability, rainfall, drainage pattern, plant cover, and land use/land cover (LULC) (Deshmukh, 2011).

OBJECTIVE

- The overall goal of this research is to use Geographic Information Systems and remote sensing methods to designate groundwater potential zones in Ujjain district.
- Using the study area's thematic maps, determining the elements that impact the demarcation of the groundwater potential zone.
- Groundwater potential zones will be delineated by merging all thematic maps and evaluating them in a GIS context.
- Validation of the research area's designated groundwater potential zone map.

STUDY AREA AND DATA COLLECTION

STUDY AREA

- Ujjain district is selected as the study area for the current research.
- The district covers 6,091 square kilometers.
- The city of Ujjain is located on the right bank of the Kshipra River. It is located on the Malwa plateau.
- The soil is stony and black. Arid-region vegetation can be found here.
- The Kshipra River, a tributary of the Chambal River in the east, is the primary river of Ujjain district. The Gambhir and Kahn rivers, both tributaries of the Kshipra, are two more tiny rivers.
- The index map of study area is shown in Fig.1.

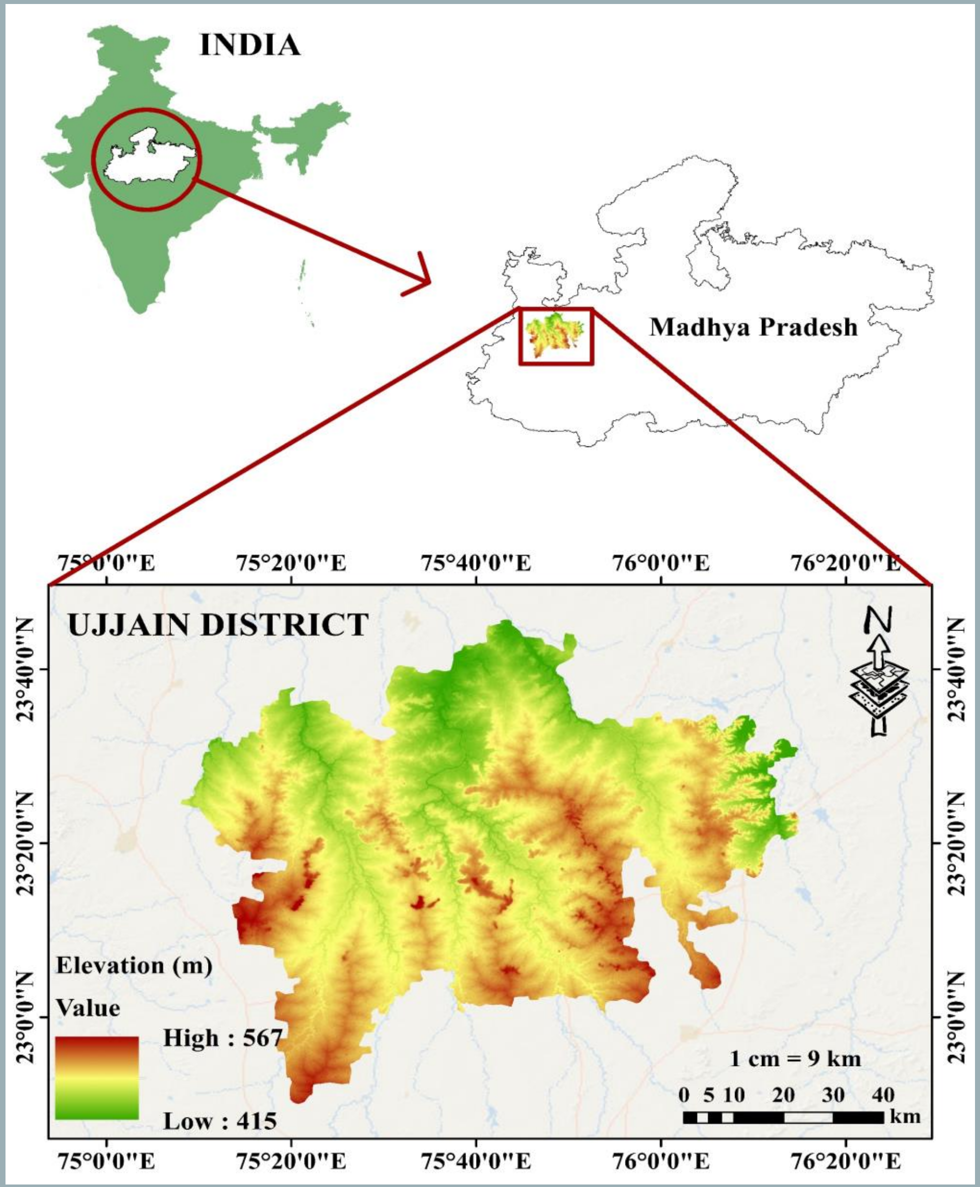


Fig.1 Index map of Study area

DATA COLLECTION

- The thematic maps have to be prepared which include LULC, Drainage Density, Elevation, Lithology, Geology, Rainfall, Slope, Soil and Geomorphology map.
- Shuttle radar topography mission (SRTM) (30m*30m Resolution) Digital Elevation Model (DEM) is downloaded from USGS website.
- The DEM is used to extract slope, drainage density and elevation map of the study area.
- The land use/cover of the study area will be prepared using a Landsat 8 image of the study area. The landsat-8 images will be download from USGS website.

Table. 1: Data source

S. No	Thematic Layers	Data Type	Source
1	Slope	Raster (SRTM)	USGS Earth Explorer
2	Geology	Polygon	Bhukosh – Geological Survey of India
3	Geomorphology	Polygon	Bhukosh – Geological Survey of India
4	LULC	Raster/LANDSAT 8	USGS Earth Explorer
5	Drainage density	Raster	USGS Earth Explorer
6	Soil	Polygon	FAO
7	Lithology	Polygon	Bhukosh – Geological Survey of India
8	Rainfall	Climatology	IMD
9	Elevation	Raster	USGS Earth Explorer

METHODOLOGY

- The study's methodology includes utilizing ArcGIS software to gather and prepare thematic layers.
- The AHP technique is used to assign weights to the thematic maps.
- After assigning the weights, the layers will be subjected to weighted overlay analysis in ArcGIS 10.8.
- Fig.2 depicts the methodology for the study area.

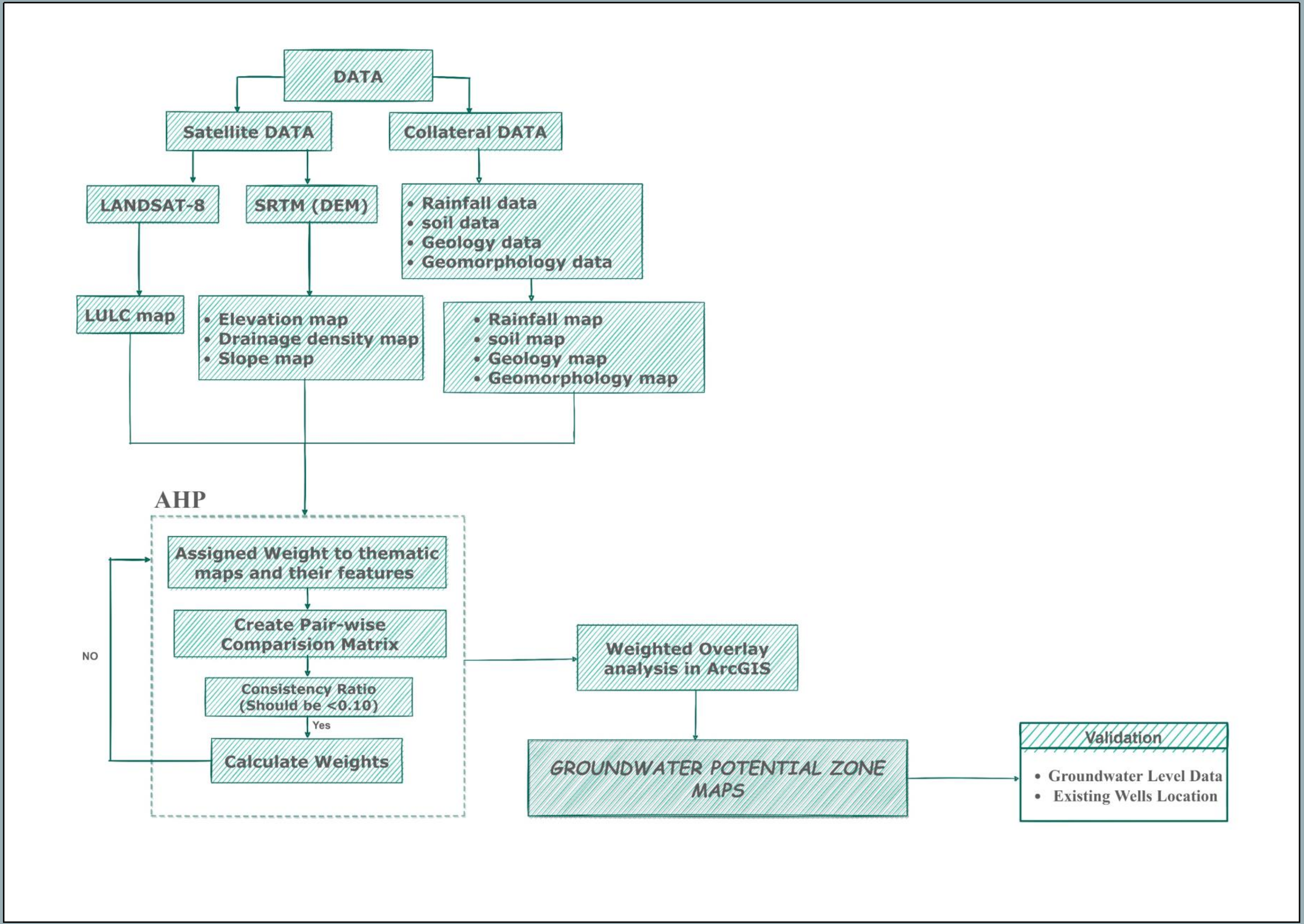


Fig.2 Flowchart of methodology for the study

THEMATIC MAPS

- In this study area for evaluating groundwater potential zones total 9 thematic maps were prepared.
- All the thematic maps are prepared using ArcGIS 10.8 software.
- After the preparation of each thematic map, reclassification of each layer is done depending upon the relative importance of each sub-parameter on the groundwater potential zone.
- The groundwater potential zone is affected by all nine parametric layers investigated for the study, both intrinsically and extrinsically.

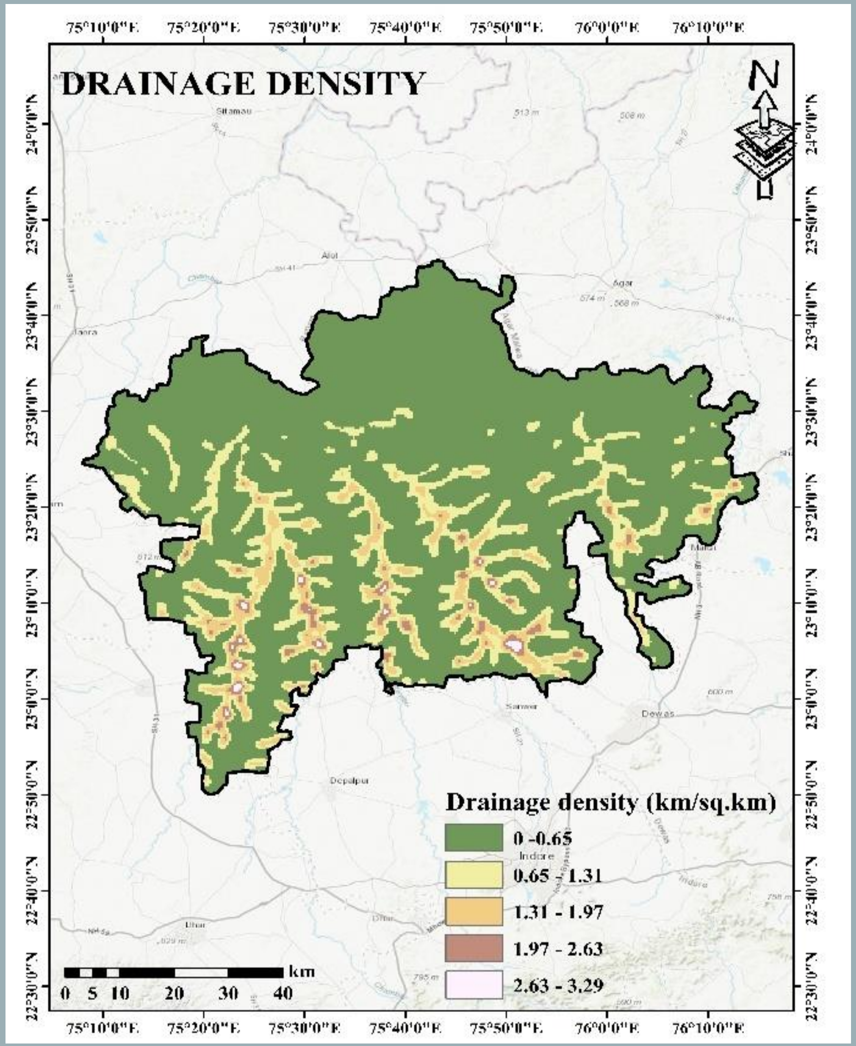


Fig. 3 Drainage Density

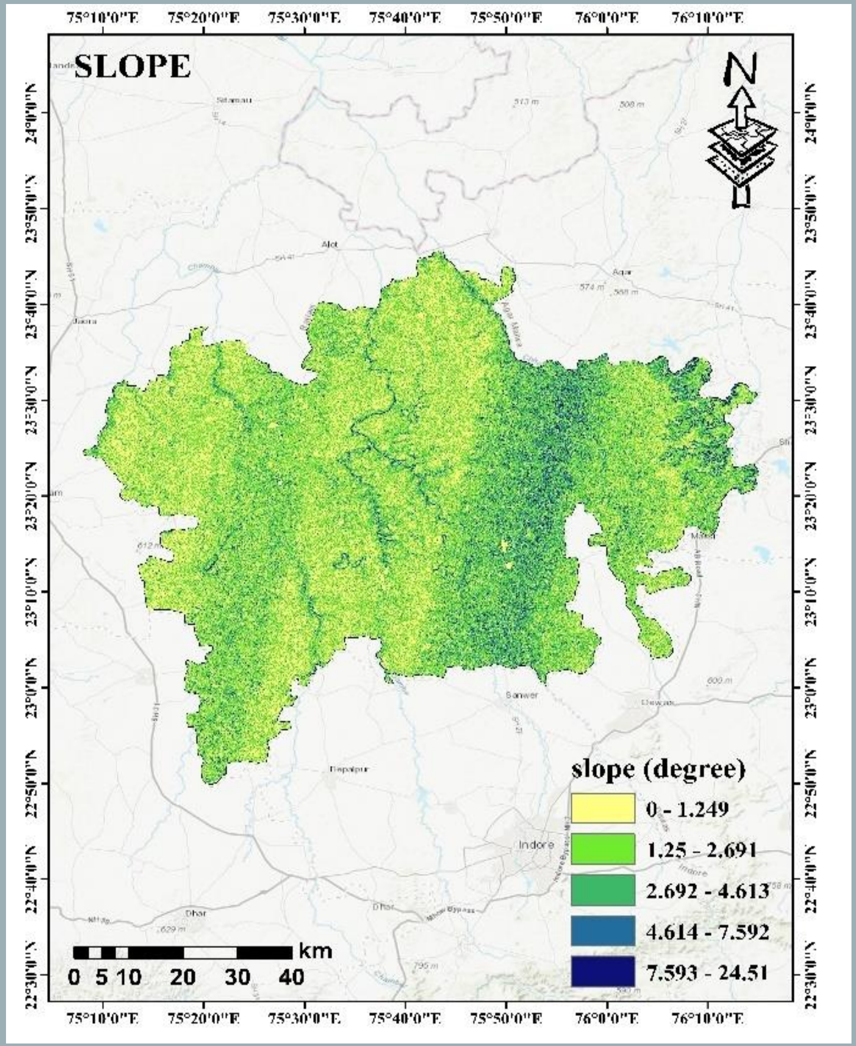


Fig. 4 Slope

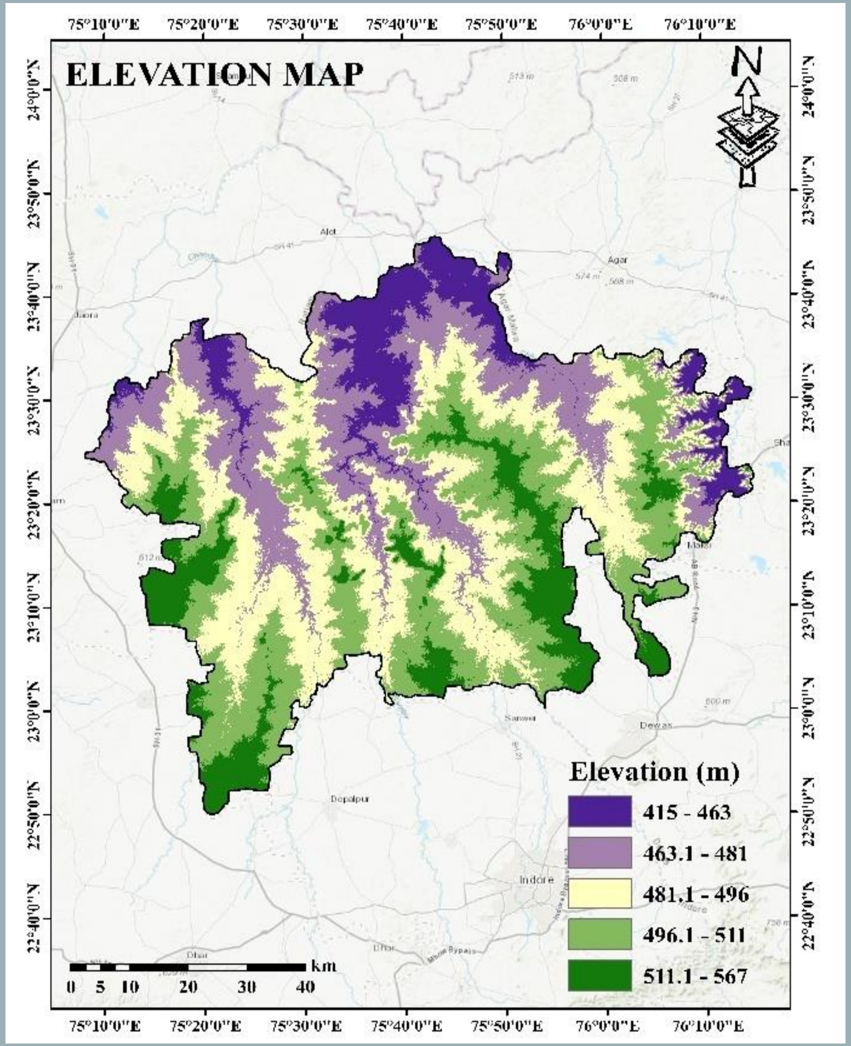


Fig. 5 Elevation

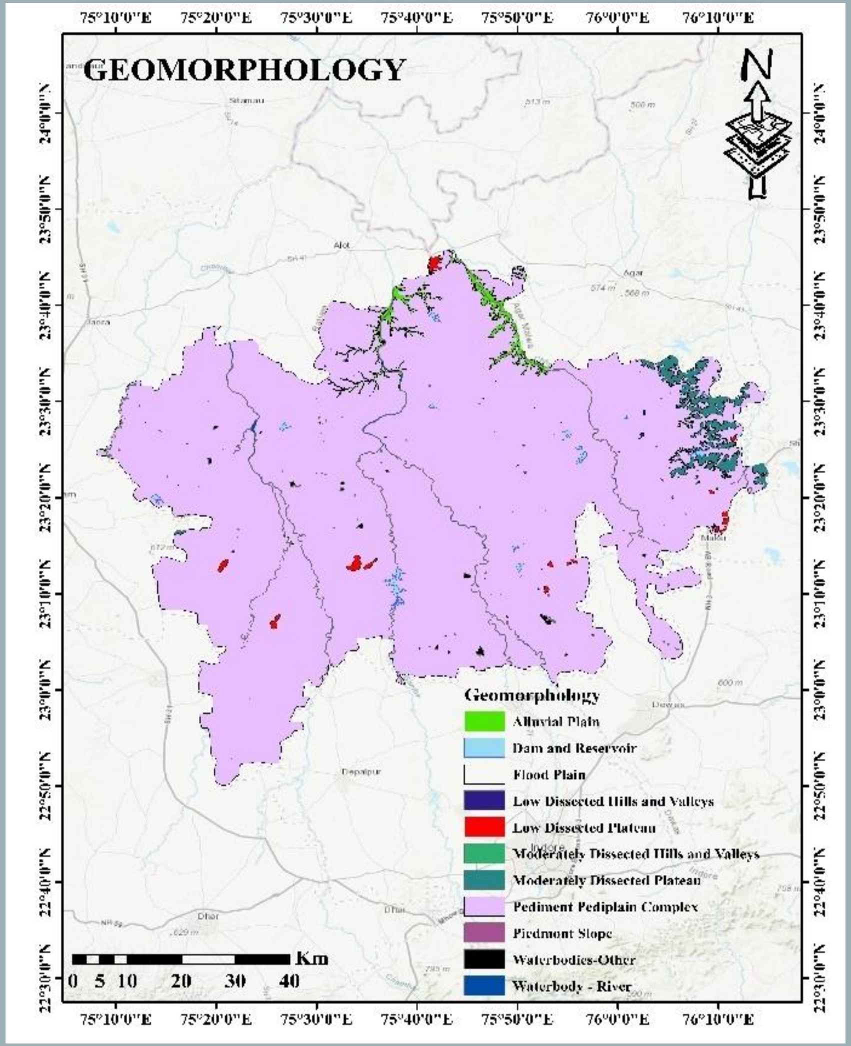


Fig. 6 Geomorphology

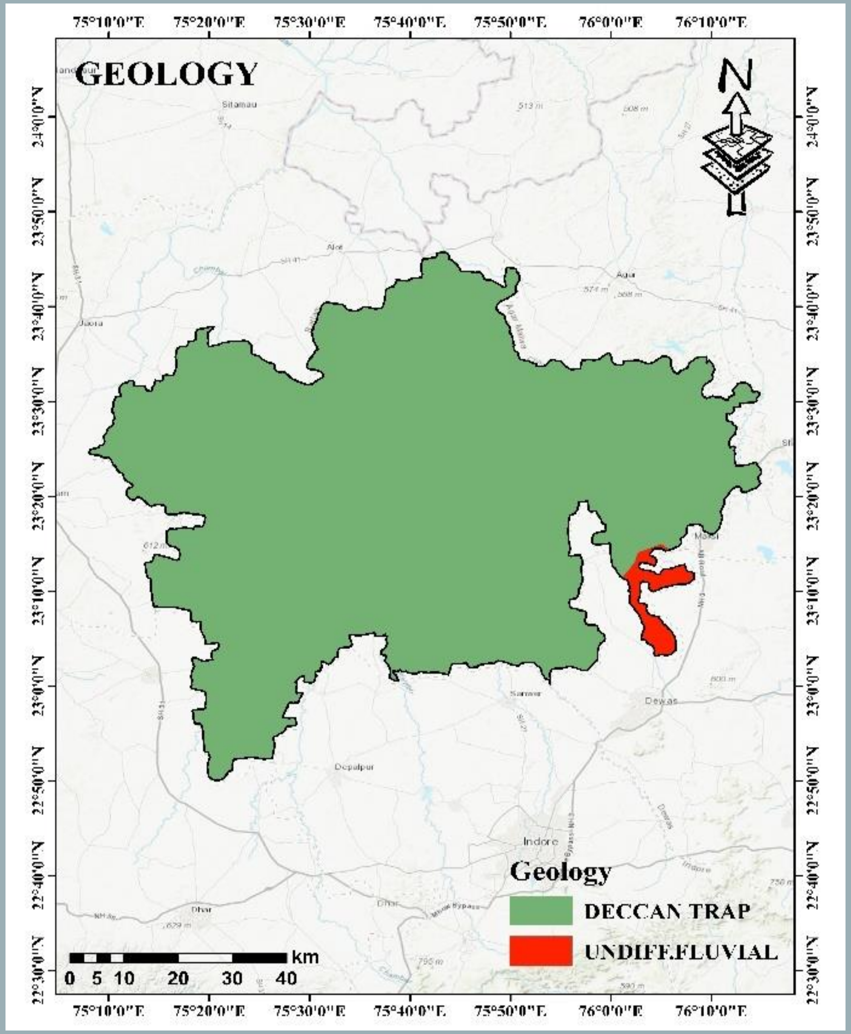


Fig. 7 Geology

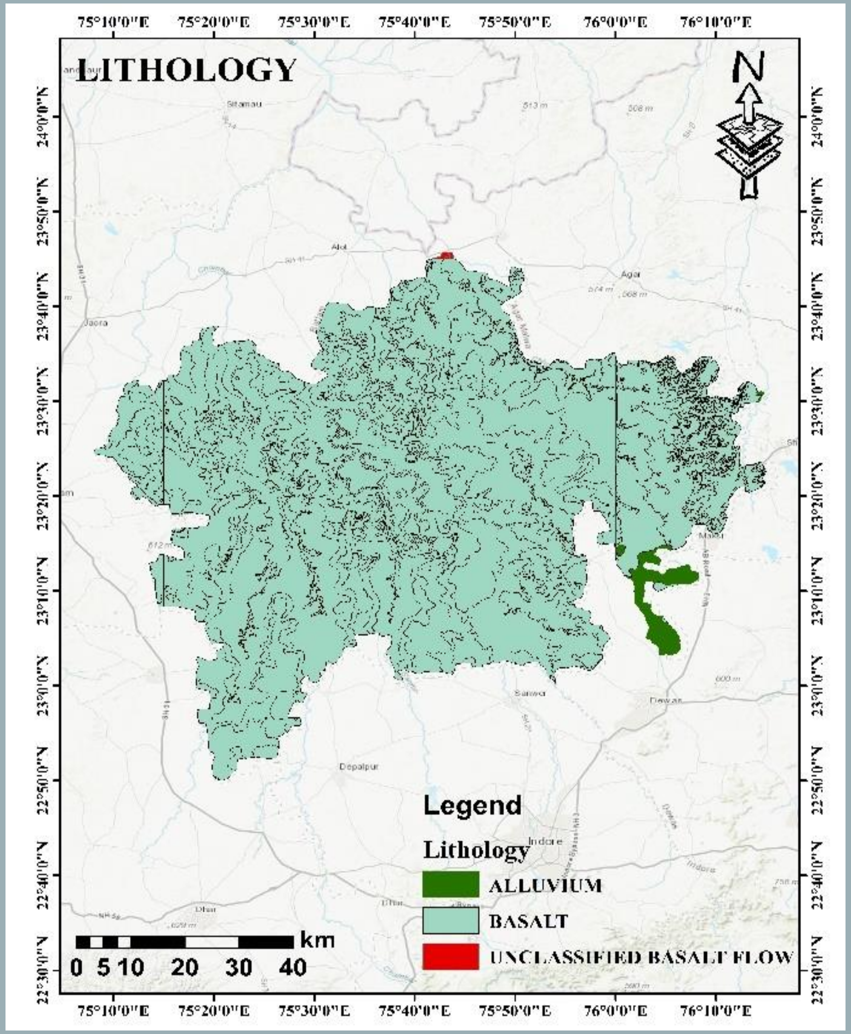


Fig. 8 Lithology

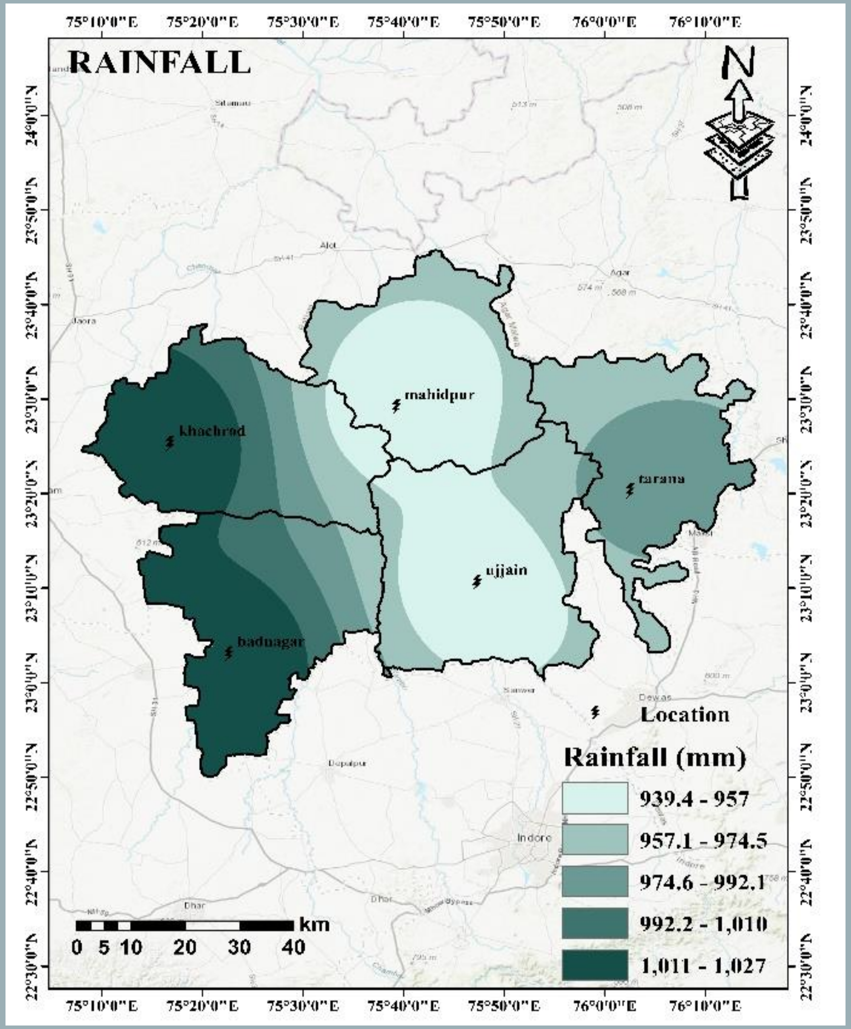


Fig. 9 Rainfall

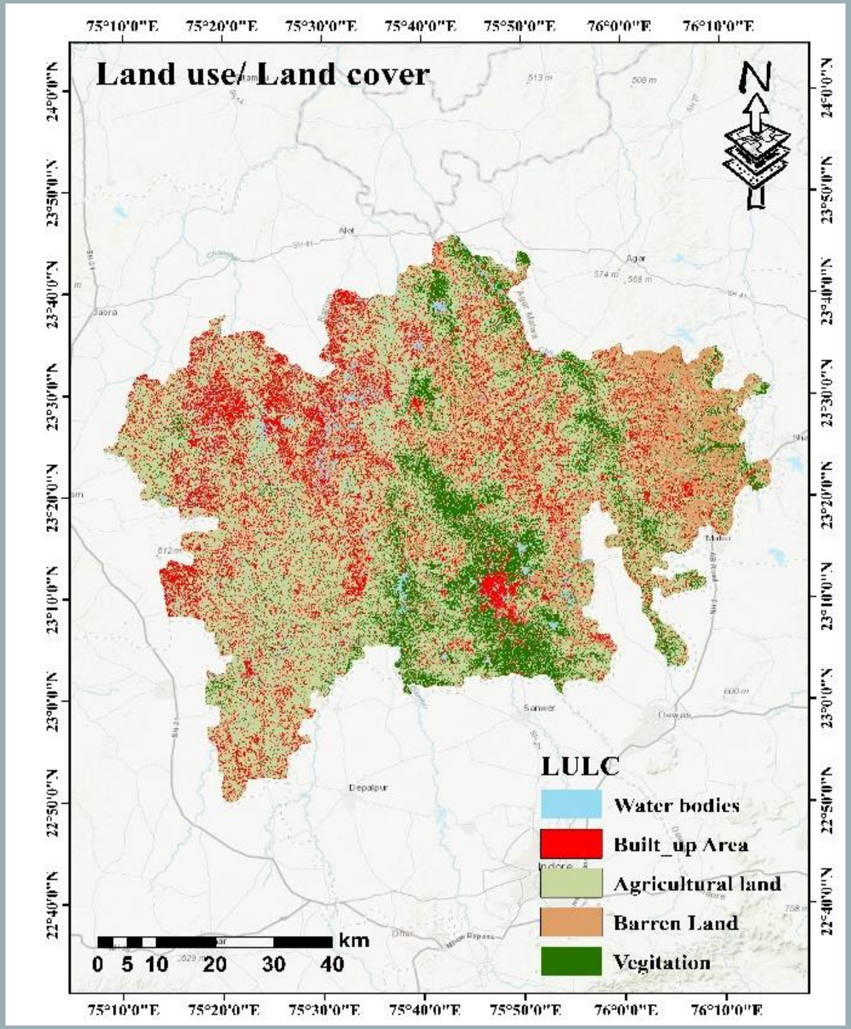
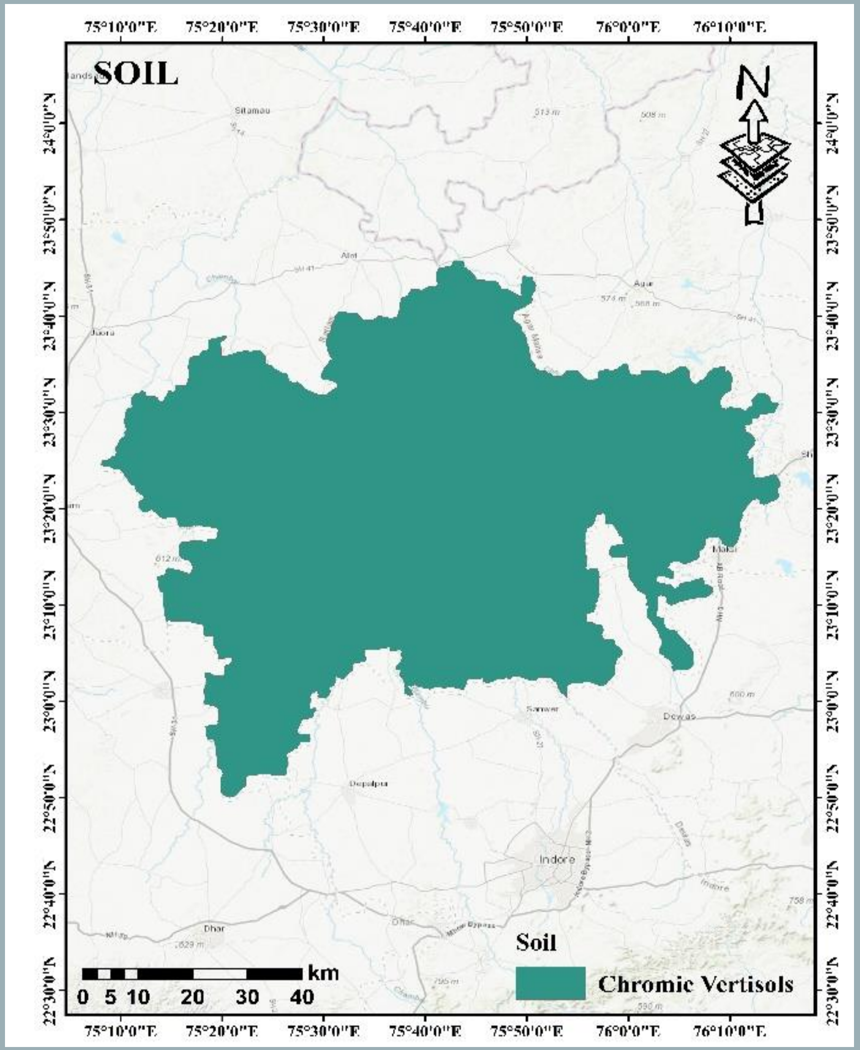


Fig. 10 LULC



SOIL
N
75°10'0"E
75°20'0"E
75°30'0"E
75°40'0"E
75°50'0"E
76°0'0"E
76°10'0"E
24°0'0"N
23°50'0"N
23°40'0"N
23°30'0"N
23°20'0"N
23°10'0"N
23°0'0"N
22°50'0"N
22°40'0"N
22°30'0"N
Soil
Chromic Vertisols
0 5 10 20 30 40 km

Fig. 11 Soil

RESULTS

- The criteria are then examined using the AHP matrix. Each criterion was given a score from 1 to 9 based on there relative importance.
- A pairwise comparison matrix (Table 1) is prepared.
- To check the consistency of the pairwise comparison matrix, consistency index is calculated, which comes out to be 6.9 % (< 10 %).
- After that weight of each thematic layers is calculated.

Table 2 Pairwise Comparison Matrix

	RF	GL	SL	DD	LULC	GM	SO	LT	EL	GM	NORMALIZED WEIGHT
Rainfall (RF)	1.00	0.25	0.24	0.28	0.14	0.12	0.38	0.27	2.00	0.34	0.024
Geology (GL)	3.98	1.00	0.57	0.31	0.17	0.12	2.43	3.00	4.29	0.92	0.066
Slope (SL)	4.24	1.75	1.00	0.57	0.20	0.17	3.86	2.71	4.14	1.22	0.088
Drainage density (DD)	3.61	3.24	1.75	1.00	0.29	0.17	4.14	3.14	4.14	1.56	0.112
LULC	7.22	5.88	5.04	3.47	1.00	0.46	6.29	5.00	7.71	3.52	0.252
Geomorphology (GM)	8.14	8.14	5.88	5.74	2.16	1.00	6.57	6.43	8.57	4.94	0.353
Soil (S0)	2.63	0.41	0.26	0.24	0.16	0.15	1.00	0.81	3.29	0.55	0.039
Lithology (LT)	3.76	0.33	0.37	0.32	0.20	0.16	1.24	1.00	4.14	0.66	0.047
Elevation (EL)	0.50	0.23	0.32	0.24	0.13	0.12	0.30	0.24	1.00	0.28	0.020

- The final GWPZ maps were prepared by integrating the selected thematic maps using a weighted overlay analysis in ArcGIS.
- Fig. 12 depicts the final groundwater potential zone map.
- The Groundwater potential (GWP) map is reclassified into five distinct classes i.e., excellent, very good, good, moderate and poor. According to the results, the excellent potential zone contains 1.15 % of the total area, very good (23.21 %), good (45.76 %), moderate (21.54 %), and low (8.35 %).
- Validation is carried out in the current work using wells and groundwater level data provided by the GWCB.

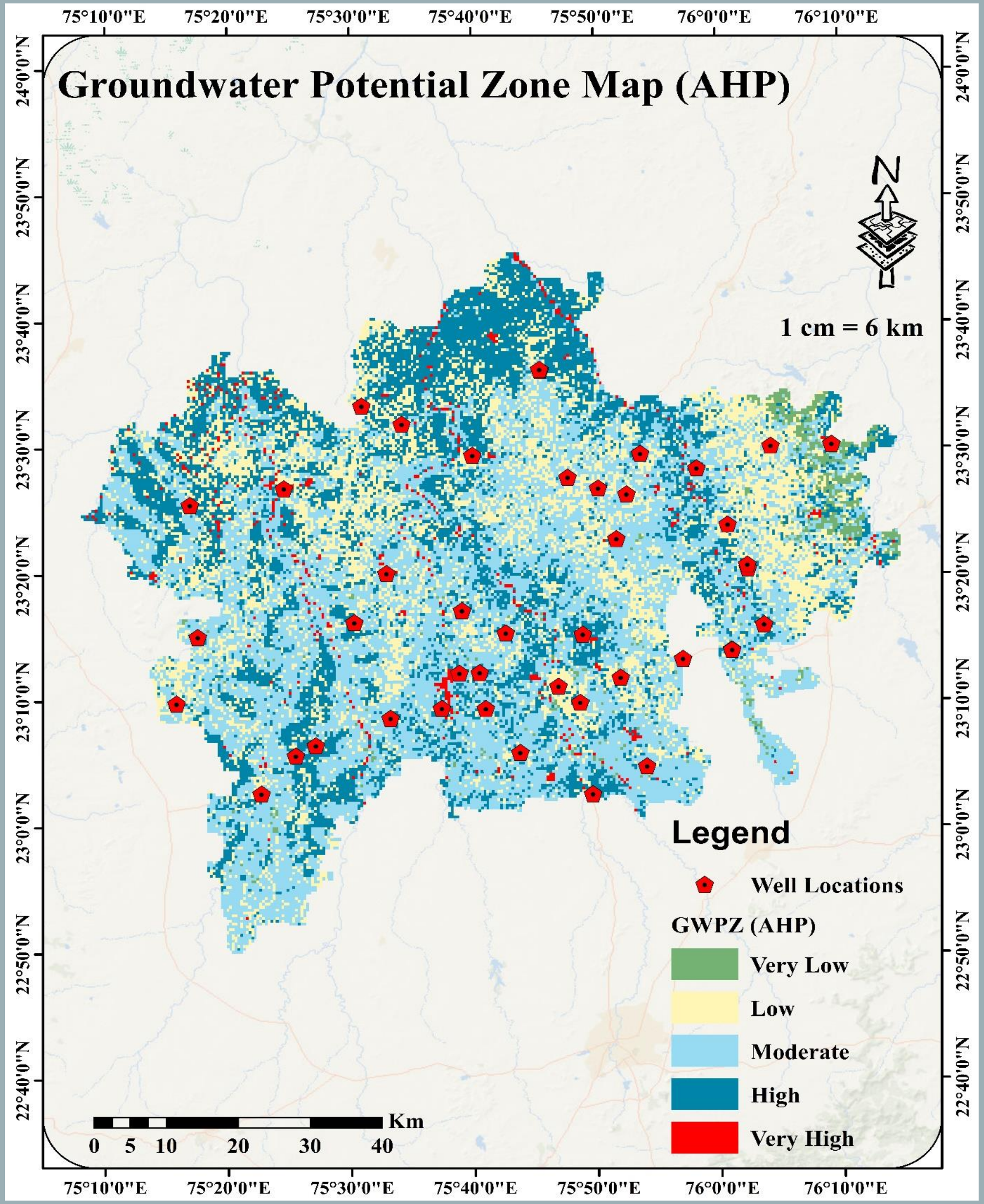


Fig. 12 GWPZ Map

CONCLUSION

- Today, groundwater shortages are a big global concern, and the situation is considerably worse in emerging countries like India, which has such a large population, resulting in massive groundwater extraction.
- A geographic information system is a useful tool for obtaining results through spatial and visual interpretation.
- In this work, the analytical hierarchy method (AHP) and GIS techniques were used to simulate the groundwater potential zone for the Ujjain district.
- To simulate the final groundwater potential zone, a total of nine characteristics were chosen: geomorphology, LULC, elevation, slope, geology, rainfall, drainage density, lithology, and soil.
- The weights are assigned to each theme layer using the AHP and the thematic layers are then combined in ArcGIS using weighted overlay analysis to produce the final groundwater potential zone maps.

- The validation is carried out using groundwater level data collected from the central groundwater board as well as existing well locations.
- After validation, we may conclude that the map generated using the AHP is satisfactory.
- The GWP map developed in this study is ideal for planners, politicians, researchers, and technicians seeking the best locations to undertake a groundwater resources scheme.

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THANK YOU