

Delineation and Evaluation of Groundwater Potential Zones Around Borkhedi Reservoir Project from Lonar Tehsil, District- Buldhana (MS), India by Using Geospatial Techniques

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ABSTRACT

The study looks into the groundwater potential in the villages in Lonar Tehsil, Buldhana District, Maharashtra, that are close to the Borkhedi Project. The study defines Groundwater Potential Zones (GWPZs) by combining thematic layers, such as Geology, Geomorphology, Land Use/Land Cover (LULC), Soil, Rainfall, Lineament Density, Drainage Density, Slope, Normalize Difference Water Index (NDWI), and Digital Elevation Model (DEM) data, using sophisticated geospatial techniques, particularly Geographic Information Systems (GIS) and Remote Sensing (RS). Because of their direct and indirect effects on the occurrence, flow, and storage of groundwater, these layers were chosen. Each parameter was given a weight using the Analytical Hierarchy Process (AHP), allowing for a fair assessment of groundwater potential. The analysis's objectivity and consistency are improved by this multicriteria decision-making method. Groundwater levels varied significantly depending on lithology, slope, land cover, and hydrological parameters, according to spatial study. Groundwater levels in villages like Weni, Sultanpur, and Borkhedi were dropping, perhaps as a result of excessive extraction or inadequate recharging. This suggests that conservation and better water management measures are required. On the other hand, Koyali, Udanapur, Karegaon, Matarkhed, Mehkar, Pardi Pr. Mehkar, and Tandulwadi had better conditions, maybe as a result of conservation or recharge strategies such check dams, percolation tanks, or afforestation initiatives. Despite seasonal variations, some regions maintained steady groundwater levels, indicating robust aquifer properties and sustainable use practices. The study emphasizes the necessity of ongoing groundwater monitoring, particularly with regard to seasonal fluctuations. Long-term planning requires an understanding of recharge and aquifer health, which can be obtained by analyzing pre- and post-monsoon oscillations. This study emphasizes the significance of sustainable groundwater management and offers crucial recommendations for planners, legislators, and other stakeholders involved in regional water resource policies.

Keywords: Borkhedi Reservoir, Analytical Hierarchy Process (AHP), Remote sensing & GIS, GWPZ (Groundwater PotentialZone).

INTRODUCTION

The issue of water is becoming a major global concern. Water is a natural resource that is crucial to all aspects of human life. Groundwater is regarded as a significant and reliable source among these water supplies. For effective management, it is now crucial to precisely identify groundwater potential areas. These fields can be found by modifying a variety of scientific disciplines, including geoinformatics, geology, topographical characteristics, soil science, meteorology, and precipitation analysis. Human civilization depends on water. Water resources are under pressure due to the rapid increase in demand. By providing crucial insights into terrain, land use, and watershed features, this technology is essential to hydrological investigations. Understanding drainage systems and groundwater potential requires the extraction and interpretation of spatial data, such as basin shape, stream networks, and slope, which are made possible by morphometric analysis and Remote Sensing and GIS (Geographic Information Systems) study.

The demand for water is rising as a result of the current decline of groundwater (Lakshmi et al., 2018). According to S. Shahid et al. (2000) and Jasrotia et al. (2013), the porosity and permeability of the surface and underlying lithology primarily regulate the occurrence and flow of groundwater. It is difficult to find groundwater in hard rock environments (Y. Srinivasa Rao & D. K. Jugran, 2003). A vital component of our daily existence is water. Water is

essential to human civilization (Biswajit Das et al., 2019; Biswas et al., 2012). According to Bera et al., (2020) and Saraf et al., (1998), groundwater is a vital resource that meets humanity's daily water needs, supports industrial growth, has an impact on agriculture, and preserves ecological equilibrium. Given the approaching water crisis in India, there is a discernible and growing sense of urgency regarding clean drinking water (Gnanachandrasamy, G et. al, 2018 and Prija et al., 2011). Any nation's economic and social development depends on the effective management of its surface and groundwater resources through systematic inventory, conservation, and appropriate planning (R.K. Jaiswal et al., 2003 and Krishnamurthi et al., 1996). Water resources are essential to human survival. These resources, which come from evaporation, precipitation, and surface runoff, comprise both surface and subsurface water (E. Masoudian, et. al., 2022 ; Fashae, et al., 2014). The need of drinking well is becoming more and more apparent.

This study's goal was to suggest a strategy for locating and defining groundwater potential zones (Deepesh Machiwal, et al, 2010). The groundwater potential zones are identified using remote sensing and Geographic Information System (GIS) techniques, which enhance the success of choosing the best locations for wells and boreholes (Sani Badamasi et al, 2016). According to Jhariya et al. (2016) and Raj et al. (2022), there is a global water crisis due to the ever-increasing needs of water for residential, irrigation, and industrial sectors. Since groundwater is a vital supply of agricultural and drinking water, adequate groundwater development is crucial for the rural people (Lee et al., 2020; Gumma et al., 2012; Biswajeet Pradhan, 2009). In areas where water shortage is a major problem, such as Lonar Taluka in Buldhana District, the assessment of groundwater potential areas is especially important. The study's goal is to use several GIS layers to investigate groundwater potential areas of the Borkhedi Project in Lonar Taluka. In addition to Antari Deshmukh and Mehkar in the Mehkar Tehsil, the villages of Matmal, Sultanspur, Lonar, Borkhedi, Weni, Pardi Pr. Mehkar, Matarkhed, Pardi Pr. Lonar, Udanpur, Wadgaon Tejan, Nijampur, Karegaon, Tandulwadi, Koyal Shara, Somthana, and Pimpalkhuta in the Lonar Tehsil. Many areas today experience drastically lower water levels as a result of population increase and excessive groundwater exploitation.

STUDY AREA

Borkhedi is a village in Lonar Tehsil of Buldhana district located in the Vidarbha region of Maharashtra state of India. The study area taken in around this famous reservoir project named after this village. due to varied geological and geomorphological conditions . Which is. This area is located between 20° 02' 44" to 20° 04' 05" North latitude and 76° 30' 12" to 76° 33' 01" East longitude and covers an area of approximately 66.8574 sq.km . The river Penganga and its tributary Daga River are included in this area. The Borkhedi Project is located in the Lonar Taluka of Buldhana District, in Maharashtra State, India. The area is situated in a rural environment and is part of the Godawari river basin, featuring local hydrological connections to the Daga River, which is a tributary of the Penganga River.

This area is essential for planning groundwater resources due to its semi-arid climate, reliance on agriculture, and seasonal water accessibility. The project area is geographically positioned within the following coordinates: Latitude: from 20°04'07. 26"N to 20°03'42.53"N and Longitude: from 76°32'58.80"E to 76°32'18.95". This region is categorized under the Deccan Volcanic Province (Plateau), marked by distinct black cotton soils, moderate inclines, and dispersed vegetation in Sahyadri group. Generally the landscape is gently rolling, massive-compact basaltic layers as surface to subsurface lava flows in horizontal manner facilitating surface runoff and impacts the conditions for groundwater recharge. The Daga River's existence furnishes a natural drainage system, and the Borkhedi reservoir (as depicted in the satellite images) is vital to the local hydrology.

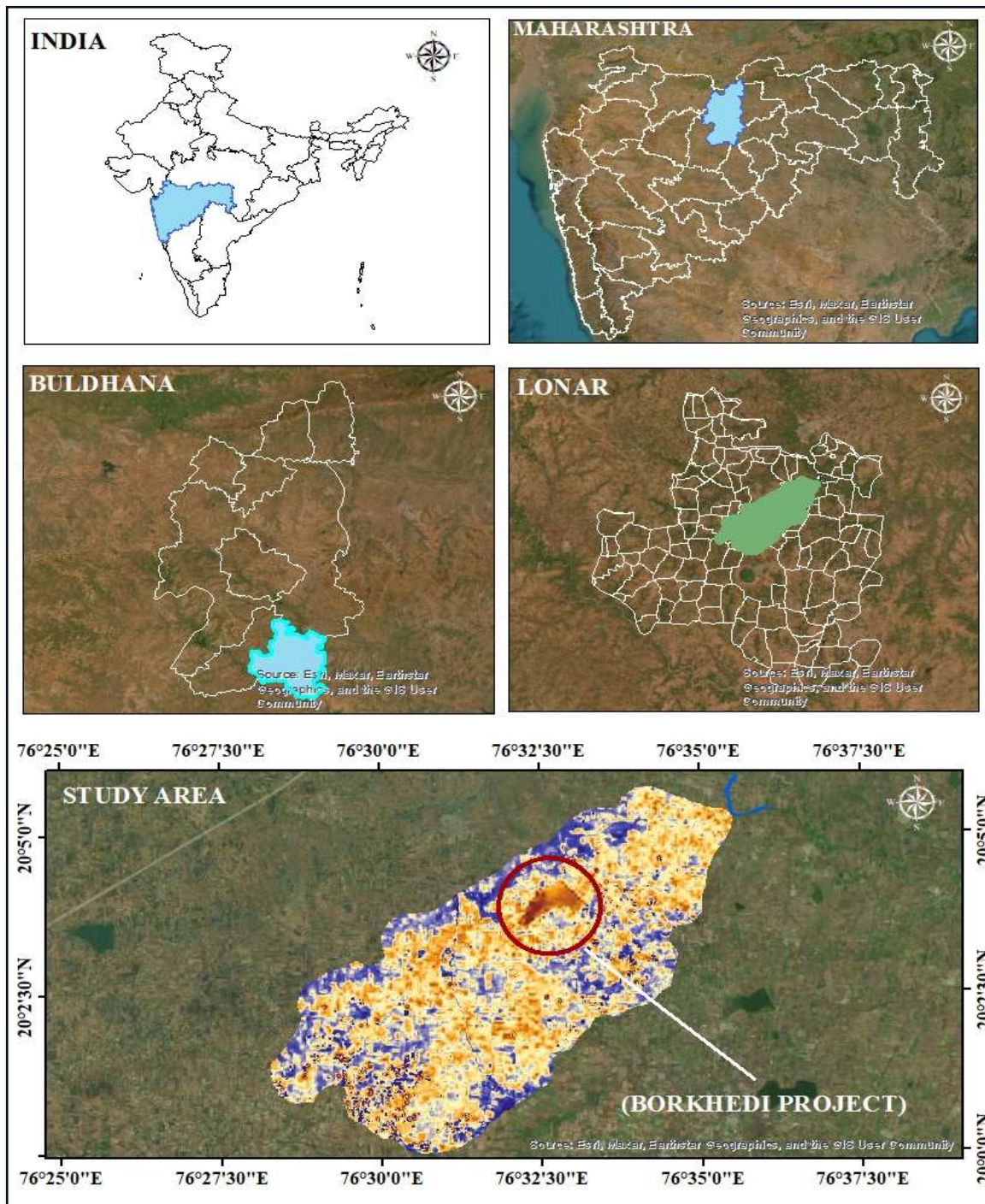


Fig.1. Location Map of Study Area

METHODOLOGY

Multicriteria-Based Method for Groundwater Potential Zone Delineation

Groundwater is a vital natural resource that sustains human use, agricultural, and industrial development. Given the rising demand and declining supply, it is critical to identify regions with high groundwater potential. Using analytical techniques and geographic data, this study seeks to identify groundwater potential locations within the study area. Methodological Strategy Groundwater potential zones are defined using a variety of geospatial data and analytical techniques. The following is a list of the methodology's primary steps:

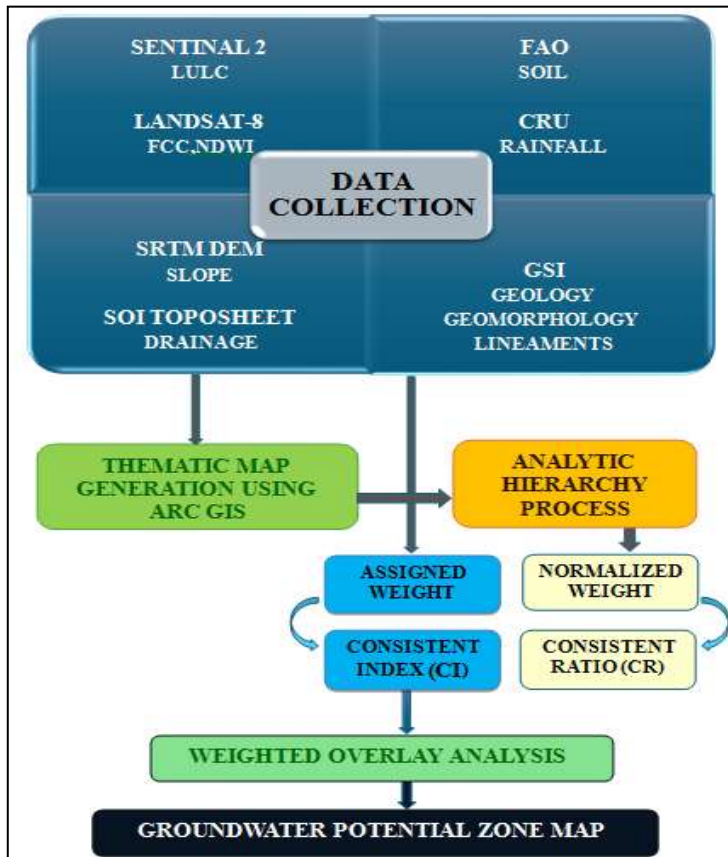


Fig.2. Flowchart of Data Collection and AHP In GWPZ

Table 1. List of Software, Tools, and Required Data Sources for GIS Analysis

Software/Tools Used	
Software/Tool	Purpose
Arc GIS	GIS mapping, spatial analysis
Google Earth Engine Pro	Cloud-based satellite data analysis
MS Word	Report Writing
MS Excel	Data organization and basic analysis
Data Required	
Data Type	Description
Satellite Imagery	LANDSAT-8, Sentinel-2, IRS, etc. (Used for LULC, FCC, NDWI etc.)
DEM (Digital Elevation Model)	SRTM, (used for slope, drainage, flow accumulation)
Rainfall Data	From CRU, or local sources (rainfall patterns)
Soil Type Data	From FAO (important for infiltration capacity)
Geological Data	From BHUKOSH Geological Survey of India (GSI) – rock type, fault lines, etc.
Lineament Data	Derived from satellite imagery or topographic maps
Land Use Land Cover (LULC)	Sentinel 2 satellite
Drainage Map	Extracted from Survey of India toposheets

- Geological Mapping: Identifying aquifer for geological structures, lithology, and formations to understand how they impact the availability of groundwater.
- Geomorphological Analysis: Evaluating how surface features and landforms contribute to groundwater storage and recharge.
- Lineament Density Mapping: Finding linear geological structures, such as faults and fractures, and assessing their connection to the water flow beneath the surface this mapping has been carried out. .
- Analyzing the drainage network to ascertain how stream density affects runoff and infiltration patterns is known as drainage density mapping.
- Assessing soil types and textures to ascertain their permeability and capacity to hold water is known as soil mapping.
- Rainfall Data Analysis: Determining the potential for natural recharge in the area under study by evaluating the spatial distribution of precipitation.
 - Slope mapping is the process of classifying slope gradients that impact surface runoff and groundwater infiltration using digital elevation data.
- Land Use/Land Cover (LULC) Mapping: Analyzing how plant cover and human activity affect groundwater recharge and infiltration

This methodology for thematic layer integration analysis A systematic analytical framework is required for the integration of several thematic layers in order to map groundwater potential zones.

To ensure a methodical and scientifically sound approach to multi-criteria decisionmaking, the Analytical Hierarchy Process (AHP) and Weighted Overlay Analysis were applied in this study.

- Process of Analytical Hierarchy (AHP) Each thematic layer was assigned relative weights based on its contribution to groundwater recharge using the AHP technique. Saaty's scale (1–9) was used to generate a pairwise comparison matrix in which each theme layer was evaluated in relation to the others. To determine the judgment matrix's dependability, the consistency ratio (CR) was calculated; a CR value of less than 0.1 was considered satisfactory. Geology, Geomorphology, Lineament Density, Drainage Density map, Soil type, Rainfall, Slope, and Land Use/Land Cover (LULC) are among the thematic layers assessed in the AHP technique. Each layer was given a normalized weight to represent its influence on the mobility and presence of groundwater.

- The thematic layers were combined using the Weighted Overlay Analysis in a GIS system. Initially, each raster layer was classed into appropriateness categories, which typically ranged from extremely low to very high. The appropriate AHP-derived weights were then multiplied by these reclassified layers. A composite map showing different levels of groundwater potential was produced as a result of this integration process, and it was further divided into zones that were very high, high, moderate, low, and very low.

RESULTS

Geology of Study area

The geology map depicts a research area that is entirely covered by Deccan Volcanic Lava flows. from weathered, jointed to massive flows of compact, vesicular, amygdaloidal basalt followed by some, Red bole and giant phenocryst basalt of Upper Cretaceous to Lower Eocene age. The Penganga River flows through the north-eastern part of the study area, acting as an important surface water source and potentially influencing subsurface hydrology. These internal features play a critical role in groundwater movement and storage, as fractures and vesicles provide pathways for infiltration and retention. The basaltic layers, depending on their degree of weathering, lineaments and fractures, may function as moderately to highly productive aquifers.

Although the map does not indicate detailed hydrogeological aspects, it clearly illustrates the foundational geology, essential for assessing groundwater behaviour. Effective groundwater research, management, and long-term planning in this area depend on an understanding of these volcanic rock formations. Additionally, the Deccan Trap's influence on geomorphology might help locate water conservation structures and possible recharge zones.

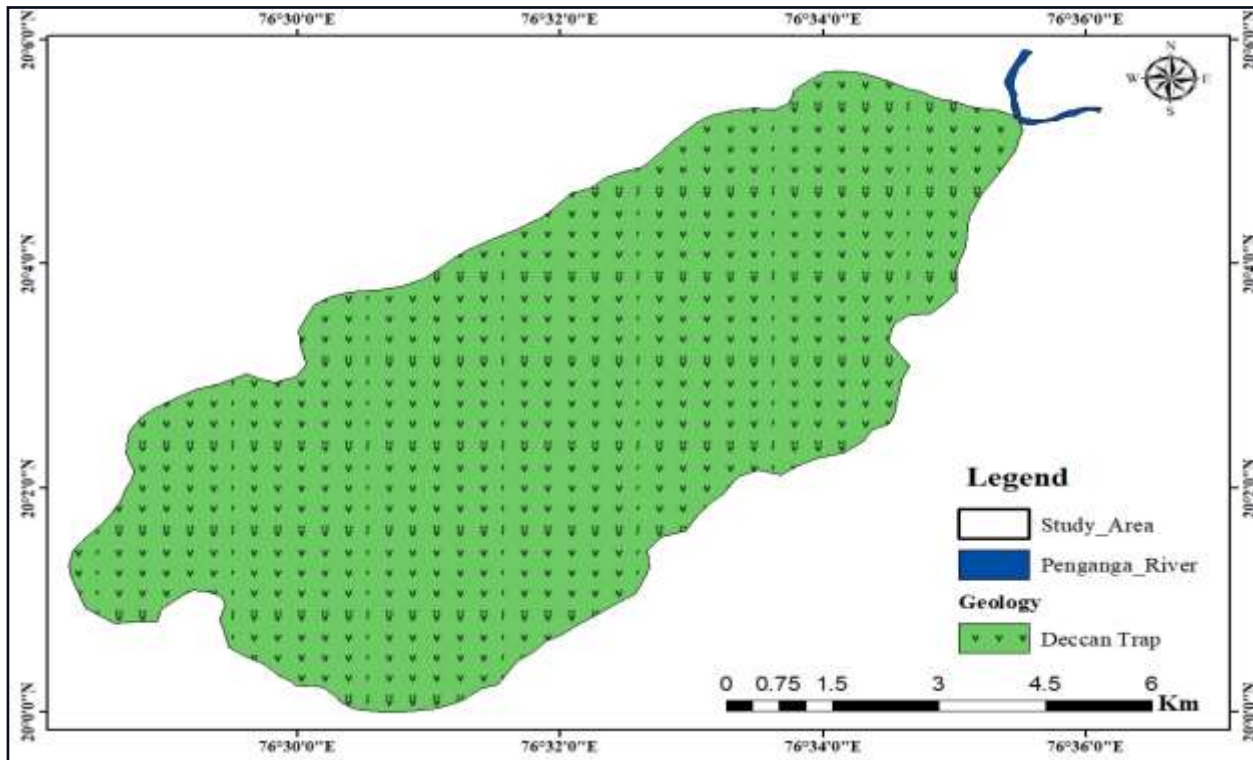


Fig. 3. Geology map of study area

Geomorphology of Study Area

Three main geomorphic units are depicted on the geomorphology map of the study area: the Penganga River, the Moderately Dissected Plateau, and the Pediment Pedi plain Complex. Soil formation, land use planning, and surface and subsurface water dynamics are all greatly impacted by these landforms. Moderately Dissected Plateau: Located mostly in the northern, central, and south-western regions of the study area, this unit is represented in orange. Because to erosional processes throughout time, these plateaus have thin soils, irregular terrain, and mild inclines. Hard basaltic rock with little weathering usually makes up their composition. These regions often have low to moderate groundwater potential because the slope promotes surface runoff, which reduces infiltration. However, some water percolation and limited aquifer formation may be facilitated by the basalt's fissures and joints. The pediment Pedi-plain Complex: This unit, which makes up the majority of the research area, is shown by the beige area on the map.

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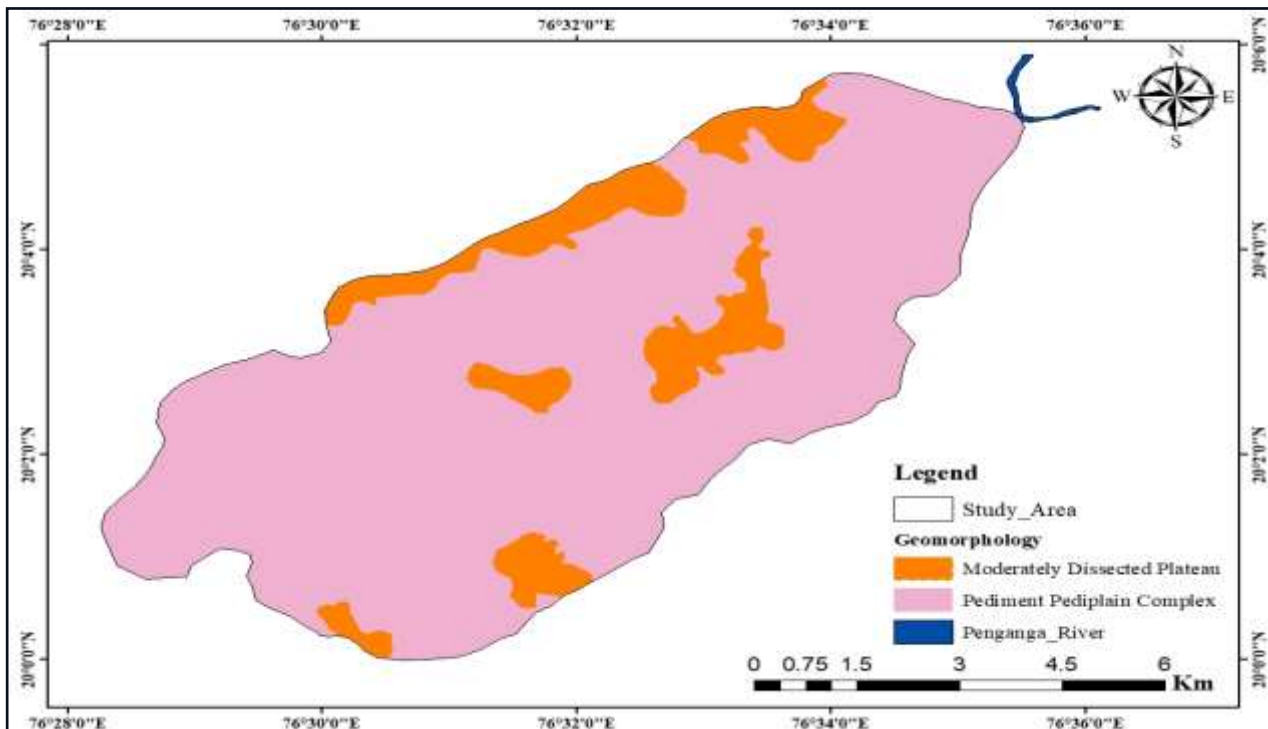


Fig.4. Geomorphology map of study area

These regions often have low to moderate groundwater potential because the slope promotes surface runoff, which reduces infiltration. However, some water percolation and limited aquifer formation may be facilitated by the basalt's fissures and joints. The pediment Pediplain Complex: This unit, which makes up the majority of the research area, is shown by the beige area on the map.

It is composed of low-relief plains and gently sloping rock surfaces that have been formed by extended weathering and erosional processes. Because of their deeper weathered zones and higher infiltration rates, these areas have a moderate to high capacity for groundwater retention. Because of their geomorphological features, pediments are suitable for groundwater recharge systems and agriculture. They also operate as transitional zones between plains and highlands. The north-eastern portion of the study area is traversed by the Penganga River, which is shown in blue. Along its banks, it is essential for groundwater replenishment and surface drainage. Local groundwater conditions may be improved by the presence of alluvial sediments and the river's interaction with the underlying geology. It affects the region's hydrological dynamics and is an essential water supply.

Soil

The distribution of soil in a research area next to the Penganga River is shown on the soil map. A constant crosshatch pattern throughout the study area indicates that the soil type in the entire region is clay-black cotton soil. The Penganga River runs along the northeastern perimeter, affecting the local hydrogeological conditions. Clay- black cotton soils, as represented on the map, usually consist of fine particles with low permeability, which may hinder groundwater infiltration and mobility. Because of its considerable capacity to keep water, this kind of soil typically holds water, which may cause underlying aquifers to recharge more slowly. In terms of groundwater potential, the presence of clay layer with black cotton soil may limit the region's overall groundwater accessibility, particularly in locations farthest from the river where surface water effect is minimal. Strategies for groundwater management in this clay-dominated area should focus on enhancing recharge through methods like artificial recharge systems or constructing percolation tanks adjacent to the river to capitalize on its proximity.

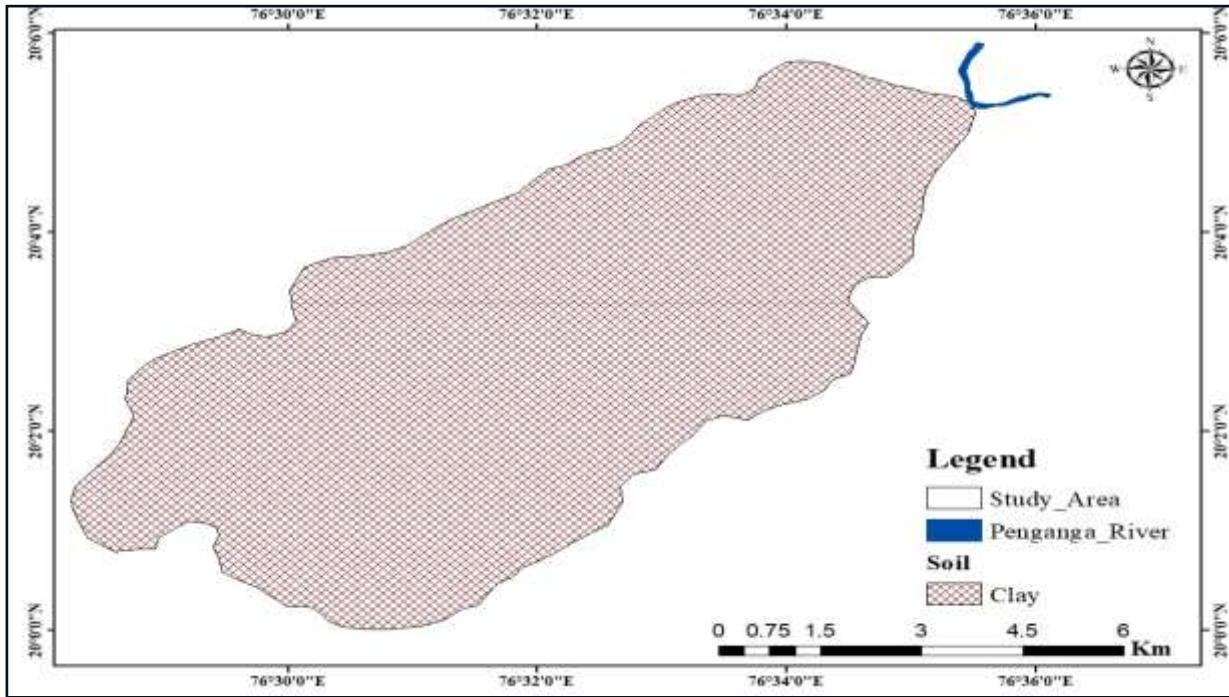


Fig.5: Soil map of study area

Land Use and Land Cover (LU/LC)

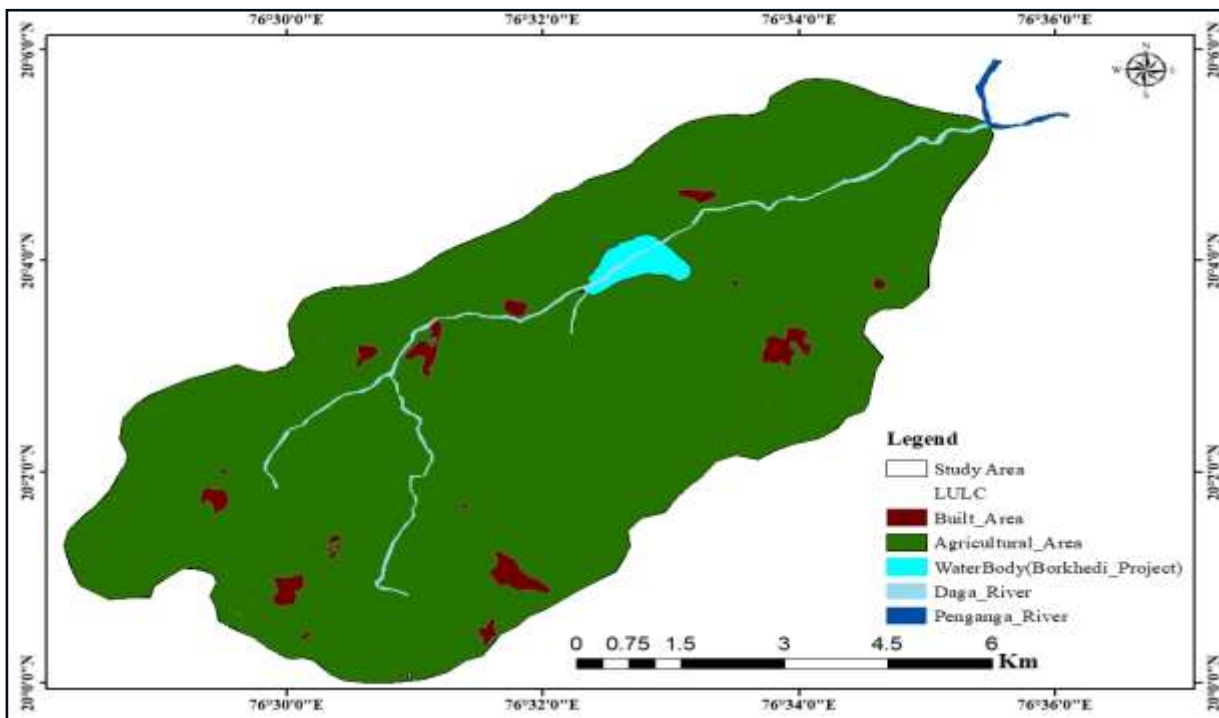


Fig.6. LULC map of study area

The research area's Land Use Land Cover (LU/LC) map was produced using remote sensing techniques and assessed using GIS tools to ascertain groundwater potential. While GIS spatial analysis provided crucial insights into their spatial distribution and relationship to groundwater recharge, satellite imagery enabled the accurate classification of surface characteristics such as urban areas, cropland, water bodies, and river networks. High-resolution satellite imagery was used to highlight the urban areas, which are shown in red. Communities and infrastructure that are distinguished by impermeable surfaces that prevent infiltration make up these locations. Due to high runoff and low permeability, these zones contribute little to recharge, according to GIS overlay study. As a result, they are considered to have the

least favorable groundwater potential. The farmlands, which are common in the region and shown in green, were found using remote sensing data and supervised classification techniques.

Using sustainable farming methods greatly enhances groundwater replenishment in these areas. Multispectral remote sensing imagery, which clearly shows open water surfaces, was used to chart the water body (Borkhedi Project), which is shown in light blue. The reservoir's GIS buffer study indicates that continuous seepage and percolation have boosted groundwater potential. This region is said to be quite conducive to recharging, especially during and after the monsoon season. The Penganga River, depicted in dark blue, was created utilizing GIS hydrological methods that included drainage network modelling and flow accumulation. Through lateral and vertical seepage, the river plays a major role in replenishing nearby aquifers. GIS-based proximity analysis confirms that areas along the river channel have substantial groundwater potential, particularly in areas with porous substrate.

Rainfall

The chart shows the groundwater potential of a study area adjacent to the Penganga River. The area has been classified into three zones based on precipitation: low (81.69 mm), middle (83.55 mm), and high (85.97 mm). The eastern area, which is nearest to the Penganga River, has the greatest groundwater potential with rainfall of roughly 85.97 mm (shown in blue). This implies that the great recharge conditions are caused by the river's influence, which encourages infiltration and aquifer repair. The central region, indicated in green, has a moderate potential and is a transitional area with adequate recharging capacity, with rainfall of approximately 83.55 mm.

The lowest potential, at roughly 81.69 mm, is found in the yellow-colored western portion. This could be because of geological features that limit groundwater storage and have little effect from surface water. To successfully manage groundwater, high-potential areas near rivers should be given priority for sustainable extraction. However, by boosting the water supply, recharge improvement strategies like rainwater collection may help low-potential areas. This regional assessment of groundwater potential provides crucial information for resource planning in order to guarantee efficient use and conservation of groundwater in the area.

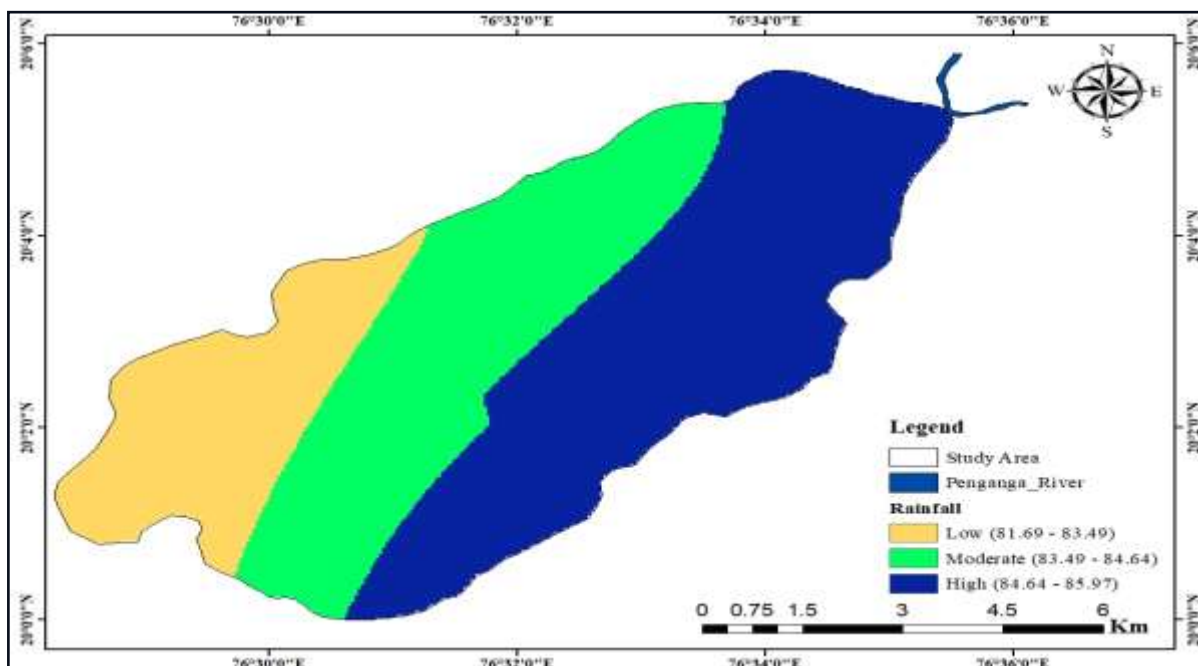


Fig.7. Rainfall map of study area

Drainage Density

The pattern of drainage density within a watershed impacted by the Penganga River system is shown on the map. Five categories comprise the drainage network: Each of the following is represented by a distinct colour, ranging from light peach (very low) to dark purple (very high): Very Low, Low, Moderate, High, and Very High. The primary watercourse, the Penganga River (shown in dark blue), is supplemented by a number of tributaries that disperse throughout the basin.

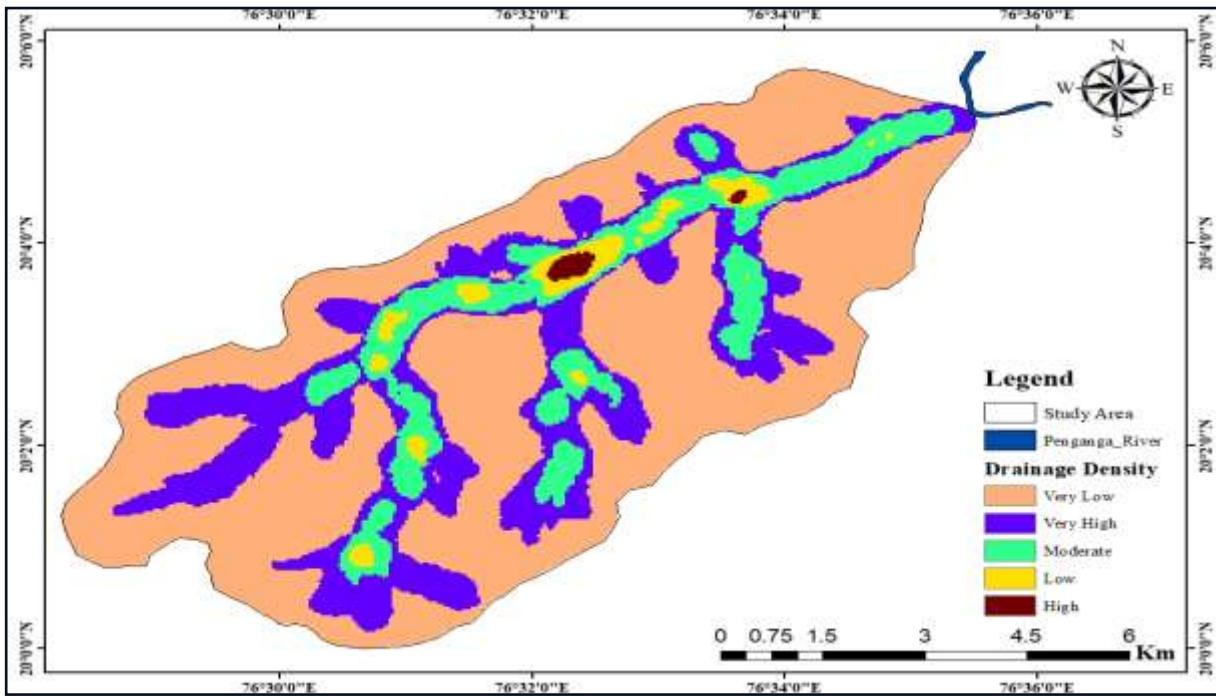


Fig.8. Drainage density map of study area

Lineaments Density

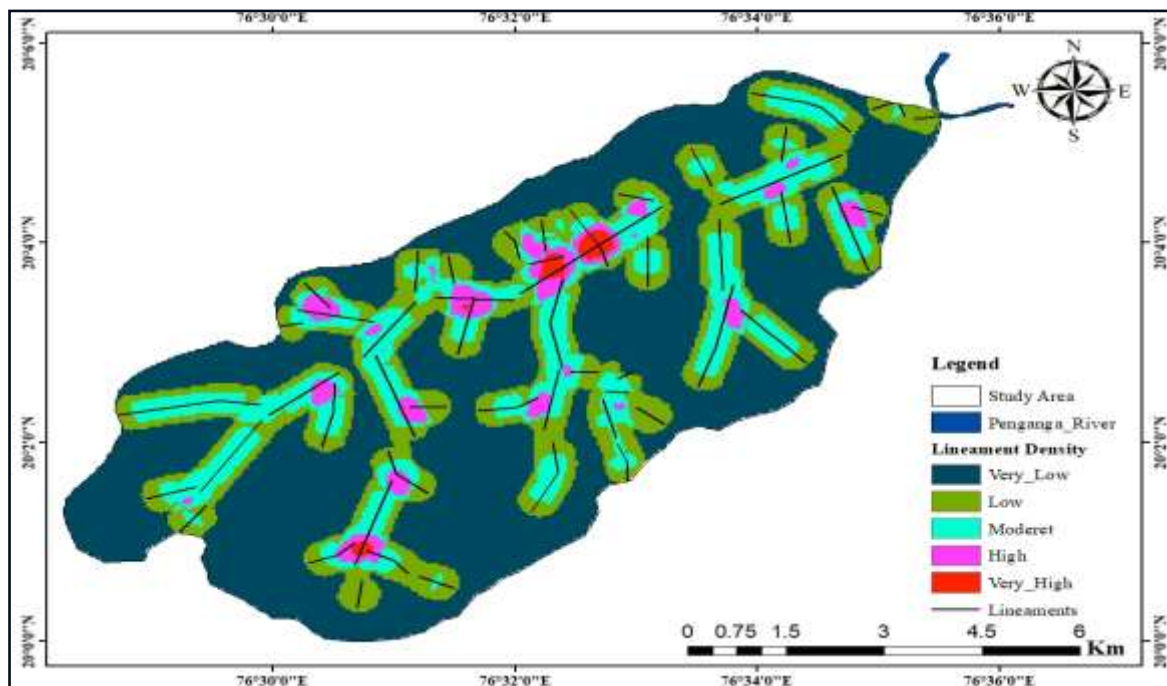


Fig.9. Lineaments Map of Study Area

The five classifications of lineament density on this map are Very Low, Low, Moderate, High, and Very High. The Penganga River, which flows through the watershed's northern region, is shown in dark blue. Digital image processing techniques like edge detection, directional filtering, or principal component analysis (PCA) has been used to extract lineaments from satellite data. Because of their higher secondary porosity and permeability, these areas are very beneficial for groundwater flow and storage. On the other hand, regions with low or extremely low lineament density (blue and green zones) indicate less broken and more consolidated rock formations.

Slope

The research area's slope map, The USGS website's Digital Elevation Model (DEM) data was used to build the map, which offers a comprehensive representation of topographic inclines. Using GIS-based geographical analysis, slope values were computed and categorized into five groups: Very Low (0–1.20°), Low (1.20–2.13°), and Moderate (2.13–3.24 °), and High (3.24–4.98 °), and Very High (4.98–11.34°).

These areas are therefore thought to have higher groundwater potential. Conversely, places with high to extremely high slopes (purple and dark blue areas) exhibit steeper gradients, where water tends to flow quickly across the surface, increasing runoff and decreasing absorption into the ground. Although they may support downstream recharge zones through effective water conveyance, these areas are often less favourable for groundwater accumulation.

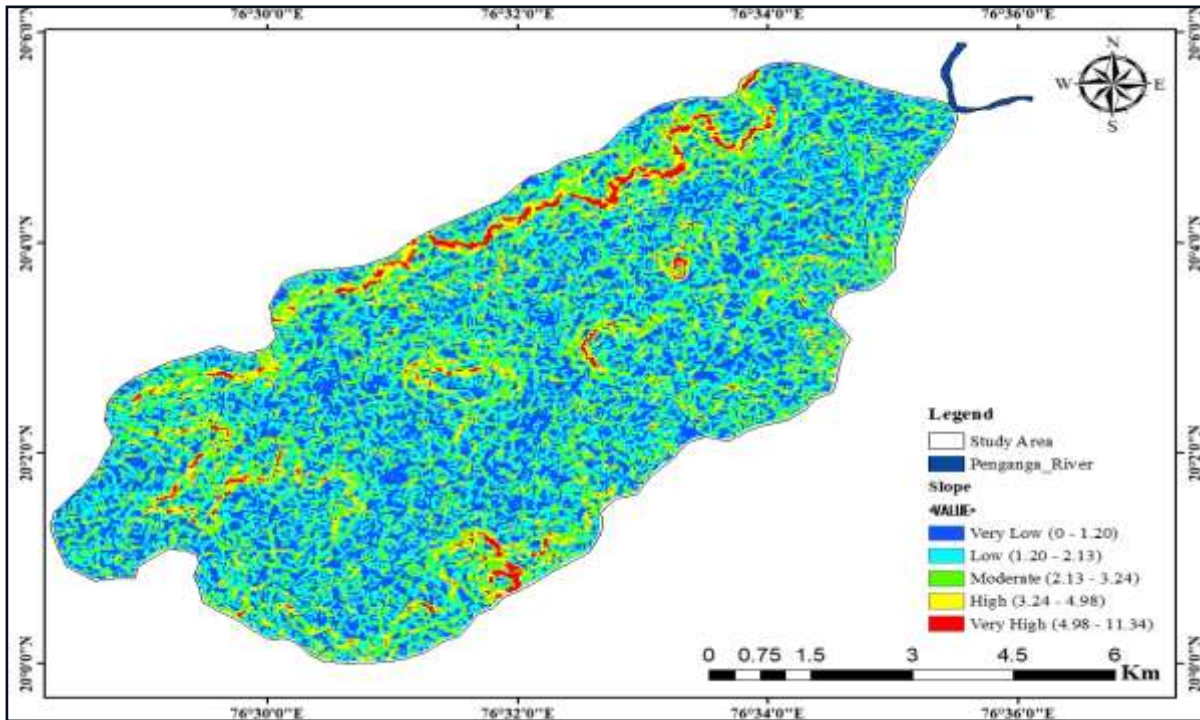


Fig.10. Slope map of study area

GWPZ Demarcation

With an emphasis on area statistics and the spatial distribution of groundwater potential, the current study uses GIS and RS methodologies to validate the identified Groundwater Potential Zones (GWPZ) within a designated study region. The study area is 66.85 km². These layers often include soil type, geology, drainage density, slope, land use/cover, and lineament density, all of which have a significant impact on the occurrence and movement of groundwater. The study region was separated into three different groundwater potential zones—the Poor Zone, the Good Zone, and the Excellent Zone—using weighted overlay analysis in GIS. The following is a breakdown of each zone's corresponding areas:

Table 2. GWPZ with Corresponding Area and Percentage Coverage

Zone	Area	Percentage
Poor Zone	6.27 km ²	9.74%
Good Zone	54.17 km ²	84.17%
Excellent Zone	3.91 km ²	6.09%

The three classed zones add up to 64.35 km², which is marginally less than the entire study area of 66.85 km². This variance could be the result of unclassified areas that were not taken into account in the investigation, such as buffer zones, built-up areas, or aquatic bodies. The majority of the area is classified as "Good" based on the GWPZs' spatial organization. This suggests a moderate to high likelihood of groundwater availability, which is associated with favorable geological and topographic characteristics. The central and northern parts of the research area, which have

moderate drainage density and mild slopes, are mostly included in this category. Conversely, the "Poor" zones are located at the northern and southern boundaries of the study region. These zones frequently have steep slopes, high runoff potential, and inadequate infiltration capacity. Because they are not appropriate for groundwater recharge, these areas frequently need artificial recharge structures for effective water management. Despite their small size, the "Excellent" zones are crucial for groundwater use planning. These places, which have flat terrain, highly permeable soil, and a high lineament density, are mostly located in the southwest and central regions. Additionally, groundwater level monitoring, borewells yield statistics, and field validation can verify the accuracy of the GWPZ mapping. However, the hydro-geomorphic features of the region are consistent with the statistical distribution of the identified zones, as shown above. According to the current study, 84.17% of the study area has good groundwater potential, 6.09% has exceptional groundwater potential, and 9.74% has poor groundwater potential.

Fig.11. GWPZ map of study area

Table 3.

Layers	Geomorphology	Slope	Geology	Lineament Density	LULC	Soil	Rainfall	Drainage Density	Normalized Weightage
Geomorphology	8/1	7/1	6/1	5/1	4/1	3/1	2/1	1/1	0.37
Slope	8/2	7/2	6/2	5/2	4/2	3/2	2/2	1/2	0.18
Geology	8/3	7/3	6/3	5/3	4/3	3/3	2/3	1/3	0.13
Lineament Density	8/4	7/4	6/4	5/4	4/4	3/4	2/4	1/4	0.09
LULC	8/5	7/5	6/5	5/5	4/5	3/5	2/5	1/5	0.08
Rainfall	8/6	7/6	6/6	5/6	4/6	3/6	2/6	1/6	0.06
Soil	8/7	7/7	6/7	5/7	4/7	3/7	2/7	1/7	0.05
Drainage Density	8/8	7/8	6/8	5/8	4/8	3/8	2/8	1/8	0.04
Total									1

Pairwise Comparison Matrix and Normalized Weightage for Thematic Layers in GWPZ

Table 4. AHP Weightages for GWPZ

Factors	Weight	Rank	Overall Weightage
GEOMORPHOLOGY			
Moderately Dissected Plateau	37	3	111
Pediment Pediplain Complex		4	148
Penganga River		5	185
SLOPE			
Very Low	18	5	90
Low		4	72
Moderate		3	54
High		2	36
Very High		1	18
GEOLOGY			
Deccan Trap	13	5	65
LINEAMENT DENSITY			
Very Low	9	1	9
Low		2	18
Moderate		3	27
High		4	36
Very High		5	45
LAND USE LAND COVER			
Built-up Land	8	3	24
Agricultural Land		4	32
Water body		5	40
RAINFALL			
High	6	3	18
Moderate		2	12
Low		1	6
SOIL			
Clay	5	5	25
DRAINAGE DENSITY			
Very Low	4	5	25
Low		4	16
Moderate		3	12
High		2	8
Very High		1	4
SUM OF INFLUENCE = 100			

Validation of GWPZ through spatial analysis of dugwells

Using dugwells data mapped within the research area, which includes the Penganga river basin, the groundwater potential zones were validated. Groundwater availability and the categorized potential zones are clearly correlated, as shown by the spatial distribution of wells in respect to the defined groundwater potential zone. It was shown that locations with outstanding and good groundwater potential have a large number of wells, whereas places with poor groundwater potential had fewer wells. Because the locations with higher groundwater potential naturally attract more

well drilling and usage due to increased water availability, this trend validates the accuracy of the groundwater potential zone mapping. Due in great part to the existence of the Borkhedi Reservoir Project, the outstanding groundwater potential zone in particular demonstrates the substantial groundwater potential. The reservoir plays a crucial role for replenishing the groundwater system, which increases the capacity of nearby aquifers. The integration of well data with GIS based analysis ensures practical applicability. Overall, the Study highlights the effectiveness of combining field data with remote sensing techniques. This combined methodology can be replicated in other regions with similar hydrological conditions.

SUM INFLUENCE = 100

Fig. 12. Spatial distribution of dugwells in the GWPZ

CONCLUSION AND DISCUSSION

Spatial Assessment of Groundwater Potential Areas

Remote sensing (RS) and GIS-based visual aids like as pie charts, categorized bar graphs, and thematic maps have been used to evaluate the Groundwater Potential Zones (GWPZ) of the communities included in the Borkhedi Project. The bar graph divides settlements into three categories based on groundwater potential: Poor (red), Good (yellow), and Excellent (green). The majority of the villages on the list have "Good" groundwater potential, however others are rated as "Poor" and "Excellent." According to the data, 57.9% of villages are classified as "Good," 26.3% as "Poor," and 15.8% as "Excellent." Koyali, Udanapur, Karegaon, Matarkhed, Mehkar, Pardi Pr. Mehkar, and Tandulwadi all exhibit areas of "Excellent" potential, but Weni, Borkhedi, and Sultanpur are primarily in the "Poor" zone. Most of the study area's potential is rated as "Good," with occasional assessments of "Poor" and "Excellent." It is necessary to categorize groundwater resources as "Poor," "Good," and "Excellent" in order to comprehend their regional variability. This study offers a strong foundation for identifying these areas so that local participants and water resource planners can implement targeted, site-specific efforts. Groundwater sustainability can be enhanced by focused initiatives in the "Poor" areas, bolstered by community involvement and seasonal analysis using satellite images.

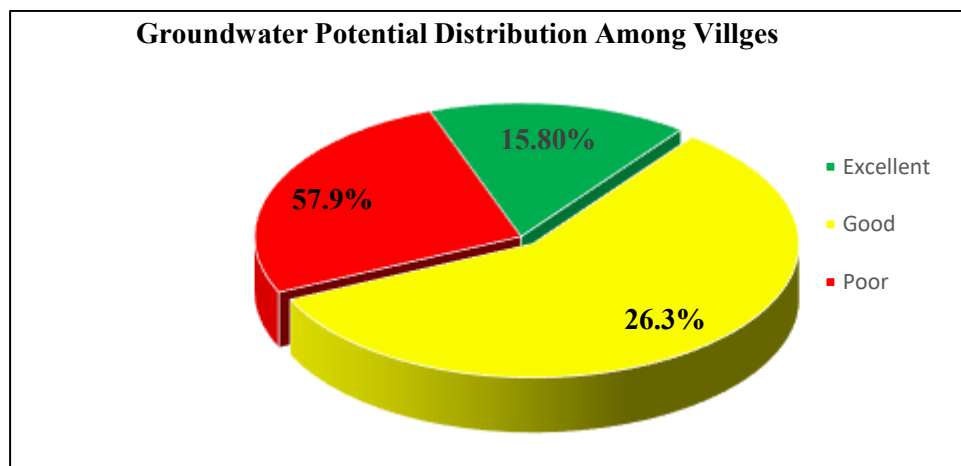


Fig.13. Distribution of groundwater potential by villages

Examination of the factors influencing groundwater variability

The geographic, environmental, and human factors that contribute to the spatial disparity in groundwater potential among villages are mapped and analysed using GIS and RS datasets: Soil Type and Texture: The Borkhedi project area is mainly comprised of clayey black cotton soil. This kind of soil, which has a low permeability, affects groundwater recharge by limiting water infiltration into lower aquifers. RS-based analysis, however, reveals that regions with finer soil textures have moderate retention and infiltration, which supports fairly productive groundwater zones. Rainfall Distribution: Satellite rainfall estimates are used to spatially analyse precipitation, which is a major input for recharge.

GIS overlay analysis verifies that villages like Koregaon and Koyali, which receive more rain, have better potential. The topographic features in these areas promote percolation, which in turn raises groundwater levels.

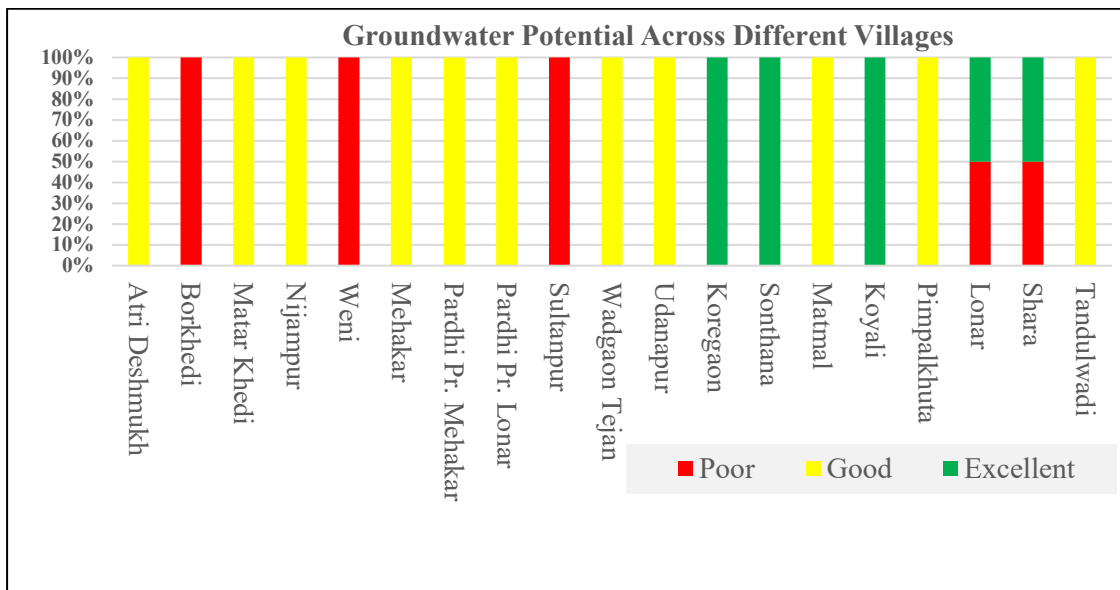


Fig.13. Bar graph showing groundwater potential in various villages

Topography and Drainage: Rivers like Penganga and Daga are visible on GIS mapping. Surface water contact around these rivers increases the possibility of recharge. Groundwater potential is higher in communities near rivers, such as Pardi Pr. Mehkar, Tandulwadi, and Wadgaon Tejan, according to RS-based images. Soil Productivity and Depth: Soil depth can range from less than 10 cm to more than 30 cm, according to digital elevation models and remote sensing-based soil assessments. While shallower soils prevent infiltration, deeper soils greatly facilitate recharge. Groundwater conditions are favorable in villages with deep, productive soils, such as Udanapur and Pimpalkhuta. Land Use and Agricultural Practices: According to satellite imagery land use/land cover (LULC) data, irrigation systems and artificial recharge improve groundwater in villages with high agricultural activity, including Mehkar, Matarkhed, Nijampur, Tandulwadi, Koyali, Udanapur, Wadgaon, and some areas of Weni and Karegaon. These practices can be found and observed using temporal RS data. Human Interventions: Significant changes in land use patterns, such as deforestation and urban growth, are shown by RS and GIS research, which have an effect on recharge dynamics. Groundwater levels have declined in some places due to excessive borewell exploitation, especially in unregulated areas. Understanding human-environment interactions using spatial tools is essential for good management. Aquifer Characteristics: The best way to understand underlying lithology and fractured aquifers is through hydrogeological mapping included into GIS layers. When suitable recharge structures are employed, several towns with strong fractured basaltic rock aquifers exhibit increased groundwater potential. Socio-Economic Conditions: By incorporating infrastructure, population density, and government program access into GIS-based socio-economic layers, the sustainability of water usage can be assessed. Villages with access to and awareness of infrastructure typically perform better when it comes to water conservation.

PLANNING FOR GROUNDWATER MANAGEMENT

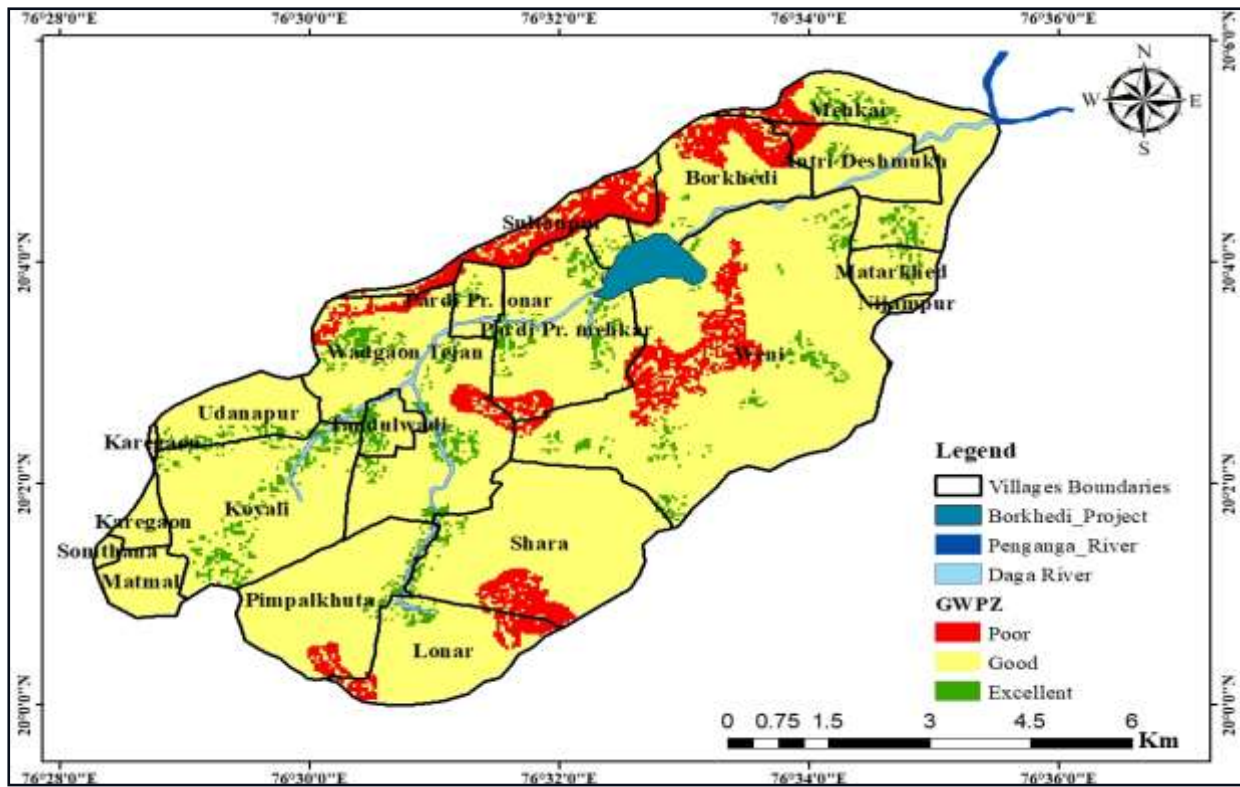


Fig. 14. Map Displaying Village Boundaries and Groundwater Potential Areas

Customized groundwater management plans are suggested for every region based on RS and GIS-assisted analysis: Regarding Low-Potential Areas (such as Sultanpur, Borkhedi, and Weni): Utilizing GIS-mapped catchment area identification, develop rainwater gathering systems. Build check dams and afforestation sites according on the slope and drainage layers found in the DEM study. For regions like Antri Deshmukh, Nijampur, Shara, Matmal, Somthana, Wadgaon Tejan, and Lonar that have a lot of potential. Maintain and map existing recharge structures using geographical datasets. Install precision irrigation systems that are tracked by RS data, such as drip systems. Groundwater monitoring networks connected to GIS can be used to control extraction rates. Regarding areas of outstanding potential (Koregaon, Koyali, Udanapur, etc.): Establish community-based groundwater sharing that is linked to digital dashboards and GIS mapping. Build intelligent communities for water management supported by mobile apps and RS-integrated sensors. For routine evaluation and reporting, make use of high-resolution satellite photos. The continuous employment of piezometers and remote sensing technology allows for dynamic monitoring of groundwater levels. Hybrid models that integrate traditional knowledge with satellite-driven insights will enhance the projects' cultural and environmental sustainability. In the end, GIS and RS frameworks need to be in line with governance and policy frameworks. Village-level water security action plans need to be in line with broader policy initiatives and informed by real-time geospatial data. Long-term water security in the Borkhedi project area depends on regulatory frameworks that control over-extraction and provide incentives for conservation.

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REFERENCES

- Agarwal, R., & Garg, P. K. (2016). Remote sensing and GIS based groundwater potential & recharge zones mapping using multi-criteria decision making technique. *Water Resources Management*, 30, 243–260.
- Badamasia, S., Sawab, B. A., & Garbac, M. L. (2016). Groundwater potential zones mapping using remote sensing and geographic information system techniques (GIS) in Zaria, Kaduna State, Nigeria. *American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS)*.
- Bera, A., Mukhopadhyay, B. P., & Barua, S. (2020). Delineation of groundwater potential zones in Karha river basin, Maharashtra, India, using AHP and geospatial techniques. *Arabian Journal of Geosciences*, 13, 693.
- Biswajeet Pradhan, (2009). Groundwater potential zonation for basaltic watersheds using satellite remote sensing data and GIS techniques, *Cent. Eur. J. Geoscience*, 1(1), 120-129.
- Biswajit Das, Subodh Chandra Pal, Sadhan Malik & Rabin Chakraborty (2019) Modeling groundwater potential zones of Puruliya district, West Bengal, India using remote sensing and GIS techniques, *Geology, Ecology, and Landscapes*, 3:3, 223-237.
- Biswas, A., Jana, A., & Mandal, A. (2013). Application of remote sensing, GIS and MIF technique for elucidation of groundwater potential zones from a part of Orissa coastal tract, Eastern India. *Research Journal of Recent Sciences*, 2(11), 42–49.
- Biswas, A., Jana, A., & Sharma, S. P. (2012). Delineation of groundwater potential zones using satellite remote sensing and geographic information system techniques: A case study from Ganjam district, Orissa, India. *Research Journal of Recent Sciences*, 1(9), 59–66.
- Das, S. (2017). Delineation of groundwater potential zone in hard rock terrain in Gangajalghati block, Bankura district, India using remote sensing and GIS techniques. *Modeling Earth Systems and Environment*, 3, 1589–1599.
- Fashae, O. A., Tijani, M. N., Talabi, A. O., & Adedeji, O. I. (2014). Delineation of groundwater potential zones in the crystalline basement terrain of SW-Nigeria: An integrated GIS and remote sensing approach. *Applied Water Science*, 4, 19–38.
- Gnanachandrasamy, G., Yongzhang Zhou, Bagyaraj, M., Venkatramanan, S., Ramkumar, T., Shugong Wang, (2018). Remote Sensing and GIS Based Groundwater Potential Zone Mapping in Ariyalur District, Tamil Nadu, *Journal Geological Society Of India Vol.92*, 484-490.
- Govender, M., Dye, P. J., Weiersbye, I. M., Witkowski, E. T. F., & Ahmed, F. (2009). Review of commonly used remote sensing and ground-based technologies to measure plant water stress. *Water SA*, 35(5).
- Gumma, M. K., & Pavelic, P. (2012). Mapping of groundwater potential zones across Ghana using remote sensing, geographic information systems, and spatial modeling. *Environmental Monitoring and Assessment*.
- Jaiswal, R. K., Mukherjee, S., Krishnamurthy, J., & Saxena, R. (2003). Role of remote sensing and GIS techniques for generation of groundwater prospect zones towards rural development—an approach. *International Journal of Remote Sensing*, 24(5), 993–1008.
- Jasrotia, A. S., Bhagat, B. D., Kumar, A., & Kumar, R. (2013). Remote sensing and GIS approach for delineation of groundwater potential and groundwater quality zones of Western Doon Valley, Uttarakhand, India. *Journal of the Indian Society of Remote Sensing*, 41(2), 365–377.

Jhariya, D. C., Kumar, T., Gobinath, M., Diwan, P., & Kishore, N. (2016). Assessment of groundwater potential zone using remote sensing, GIS and multi-criteria decision analysis techniques. *Journal of the Geological Society of India*, 88, 481–492.

Krishnamurthy, J., Venkatesa, K. N., Jayaraman, V., & Manivel, M. (1996). An approach to demarcate groundwater potential zones through remote sensing and a geographical information system. *International Journal of Remote Sensing*, 7(10), 1867–1884.

Lakshmi, S. V., & Reddy, Y. V. K. (2018). Identification of groundwater potential zones using GIS and remote sensing. *International Journal of Pure and Applied Mathematics*, 119(17), 3195–3210.

Lee, S., Hyun, Y., Lee, S., & Lee, M. J. (2020). Groundwater potential mapping using remote sensing and GIS-based machine learning techniques. *Remote Sensing*, 12, 1200.

Masoudian, E., & Pahlavani, P. (2022). GIS-based groundwater potential mapping using machine learning models: A case study: Qom Province, Iran. *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, X-4/W1-2022.

Panigrahi, B., Nayak, A. K., & Sharma, S. D. (1995). Application of remote sensing technology for groundwater potential evaluation. *Water Resources Management*, 9, 161–173.

Preeja, K. R., Joseph, S., Thomas, J., & Vijith, H. (2011). Identification of groundwater potential zones of a tropical river basin (Kerala, India) using remote sensing and GIS techniques. *Journal of the Indian Society of Remote Sensing*, 39(1), 83–94.

Saket Raj, Kishan Singh Rawat, Sudhir Kumrar Singh & Anil Kumar Mishra (2022): Groundwater potential zones identification and validation in Peninsular India, *Geology, Ecology, and Landscapes*.

Saraf, A. K., & Choudhury, P. R. (1998). Integrated remote sensing and GIS for groundwater exploration and identification of artificial recharge sites. *International Journal of Remote Sensing*, 19(10), 1825–1841.

Shahid, S., Nath, S. K., & Roy, J. (2000). Groundwater potential modelling in a soft rock area using a GIS. *International Journal of Remote Sensing*, 21(9), 1919–1924.

Waikar, M. L., & Nilawar, A. P. (2014). Identification of groundwater potential zone using remote sensing and GIS technique. *International Journal of Innovative Research in Science, Engineering and Technology*, 3(5), 12163–12170.

Y. Srinivasa rao & D. K. Jugran (2003). Delineation of groundwater potential zones and zones of groundwater quality suitable for domestic purposes using remote sensing and gis, *hydrological sciences journal*, 48:5, 821-833.