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Y HPM Mohana Prasada Rao
 Project associate -II, CoE
 Land and water resources
 Management, Sri
 Venkateswara University,
 Tirupati, Andhra Pradesh,
 India

N Chendrayudu
 CoE-Land and Water
 Resources Management, Sri
 Venkateswara University,
 Tirupati., Andhra Pradesh,
 India

Corresponding Author:
Y HPM Mohana Prasada Rao
 Project associate -II, CoE
 Land and water resources
 Management, Sri
 Venkateswara University,
 Tirupati, Andhra Pradesh,
 India

Identification of groundwater potential zone of Handri river basin using geospatial techniques: Kurnool district, Andhra Pradesh

Y HPM Mohana Prasada Rao and N Chendrayudu

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Abstract

Groundwater is a critical natural resource sustaining agricultural, domestic, and industrial needs, particularly in semi-arid regions where surface water is scarce. The Handri River basin in Kurnool District, Andhra Pradesh, India, faces acute water scarcity challenges, making the identification and management of groundwater potential zones of paramount importance for sustainable development and water security. This study seeks to identify and delineate groundwater potential zones (GWPZs) in the Handri River basin using an integrated geospatial approach. This study used remote sensing (RS), geographic information systems (GIS), and analytical hierarchical processing (AHP) methods. Various thematic maps were produced to assess potential groundwater areas, including land use and cover, geomorphology, lineament density, geology, drainage density, slope, and soil. This map was created using RS and GIS techniques. The AHP approach was used to assign relative weights to the thematic maps and determine the ranking of each sub-criterion based on expert advice. The groundwater potential zone map was created by combining seven thematic layers in ArcGIS. This map provides information on the distribution of groundwater potential areas, including high (26% or 131.60 km²), moderate (12.76% or 452.56 km²), low (63.47% or 2250.75 km²), and the least (15.99% or 567.16 km²). work It is a very poor area (5.32%, or 188.73 km²). The accuracy of the results was verified with 85% accuracy using bore hole observation data. However, yields were reduced in areas with low water potential. In conclusion, the AHP model has proven to be a reliable method for assessing groundwater potential. Groundwater management programs implemented in these favourable areas will be of great benefit to stakeholders.

Keywords: Remote sensing, gis, ahp, groundwater potential zones

Introduction

Groundwater, a crucial natural resource, is stored in subsurface geological formations within the critical zone of the earth's crust. It plays a vital role as a water source for various purposes, such as domestic, industrial, agricultural, and developmental initiatives. Groundwater is stored beneath the ground's surface in small pore spaces between rock, sand, soil, and gravel. It exists in two distinct zones: an upper unsaturated zone, primarily filled with air, and a deeper saturated zone, where all pore spaces are filled with water. The depth of the water table can vary from a few feet to several hundred feet below the ground surface (Harter, 2003; Nampak *et al.*, 2014; Rajasekhar *et al.*, 2022) ^[1-3]. The continuously growing need for water to fulfil human needs and advancements has placed significant stress on this finite freshwater resource. The presence and allocation of groundwater rely on diverse natural and human-induced factors (Saraf and Choudhury, 1998) ^[4]. According to the United Nations Environment Programme (UNEP, 2021) ^[5], over 2 billion individuals are projected to experience significant water stress by 2050. This alarming statistic is expected to obstruct the progress and growth of numerous nations globally (Boretti *et al.*, 2019) ^[6]. A delineated map of groundwater zones can also serve as a tool for determining suitable locations for domestic and irrigation wells (Arulbalaji *et al.*, 2019) ^[7]. The identification of groundwater as a subsurface phenomenon can be indirectly determined through the analysis of observable terrain features. Recent technological advancements enable us to delineate with greater effectiveness and efficiency than ever before. Remote sensing and Geographic Information System (GIS) is a powerful tool for effectively managing spatial data. (Manson *et al.*, 2015) [8] MCDM approaches have improved understanding of the links and interactions between many layers of geo-environmental and hydrological inputs in conjunction with the governing system. The analytical hierarchy process (AHP) technique is among the most

commonly utilized multi-criteria decision-making (MCDM) approaches. It was invented by Thomas Saaty in 1980. Many investigations have employed various decision-making approaches in combination with remote sensing (RS) and geographical information systems (GIS) to produce more concrete outcomes in the appraisal of groundwater resources. Another famous technique is the Analytical Hierarchy Process (AHP) (Kanak *et al.*, 2023; Rajasekhar *et al.*, 2019; Gnanachandrasamy *et al.*, 2018; Ramachandran *et al.*, 2022) [9-12]. As a result, this research aims to use GIS and AHP to identify the GWPZs of the Handri River basin. For this reason, seven thematic layers were used land use/land cover, geomorphology, lineament density, geology, drainage density, slope, and soil. This research will be valuable for groundwater resource planners and policymakers in developing sustainable groundwater strategies in this basin area.

Literature review

Geospatial technologies including Remote Sensing (RS) and Geographic Information Systems (GIS) have been widely used for groundwater potential zone (GWPZ) delineation worldwide. Nampak *et al.* (2014) [12] applied an evidential belief function model using GIS-based data to map groundwater potential zones with satisfactory accuracy. Harter (2003) [11] provided foundational concepts of groundwater hydrology, emphasising the importance of geological formations in controlling groundwater occurrence. Rajasekhar *et al.* (2022) [3] demonstrated the effectiveness of geospatial and decision-making techniques for GWPZ identification in southern India. Arulbalaji *et al.* (2019) [7] combined GIS and AHP techniques to delineate GWPZs in the southern Western Ghats, achieving high validation accuracy. Saraf and Choudhury (1998) [4] pioneered the integration of RS and GIS for groundwater exploration and artificial recharge site identification. Subsequent studies by Rajasekhar *et al.* (2019) [10] and Gnanachandrasamy *et al.* (2018) [11] confirmed that multi-criteria decision-making methods, particularly the Analytical Hierarchy Process (AHP), produce reliable and reproducible results in groundwater potential assessment across diverse geo-environmental settings. Ramachandran *et al.* (2022) [12] further validated AHP-based GIS approaches for sustainable groundwater management in Tamil Nadu. Collectively, this body of literature establishes the scientific foundation for the methodology adopted in the present study.

Theoretical background

The Analytical Hierarchy Process (AHP), introduced by Thomas L. Saaty (1980) [13], is a structured multi-criteria decision-making (MCDM) framework that decomposes a complex decision problem into a hierarchy of simpler sub-problems. In the context of GWPZ delineation, AHP enables experts to assign relative importance weights to thematic parameters (such as geology, lineament density, drainage density, slope, soil, geomorphology, and LULC) through pairwise comparisons on a 1–9 intensity scale (Saaty, 1980; Table 1) [13]. The pairwise comparison matrix is then normalised to yield priority weights (eigenvectors), and the consistency of the expert judgments is verified using the Consistency Ratio (CR). A CR value below 0.10 confirms that the pairwise comparisons are sufficiently consistent for reliable weight derivation (Saaty, 2008) [14]. Remote sensing data provide multi-spectral imagery for mapping surface features, while GIS platforms facilitate the spatial integration of heterogeneous

thematic layers through weighted overlay analysis. The combination of RS, GIS, and AHP thus offers a robust, reproducible, and spatially explicit framework for groundwater resource assessment.

Novelty and limitations of the study

The novelty of the present study lies in its comprehensive geospatial assessment of the Handri River basin a hydrogeologically significant yet understudied watershed in semi-arid Andhra Pradesh using an integrated RS-GIS-AHP framework incorporating seven thematic layers validated against Central Ground Water Board (CGWB) observation well data. Unlike previous studies in the region that focused on broader administrative units, this study provides watershed-scale, high-resolution GWPZ mapping that can directly support local-level groundwater governance. The limitations of the study include: (i) reliance on Landsat 8 imagery at 30 m resolution, which may not capture micro-scale hydrogeological variability; (ii) AHP weights are based on expert judgment and may reflect subjectivity; (iii) the validation dataset is limited to 20 CGWB observation wells, which may not fully represent the spatial heterogeneity of the basin; and (iv) temporal variations in groundwater levels and seasonal recharge dynamics are not addressed in the current framework.

Objectives

- Develop a groundwater potential map of Handri River basin using RS, GIS, and AHP.
- Integrate thematic layers to analyse factors influencing groundwater potential.
- Generate zones and insights for sustainable water resource planning in the area.

Study area

The Handri River Basin study area (Fig. 1) is located in the western part of Kurnool District. Administratively, the study area consists of 19 Mandals and covers parts of 13 Survey of India toposheets on a 1:50,000 scale. The study area covers an area of 3548 km². It is located between latitudes of 15° 12' 37" N to 15° 49' 20" N and longitudes 77° 16' 49" E to 78° 04' 52" E. The mean altitude of the basin is 469.5 meters with peak and trough values; the weather is warm and arid for a significant portion of the year. The summer period experiences intense heat, with temperatures soaring to +42° Celsius, while the winter months bring agreeable conditions, with nighttime temperatures reaching approximately 13° Celsius. The study region experiences an annual average precipitation of 665 mm. Handri River rises from the western part of the study area in Erramala hills and merges into the Tungabhadra River at Kurnool town, and the drainage pattern was found to be dendritic; the study area is distinguished by a wide range of geological formations from the Archaean period to the recent. Granite and Granite gneisses dominate the western district, while quartzites, shales, and limestones from the Cuddapah and Kurnool groups present in the eastern part.

The Handri River basin was selected as the study area based on the following considerations: (i) the basin is located in the semi-arid Kurnool district of Andhra Pradesh, a region historically prone to droughts and water scarcity (Rajasekhar *et al.*, 2019) [10]; (ii) rapid population growth and agricultural expansion have led to overexploitation of groundwater, creating an urgent need for resource mapping; (iii) the basin exhibits diverse geological formations from Archaean granites to Cuddapah and Kurnool

Group sedimentaries, making it an ideal test bed for geospatial hydrogeological analysis; and (iv) limited published studies on the basin's groundwater potential offer scope for original scientific contribution. Data sources used for the study include

USGS Landsat 8 imagery (30 m resolution), SRTM DEM (30 m), GSI Bhukosh portal for geology, SOI toposheets at 1:50,000 scale, NBSS soil resource maps, and CGWB observation well records.

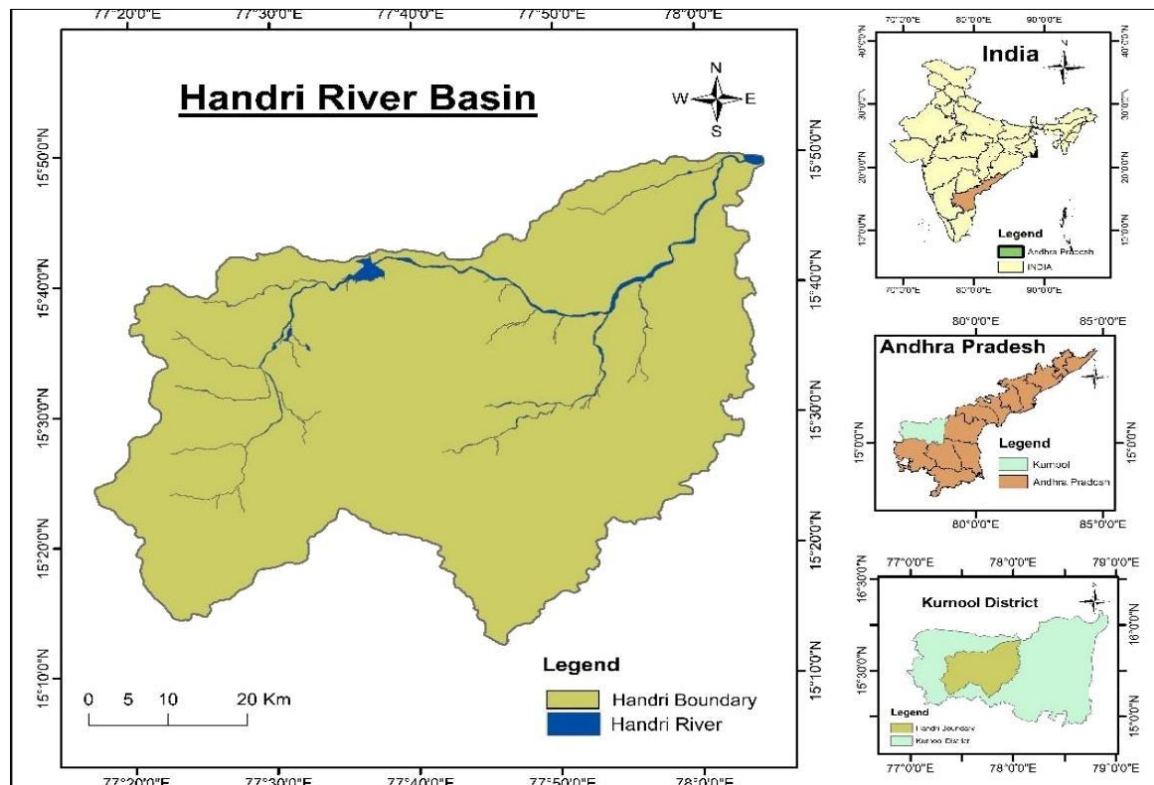


Fig 1: Location map of Handri River basin

Materials and Methods

The current study aims to identify groundwater potential zones (GWPZ) in the Handri River Basin. The process involves the evaluation of various thematic layers, comprising geomorphology (GM), Lineament Density (LD), Drainage Density (DD), geology, land use/land cover (LULC), soils, and slope. The layers are collectively appraised through information-based weighted overlay analysis (WOA) using the AHP method. The resulting GWPZ map is prepared based on the methodology presented in (Fig.2). The technique used in the study involved collecting and preparing all seven thematic layers using ArcGIS software. Weights were assigned to geo-referenced maps using the analytical hierarchy process. The normalized weights for the layers were obtained by ensuring consistency in the pairwise matrix, meeting the consistency index and consistency ratio values. The pairwise matrix is considered consistent if its CR value is below 0.1 (Table 4). The layers were assigned the determined weights and underwent

weighted overlay analysis. The groundwater potential zone was classified into four classes based on the index value calculated using Eq. 1. The results were verified by comparing them with borehole yield. The methodology adopted for this study is depicted in Figure 2. The following equation represents the groundwater potential zone:

$$GWPZ = LurLuw + GrGw + LrLw + GerGew + DrDew + SlrSlw + SrSw.$$

Eq.1

In this equation, GWPZ refers to the potential zone for groundwater, Lu represents land use and land cover, G represents geomorphology, L represents lineament density, Ge represents geology, D represents drainage density, Sl represents slope, and S represents soil. The suffixes 'r' and 'w' denote each layer's rank and weight, respectively.

Table 1: DS. Data availability sources used in this study

Data Layer	Data Source	Resolution / Scale	Purpose
LULC and Geomorphology	USGS EarthExplorer – Landsat 8 OLI(www.earthexplorer.usgs.gov)	30 m spatial resolution	Land use/land cover classification and geomorphological mapping via ERDAS Imagine
Geology	Bhukosh Portal, Geological Survey of India (GSI)	1:50,000	Lithostratigraphic unit mapping of the basin
Drainage Density	Survey of India (SOI) Topographical Sheets	1:50,000	Drainage network digitisation and density computation
Soil	National Bureau of Soil Survey (NBSS), Kurnool District Soil Resource Map	1:50,000	Soil texture, type, and infiltration-rate classification
Slope and Lineament Density	SRTM DEM – NASA / USGS (earthexplorer.usgs.gov)	30 m spatial resolution	Slope generation and lineament extraction using ArcGIS
Observation Wells (Validation)	Central Ground Water Board (CGWB)	Point data – 20 wells	Cross-validation of GWPZ map against borehole yield data

Preparation of thematic maps

seven thematic layers to assess groundwater potential zones, including LULC, geomorphology, lineament density, geology, drainage density, slope and soil. Used remote sensing and conventional/existing data with the help of ERDAS Imagine and ArcGIS software. Which included Geomorphology, Lineament Density, Drainage Density, geology, LULC, soils, and slope. The LULC layer and geomorphology were created using the Landsat 8 satellite dataset (www.earthexplorer.usgs.gov) and the image classification technique in ERDAS Imagine. Bhukosh, the gateway of the geoscientific data of a geological survey of India, was the source of geology data. The Survey of India (SOI) provided the topographical sheets used to prepare the drainage density map. The soil map was derived from the district soil resource map, which was digitised from NBSS groundwater department in Kurnool. The Shuttle Radar Topographical Mission Digital

Elevation Model (SRTM DEM) with a spatial resolution of 30 m was used to generate the thematic layers of slope and lineament.

Table 2: Scale for the pair-wise comparison

Intensity of importance	Definitions
1	Equal importance
2	Equal to moderate importance
3	Moderate importance
4	Moderate to strong importance
5	Strong importance
6	Strong to very strong importance
7	Very strong importance
8	Very to extreme strong importance
9	Extreme importance

Table 3: The RI ratio of the distinct value of n (Saaty, 1980)^[13]

N	1	2	3	4	5	6	7	8	9	10
RI	0.0	0.0	0.58	0.89	1.12	1.25	1.32	1.4	1.45	1.49

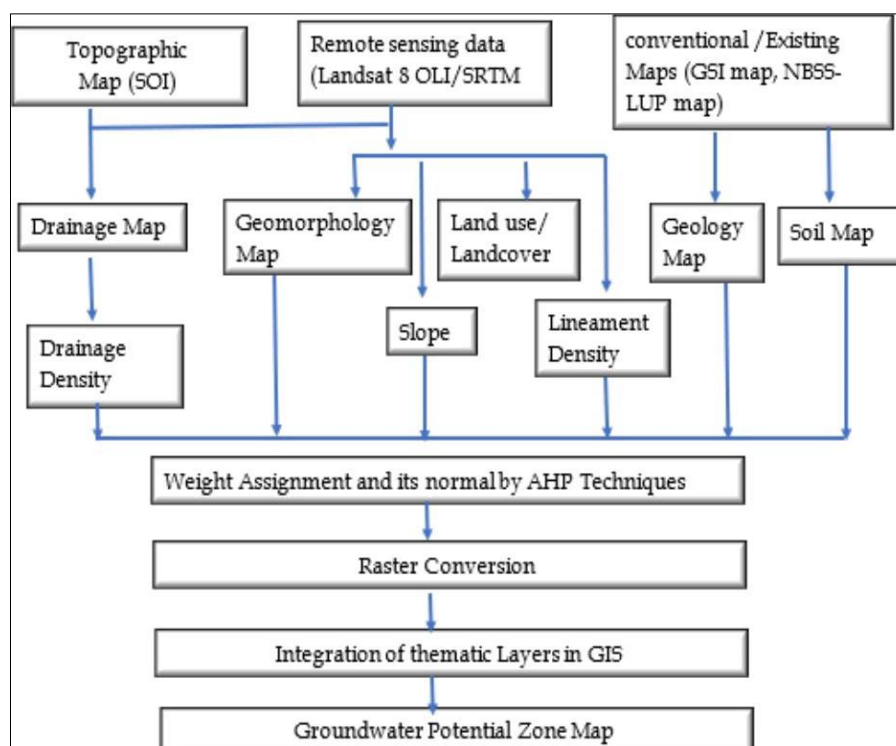
**Fig 2:** Flowchart of methodology adopted for delineation of groundwater potential zones Table.3 Pair-wise comparison matrix of thematic layers

Table 4: Pair-wise comparison matrix of thematic layers

Factors	LULC	GM	LD	Geology	DD	Slope	Soil
LULC	1	2	3	4	5	6	7
GM	0.5	1	2	3	4	5	6
LD	0.33	1	1	2	3	4	5
Geology	0.25	0.33	0.5	1	2	3	4
DD	0.2	0.25	0.33	0.5	1	2	3
Slope	0.16	0.2	0.25	0.33	0.25	1	2
Soil	0.14	0.16	0.2	0.25	0.33	0.5	1

Note: GM: Geomorphology; LD: lineament density; DD: Drainage density

Determination of rank and weights using AHP

The Analytical Hierarchy Process is a decision-making technique that leverages the expertise of professionals to establish the priority and significance of different criteria by creating an eigenvalue pairwise comparison matrix. This method is particularly advantageous in intricate scenarios with multiple variables influencing the outcome. The process involves developing a pairwise matrix to give weights (Table 3) to each criterion based on the relative importance of all other criteria, utilizing Saaty's 1-9 scale (Table 1) to determine the significance of values. A rating of signifies equal importance, while a score of 9 indicates the highest level of significance. This approach has gained widespread acceptance and proven in decision making across various fields as demonstrated in Saaty's 1980 [13]

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

Eq.2

where λ_{max} = consistency vector;

n=criteria or factors

CR is calculated using Eq. 3

$$CR = \frac{CI}{RI}$$

Eq.3

where RI (Table 2). random consistency index, provided by Saaty (2008) [14]

Equations and are utilised to calculate the consistency index and consistency ratio of a given matrix. The matrix is then checked for consistency. If the consistency ratio is less than 0.1, the criteria weights obtained are considered reliable for analysis. This approach offers the decision-maker several options. Additionally, the consistency ratio can be verified to ensure the objectivity of the weights calculated. If the requirement is not met, the matrix can be reconstructed with different options. Table illustrates the normalized weight values of the criteria used in the study. The pairwise comparison consistency ratios (CR) are all below 0.1 (Table 4).

Table 5: Normalised weight for thematic maps

Factors	LULC	GM	LD	Geology	DD	Slope	Soil	Normalised -weight	CR
LULC	0.3857	0.4494	0.4119	0.3609	0.3158	0.2791	0.2500	0.3451	0.02
GM	0.1928	0.2247	0.2746	0.2707	0.2526	0.2326	0.2143	0.2350	
LD	0.1286	0.1124	0.1373	0.1805	0.1895	0.1860	0.1786	0.1722	
Geology	0.0964	0.0749	0.0686	0.0902	0.1263	0.1395	0.1429	0.1056	
DD	0.0771	0.0562	0.0458	0.0451	0.0632	0.0930	0.1071	0.0696	
Slope	0.0643	0.0449	0.0343	0.0301	0.0316	0.0465	0.0714	0.0429	
Soil	0.0551	0.0375	0.0275	0.0226	0.0211	0.0233	0.0357	0.0310	
	LULC	GM	LD	Geology	DD	Slope	Soil	Sum	Weightage
LULC	0.388	0.405	0.412	0.361	0.321	0.279	0.250	2.416	0.345
GM	0.194	0.202	0.275	0.271	0.257	0.233	0.214	1.645	0.235
LD	0.128	0.202	0.137	0.181	0.193	0.186	0.179	1.205	0.172
Geology	0.097	0.067	0.069	0.090	0.128	0.140	0.143	0.733	0.105
DD	0.078	0.051	0.045	0.045	0.064	0.093	0.107	0.483	0.069
Slope	0.062	0.040	0.034	0.030	0.016	0.047	0.071	0.301	0.043
Soil	0.054	0.032	0.027	0.023	0.021	0.023	0.036	0.217	0.031
Sum	2.580	4.940	7.280	11.080	15.580	21.500	28.000		1.000
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Geology	0.097	0.067	0.069	0.090	0.128	0.140	0.143	0.733	0.105
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Slope	0.062	0.040	0.034	0.030	0.016	0.047	0.071	0.301	0.043
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	LULC	GM	LD	Geology	DD	Slope	Soil	Sum	Weightage		λ_{max}	CI	CR
LULC	0.134	0.095	0.071	0.038	0.022	0.012	0.008	0.380	0.345	1.100	7.220	0.037	0.028
GM	0.067	0.048	0.047	0.028	0.018	0.010	0.007	0.224	0.235	0.955			
LD	0.044	0.048	0.024	0.019	0.013	0.008	0.006	0.161	0.172	0.936			
Geology	0.033	0.016	0.012	0.009	0.009	0.006	0.004	0.090	0.105	0.856			
DD	0.027	0.012	0.008	0.005	0.004	0.004	0.003	0.063	0.069	0.912			
Slope	0.021	0.010	0.006	0.003	0.001	0.002	0.002	0.045	0.043	1.054			
Soil	0.019	0.008	0.005	0.002	0.001	0.001	0.001	0.037	0.031	1.194			
Sum	2.580	4.940	7.280	11.080	15.580	21.500	28.000						

Table 6: Assigned normalized weights and ranks of thematic layers

Factors	Classes	Class rank	Weight (%)
LULC	Water body	5	35
	Forest	4	
	Agriculture	4	
	Buildup area	2	
	Barren land	1	
Geomorphology	Fluvial origin	5	24
	Water body	5	
	Anthropogenic	3	
	Denudational Hill	2	
	Structural Hill	1	
Lineament density	Very High	5	16
	High	4	
	Moderate	3	
	Low	2	
	Very Low	1	
Geology	Koilakuntla limestones	5	10
	Vempalli dolomites	4	
	Meta rhyolite /Meta basalt	3	
	Volconic conglomerate	3	
	Gulcheru quartzite	2	
	Banaganapalli quartzite	2	

	Paniam quartzite	2	
	Granite	2	
	Granite gneiss	2	
	Closepet granite	2	
	Quartz reef	1	
	Dyke	1	
Drainage density	Very low	5	7
	Low	4	
	Moderate	3	
	High	2	
	Very high	1	
Slope	Very High	5	5
	High	4	
	Moderate	3	
	Low	2	
	Very low	1	
Soil	Gravelly clayey moderately deep red soil	4	3
	Gravelly clayey shallow dark brown soil	3	
	Loamy to clayey skeletal deep reddish brown soil	5	
	Moderately Deep calcareous black clayey soil	2	

Results and discussion

Land use/land cover (LULC)

Land use and land cover play a crucial role in controlling surface runoff as it is influenced by factors such as vegetation type and soil wetness, which affect evapotranspiration, penetration, and condensation. Consequently, it greatly

influences the recharge of groundwater. In terms of significance, the land use/land cover pattern is ranked first with a normalized weight of 0.3451 (Table 4). The Handri River Basin showcases a diverse range of land use categories, including Forest, Build-up areas, Barren land, Agriculture area, and water bodies (Fig. 3).

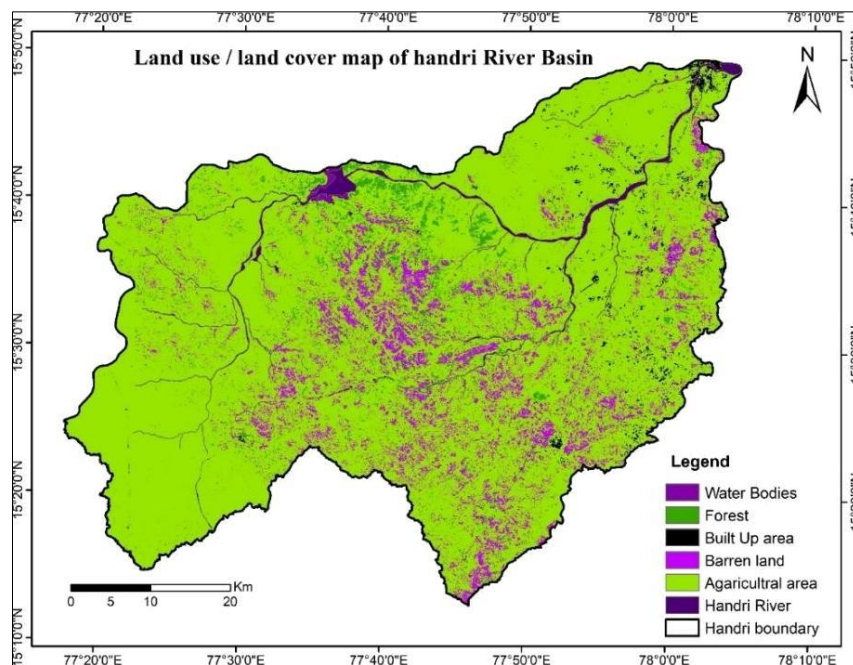


Fig 3: Land use/land cover map of the Handri River Basin.

Geomorphology

Geomorphology is a scientific field that studies the development and changes of landforms, as well as their relationship to groundwater potential zones and structural characteristics. It holds the second important position, with a normalized weight of 0.2350 (Table 4). Geomorphology can be divided into different classes based on their origins:

anthropogenic, denudational, fluvial, structural, and water body (fig 4). From a geomorphological perspective, the majority of the area is characterized by denudational origin, where pediments are formed around structural and denudational hills. In the eastern part of the basin, structural hills give rise to low and moderately dissected hills. The Handri River flows in a northeastern direction, resulting in sparsely distributed water

bodies and hill ranges that are predominantly granitic. This dominance of granite contributes to a dendritic drainage pattern

and the occurrence of low to moderate levels of groundwater in hard rock structures with high runoff and low infiltration.

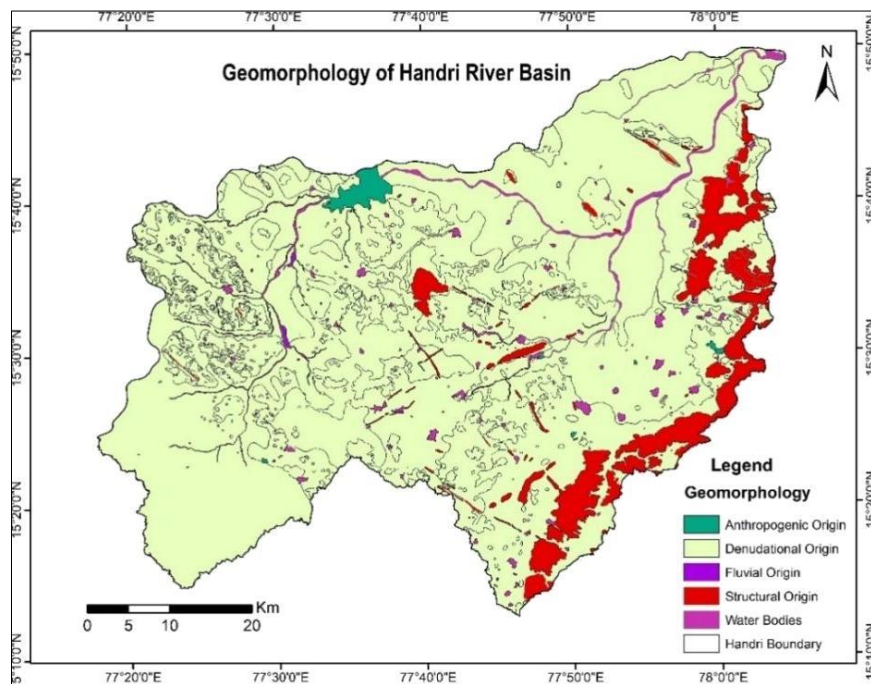


Fig 4: Geomorphology map of the Handri River Basin

Lineament density

Lineament density (Fig 5) is a crucial factor in groundwater potential zone identification, as fracturing and permeability in the subsurface, which can enhance groundwater recharge and

movement. The lineament density analysis of the Handri Basin was classified into five categories ranging from very high to very low, with a normalized weight of 0.1722 (Table 4).

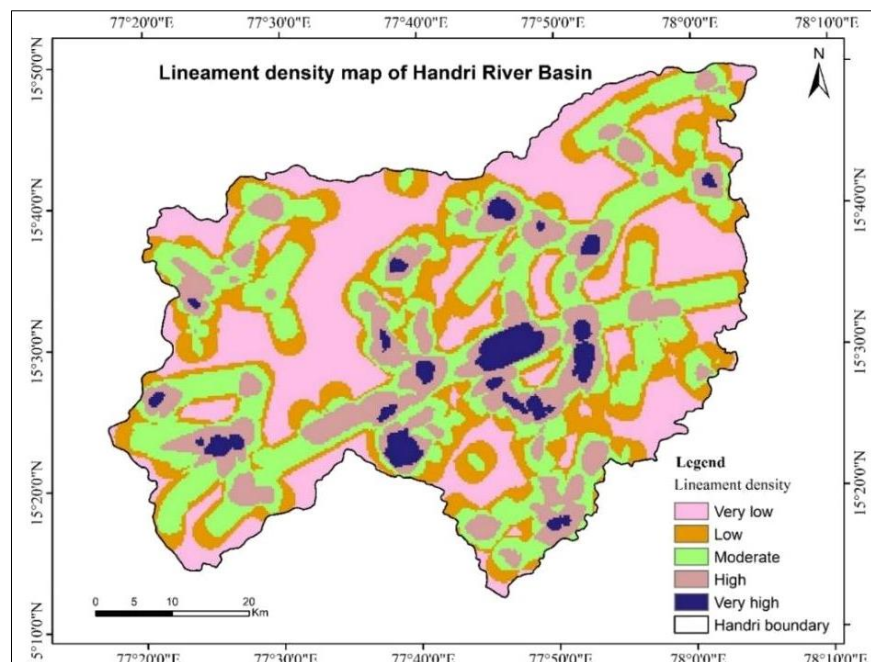


Fig. 5 Lineament density map of the Handri River Basin

Geology

The Handri basin boasts diverse litho units (fig.6), each classified based on their distinct properties. Predominantly characterized by Archean granite and granite gneiss formations, the basin showcases a range of geological features vital for

identifying groundwater potential zones. Quartz reefs, basic dykes, and granites demonstrate heightened water infiltration and storage capabilities owing to their unique fracturing and weathering characteristics. Conversely, volcanic conglomerates and meta rhyolites exhibit varying porosity levels, influencing

their suitability as aquifers. The presence of granite gneiss contributes to the development of diverse groundwater flow patterns. Furthermore, formations rich in carbonates, like Koilakuntla limestone, and quartz-rich ones, such as Paniam quartz, serve as significant reservoirs for groundwater. In some localized regions, Banaganapalli quartzite and Gulcheru

quartzite form aquifers through the presence of fractures and joints, thereby playing a pivotal role in facilitating sustainable groundwater management practices within the basin. Ranked fourth in importance, it holds a normalized weight of 0.1048 (Table 4).

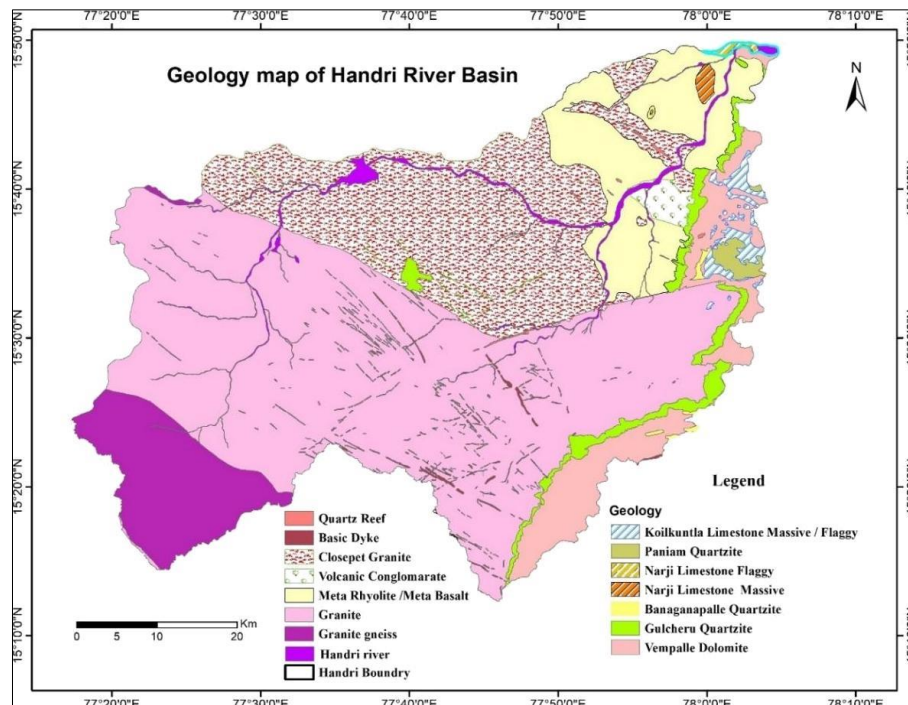


Fig 6: Geology map of the Handri River Basin

Drainage density

Drainage density is a key indicator of hydrogeological features as it directly correlates with the underlying lithology. This metric, defined as the proximity of stream channel spacing, inversely relates to permeability. It quantifies the total length of stream channels within a given area. The drainage pattern reflects surface characteristics and provides insights into

subsurface formations. Higher drainage density indicates increased runoff, whereas lower density suggests more significant potential for recharge or groundwater zones. In the study area, drainage density ranges from 0 to 1.81 km/km² (fig.7) classified into five categories: very low, low, moderate, high, and very high, with a normalized weight of 0.0690 (Table 4). and is

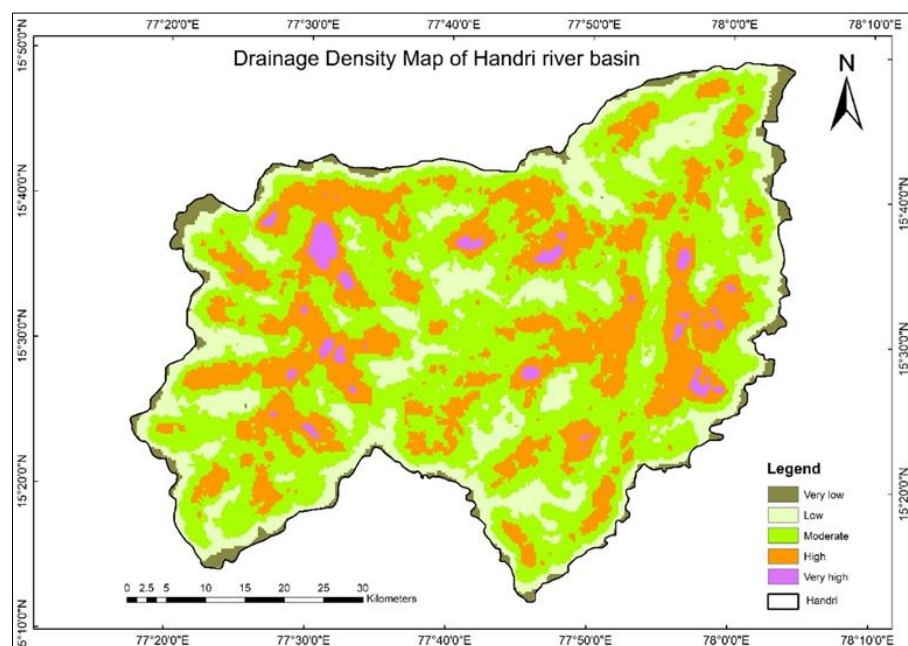


Fig 7: Drainage density map of the Handri River Basin

Slope

Slope significantly influences land-use patterns and suitability, particularly impacting agricultural practices in varied topographies. High degrees of Slope, notably observed in the southwest region due to hilly terrain, pose challenges such as increased runoff and reduced infiltration, affecting groundwater potential. In assigning ranks based on slope classes, the lowest

value class (gentle) receives a higher rank due to its flat terrain. In comparison, the highest value class (steep) is assigned a lower rank owing to its relatively higher runoff characteristics. In the study area, the Slope ranges from 00 to greater than 400 (fig.8) and is classified into five categories: very low, low, moderate, high, and very high, with a normalized weight of 0.0429 (Table 4).

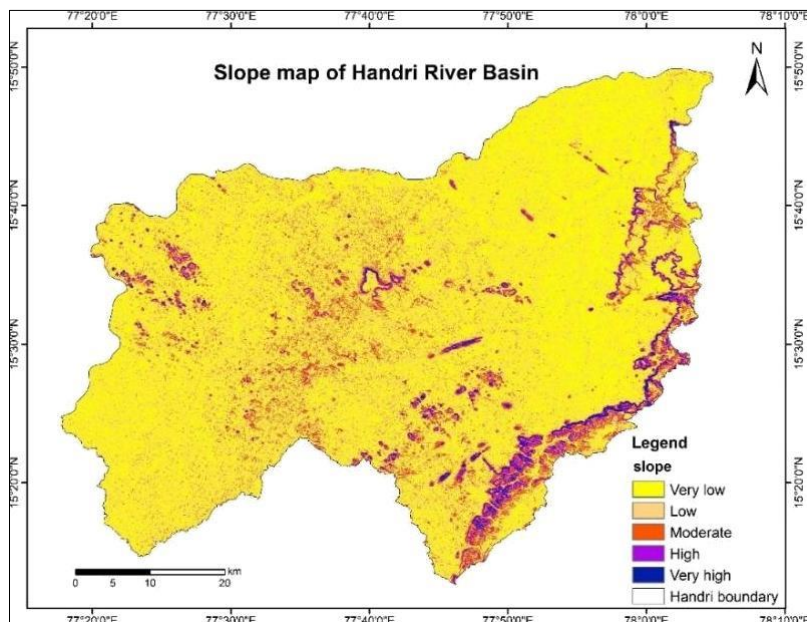


Fig 8: Slope map of the Handri River Basin

Soil

Soil texture holds significance in both groundwater recharge and surface runoff processes. The recharge of groundwater relies on factors such as soil types, infiltration rate, percolation, and permeability. The study area comprises four kinds of soil: gravelly clayey moderately deep red soil, Gravelly clayey shallow dark brown soil, Loamy to clayey skeletal deep reddish brown soil, and Loamy to Clayey Skeletal Deep Reddish Brown

Soils. Ranks have been subjective to each soil unit after considering the soil types and their infiltration rate. Loamy to Clayey Skeletal Deep Reddish Brown Soils have a higher infiltration rate, while Moderately Deep Calcareous Black Clayey Soil

has a lower rate low priority final soil classes (Table 5) normalized 0.0310 infiltration assigned to (fig.9). The weights of the are shown in and with a weight of (Table 4)

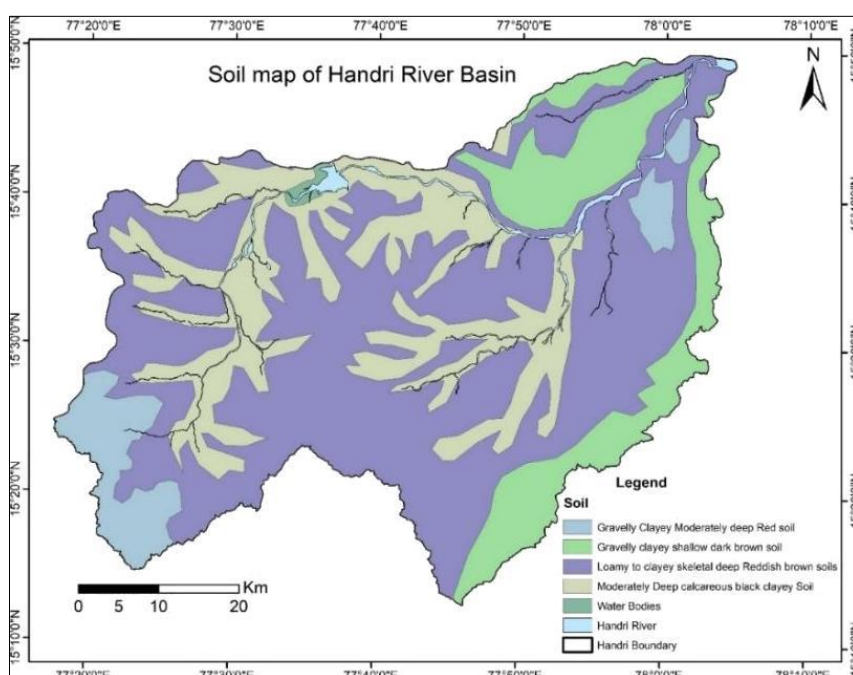


Fig 9: Soil map of the Handri River Basin

Assessment of groundwater potential zones

The ultimate standard weights for each thematic layer and their specific characteristics were computed as part of the process. Next, the layers were transformed into a raster format and combined using the raster calculator function in ArcGIS

software. The objective was to define the zone of groundwater potential. Based on the total score, the groundwater potential zone was classified into four categories: High (26%), moderate (31%), low (34%), and very low (9%), as shown in Fig. 10.

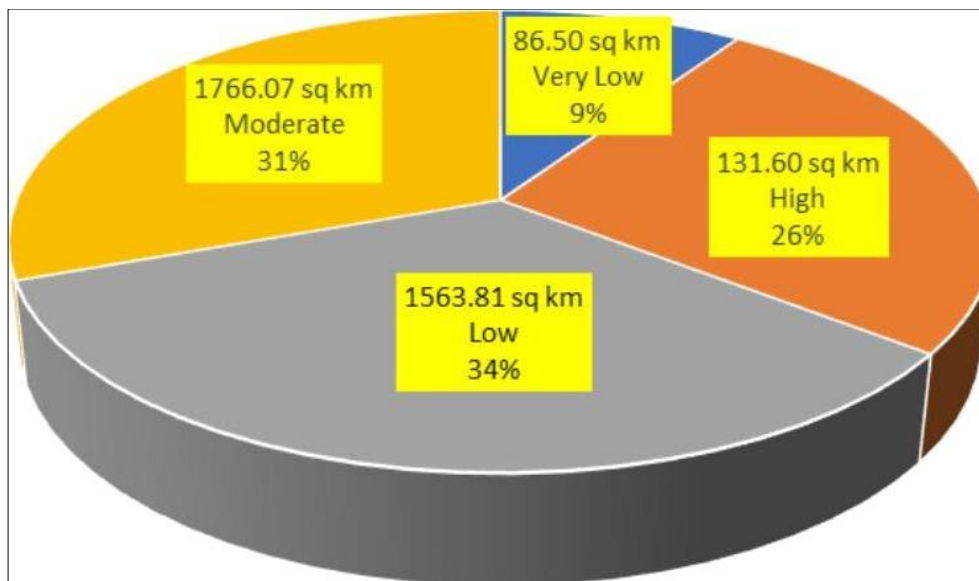


Fig 10: Groundwater potential zone statistics

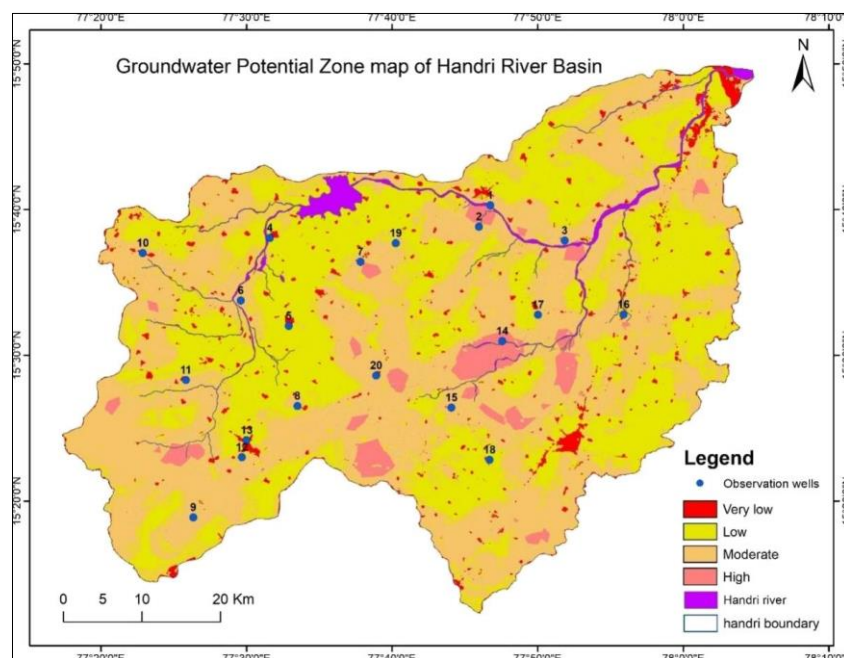


Fig 11: Groundwater potential zone map of the Handri River Basin

Validation of groundwater potential zones

The groundwater potential zones in the area were identified and cross-validated using the observation well data from the Central Ground Water Board (CGWB) in the present study. A total of 20 observation wells were analysed, and it was observed that wells in the very low and low groundwater potential zones have a water yield capacity ranging from 10 to 40 Liters per minute (LPM). On the other hand, wells in the moderate groundwater potential zones have a water yield capacity ranging from 40 to 80 LPM, while wells in the high groundwater potential zones have a water yield capacity exceeding 80 LPM. Out of the 20

wells, 17 wells align with the groundwater potential zone categories in the Handri River Basin. However, the remaining wells only partially match due to their proximity to dense settlements or intensive agricultural areas. Despite being located in high-potential zones, wells and have low yields. The areas where these wells are located are commonly exploited for groundwater use, either for urban or agricultural purposes. Well number has a low yield due to its proximity to a low-to-moderate groundwater potential zone. Out of the 20 observation wells, 8 wells have a water yield of 40 to 80 LPM, while wells have a yield exceeding 80 LPM. The remaining wells have a

water yield ranging from 10 to 40 LPM. The study found that the use of GIS and AHP-based techniques to identify groundwater potential zones is highly beneficial for planning and development and is essential in tropical and sub-tropical regions that have diverse geo-environmental settings.

The accuracy calculation was done as follows:

Number of boreholes = 20

Number of boreholes that agreed with the result of the mapping = 17

Number of boreholes that disagreed with the result of the mapping =

Accuracy of the potential mapping = $17/20 \times 100 = 85\%$

Table 7: Location and characteristics of the observation well CGWB

Well No.	Location	Latitude	Longitude	GWL (mbgl)	Yielding (LPM)	Total depth in (M)
1	Kodumuru	15.67139	77.77889	3.95	120	160
2	Kirshnapuram	15.64694	77.76611	5.8	75	190
3	Gorantla	15.63111	77.86417	7	30	190
4	Ternekallu	15.63417	77.52667	9.5	38	200
5	Devarakonda	15.53333	77.54833	11	18.96	180
6	Khairuppala	15.56250	77.49333	10	24	200
7	Kapatrala	15.60667	77.63056	6	72	200
8	Pandikona	15.44167	77.55833	4.5	140	80
9	Burjula	15.31444	77.43889	8	50	198
10	Sambigallu	15.61667	77.38111	6.4	65	170
11	Nalakaladoddi	15.47167	77.43056	6.8	58	140
12	Hosun Road	15.38333	77.49444	5.6	60	160
13	Pattikonda	15.40278	77.50000	9	29	200
14	Penumada	15.51619	77.79263	4.5	85	120
15	Alamakonda	15.43988	77.73449	5.5	70	130
16	Veldurthi	15.54641	77.93145	9.8	19.2	200
17	Krishnagiri	15.54621	77.83359	5	50	150
18	Yapadinne	15.38019	77.77803	9	18	170
19	Devarabanda	15.62794	77.67070	7.5	35	180
20	Gundlakonda	15.47661	77.64844	8.5	28	191

Conclusions

The current study focused on the Handri River basin in the western part of the Kurnool district to assess its groundwater potential. The study utilized a combination of AHP and GIS, employing thematic layers, including LULC, geomorphology, lineament density, geology, drainage density, slope, and soil. These themes were weighted between individuals by pairwise comparisons and were aggregated in the GIS utilizing the weighted overlay. Based on the final output map, the study region was divided into four different zones of groundwater potential high (26%), moderate (31%), low (34%), and very low (9%). To determine the accuracy of the resulting groundwater potential zone map, it was compared with borehole yield spread throughout the study region. Boreholes located in very low and low potential zones yielded 10 to 40 liters per minute. In contrast, those in moderate potential zones yielded 40 to 80 LPM, and those in high potential zones yielded more than 80 LPM. The potential groundwater zones map produced in this study can aid policymakers in managing and planning these resources for agricultural and urban uses. As the majority of the study area is covered by agricultural land, this study will assist in improving irrigation facilities and enhancing agricultural productivity in the region.

References

- Harter T. Basic concepts of groundwater hydrology. UCANR Publications. 2003.
- Nampak H, Pradhan B, Manap MA. Application of GIS based data driven evidential belief function model to predict groundwater potential zonation. *J. Hydrol.* 2014;513:283–300.
- Rajasekhar M, Upendra B, Raju GS. Identification of groundwater potential zones in southern India using geospatial and decision-making approaches. *Appl Water Sci.* 2022;12:68.
- Saraf AK, Choudhury PR. Integrated remote sensing and GIS for groundwater exploration and identification of artificial recharge sites. *Int. J. Remote Sens.* 1998;19:1825–1841.
- United Nations Environment Programme (UNEP). Making Peace with Nature: A Scientific Blueprint to Tackle the Climate, Biodiversity and Pollution Emergencies. Nairobi: UNEP; 2021. <https://www.unep.org/resources/making-peace-nature>
- Boretti A, Rosa L. Reassessing the projections of world water Development Report. *npj Clean Water.* 2019;2:15. <https://doi.org/10.1038/s41545-019-0039-9>
- Arulbalaji P, Sreelash K, Padmalal D. GIS and AHP Techniques Based Delineation of Groundwater Potential Zones: a case study from Southern Western Ghats, India. *Sci Rep.* 2019;9:2082. <https://doi.org/10.1038/s41598-019-38567-x>
- Manson S, Bonsal D, Kernik M, Lambin E. Geographic Information Systems and Remote Sensing. *International Encyclopaedia of the Social & Behavioural Sciences.* 2015. <https://doi.org/10.1016/B978-0-08-097086-8.91027-4>
- Kanak N, Thirumalaivasan D, Balasubramanian A. Delineation of groundwater potential zones using remote sensing, GIS and AHP techniques. *Environmental Science and Pollution Research.* 2023. <https://doi.org/10.1007/s11356-023-26891-3>
- Rajasekhar M, Raju GS, Sreenivasulu Y, Raju RS. Delineation of groundwater potential zones in semi-arid region of Jilledubanderu river basin, Anantapur District, Andhra Pradesh, India using fuzzy logic, AHP and integrated fuzzy-AHP approaches. *Hydro Research.*

2019;2:97–

108.<https://doi.org/10.1016/j.hydres.2019.11.006>

11. Gnanachandrasamy Y, Bagyaraj G, Zhou. Remote Sensing and GIS Based Groundwater Potential Zone Mapping in Ariyalur District, Tamil Nadu. J Geol Soc India. 2018;92:484–490.<https://doi.org/10.1007/s12594-018-1046-z>
12. Ramachandran R, Perumal M, Udayaganesan P, Samy M, Selvam D. Geospatial and an AHP approach for delineating potential groundwater zone for Sakkottai block, Tamil Nadu. Arabian Journal of Geosciences. 2022;15:633.<https://doi.org/10.1007/s12517->
13. Saaty TL. The Analytic Hierarchy Process. New York, NY: McGraw Hill; 1980.
14. Saaty TL. Decision making with the analytic hierarchy process. Int J Serv Sci. 2008;1(1):83.