Delineation of the groundwater potential zone in Kantli River Basin, Jhunjhunu District, Rajasthan: A Geospatial Approach

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Research Article

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Abstract

Remote sensing and GIS are advanced techniques and tools that have been used for various researches including groundwater geology. The Landsat and the IRS satellite datasets have been utilized to extract information on the hydrogeomorphic and groundwater related features of a semi-arid Precambrian hard rock terrain in the Kantli River Basin of Jhunjhunu District, Rajasthan, India. It is the upper part of the Shekhawati River. The study area is covering about 2313.2013 km^2 in the Jhunjhunu District, Rajasthan. In the present study, the groundwater potential zone is identified by the GIS overlay techniques using the spatial analyst tool in ArcGIS 10.2. The developed methodology is demonstrated in the Kantli River Basin of Rajasthan, western India. Originally, nine thematic layers, viz. topographic elevation, land slope, geomorphology, geology, soil, pre and post-monsoon groundwater depths, annual net recharge, annual rainfall and proximity to surface water bodies were considered in this study. Therefore, five groundwater potential zones were identified and distinguished in the study area, viz. 'very good', ‘good’, ‘moderate’, ‘poor’ and ‘very poor’ based on groundwater potential index values, which will enable the local bodies for the future planning and management of the groundwater resource. Severe groundwater contamination has been found occasionally in the study area. Every year during the summer, the region is facing a lot of problems with portable groundwater. As the study area is semi-desert, the influences of salinity have been increasing day by day in the groundwater.

Keywords: Groundwater, Remote Sensing, Kantli River, Satellite Images, GIS, Potential zone.

Introduction

Groundwater is a precious natural resource, which provides life support to all natural beings (Agarwal et al., 2013). It is gradually declining due to rampant and unscientific use by the growing population. Over the past few decades, groundwater is being enormously exploited for drinking water in both urban and rural areas (Das et al., 2010, 2012, 2013, 2015; Nandi et al., 2017). The planning and development of any administrative area can be feasible through groundwater management (Anuradha et. al., 2010). Remote Sensing and GIS technology can facilitate to explore the groundwater sources in urban areas, especially for drinking water (Krishnamurthy et al., 2000; Khan et al., 2006). Remote sensing, GIS and field data play the most significant role in the detection and mapping of groundwater. Groundwater crisis in arid and semi-arid regions is a regular seasonal event. Over the past few decades, the international scientific community has shown a key interest in the extensive application of remote sensing and GIS techniques in the delineation of groundwater potential zones (Singh and Prakash, 2003; Sikdar et al., 2004; Kusky and Gad, 2006; Sultan et al., 2008; Dinesh Kumar et al., 2007; Jasrotia et al., 2007; Sreedhar et al., 2009; Chowdhury et al., 2009; Chowdhury et al., 2010; Jha et al., 2010; Mohammed-Aslam et al., 2010; Agarwal et al., 2013; Abdalla, 2012; Adhikary et al. 2021; Patra et al., 2021; Mahanta et al., 2020). The present investigation is an attempt to explore the possibility and prospect of groundwater in the Kantli River Basin. Various hydrogeological parameters have been applied to identify the groundwater potential zones. The occurrence and movement of groundwater depend on several factors, namely, the depth of porous sediments, the presence of diverse morphology, surface hydrology, climate, physiography, geology, soil, and lineaments (Sreedhar et al., 2009; Abdalla, 2012; Patel et al., 2014; Goswami and Pati, 2008; Das et al., 2016, 2020; Hota and Goswami, 2018; Singh et al., 2022). The main objective of the present study is to evaluate the groundwater controlling features and identify the potential zones through geospatial techniques.

Study Area

The Kantli River basin is situated in the north-eastern parts of Rajasthan. It extends from 27° 38' 32" N to 28° 22' 14" N latitudes and 75° 21' 09" E to 76° 02' 31" E longitudes. It covers an area of 2313.2013 Km^2 in the central part of the Jhunjhunu District (Fig. 1). The eastern parts of the Kantli River basin are the part of Aravalli Mountain chain.

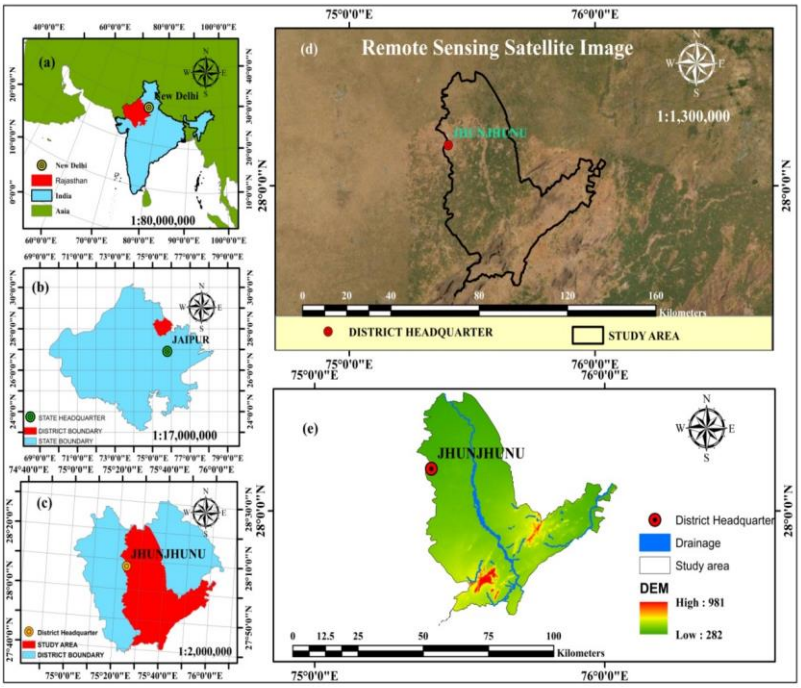


Fig.1 Study area of the upper Shekhawati River basin, India, Rajasthan, Jhunjhunu (a, b, c). Remote sensing images of the study area (d) and DEM topography of the Study area (e)

Geology of the study area

Geologically the north-northwestern part of the study area is covered by rocks of the Quaternary period and the south-eastern region is occupied by igneous rocks of the Precambrian period. The distribution of various litho-groups and their spatial extension is depicted in Table 1. The study area is occupied by the Quaternary group of rocks (89.59%), extrusive Malani Plutonic Group (0.40%) and mafic volcanic rocks of Delhi Supergroup (Alwar and Ajabgarh groups) (10.01%) (Sinha Roy, 1984; Sarkar and Dasgupta, 1980; Roy and Jakhar, 2002; Dasgupta, 1968; Pandey et al. 2010). The various geological data are derived not only from SAC and world geology USGS but also from Landsat ETM+ satellite imagery which played a significant role in map preparation. The geological map of the study area is presented in Figure 2.

Table 1 Distribution of Geology

Geological history	Geological group	Area (%)	Area sq.km
Undivided Precambrian	Malani Plutonic	0.4	9.25
	Delhi Group	10	231.32
Quaternary	Alluvium and windblow Sand	89.6	2072.63

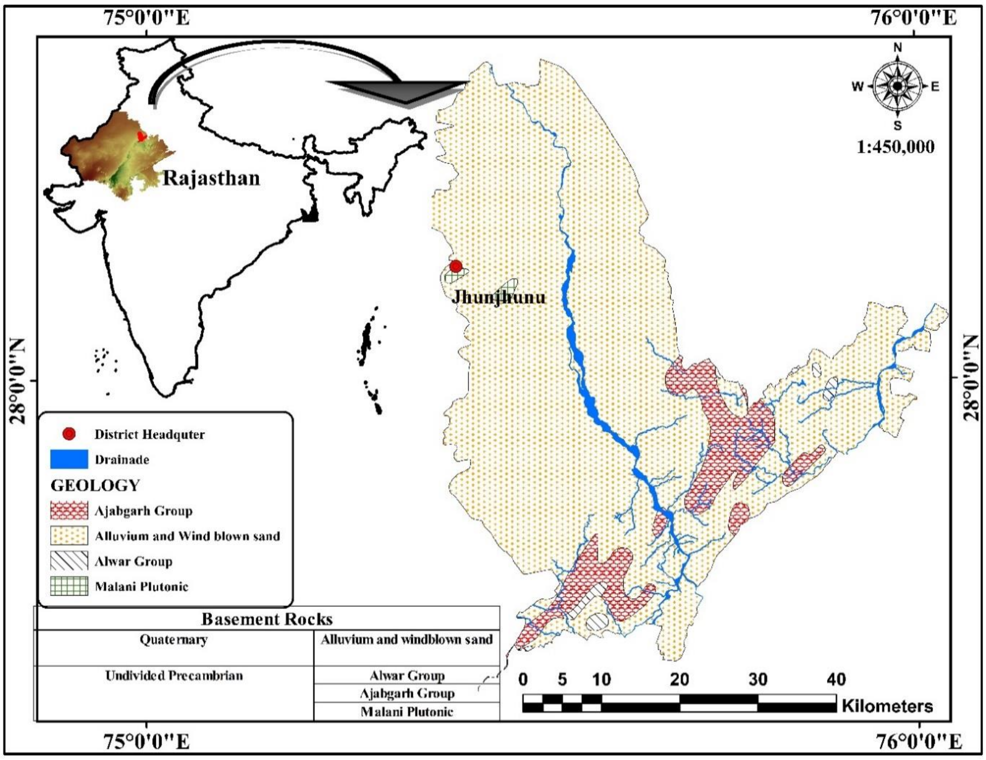


Fig. 2 Geological map of the study area

Hydrogeology of the study area

In the study area, the unconfined aquifer consists of two water-bearing formations, namely the Quaternary alluvial and the Precambrian hard rock formation. The shallow alluvial aquifer is filled with sand, silt and clay, and is observed below a depth of 50 meters in the phreatic region. Most shallow unconfined conditions are observed within the depth of 10 meters below the ground level (Ibrahim et al., 1997; Abu El-Ela et al., 1997; Sander et al, 1997). The direction of groundwater flow is decreasing from east to west. A remarkable variation in the water table has been observed in the pre-monsoon and post-monsoon periods. Most of the open wells dry out during the summer season. The hydrogeological data of the study area is given in Table 2. The confined aquifer is located in between 10-20 (m) thicknesses that occupied an area of 775.88 km^2 within the study area. An unconfined aquifer is found in between 0-20 (m) thicknesses that covered an area of 1923.15 km^2 in the investigated area. The top bedrock depth is of 80-100 m-bgl depths covering an area of about 1091.93 km^2 of the entire study area. The hydrogeological map of the study area is presented in Figure 3. The unconfined aquifer is available at very shallow depths (10-20 m) to the northwest of the study area. At the lowest depths, the confined aquifer is found in the north portion of the study area and the deepest depth of the bedrock is found in the north and west parts of the study area. To know the hydrology of the study area the field data has been taken into consideration during analysis.

Table 2 Hydrogeological condition of the study area

Aquifer				Depth of Bed Rock	
Confined		Unconfined			
Thickness (m)	Area (sq.km)	Thickness (m)	Area (sq.km)	m-bgl	Area (sq.km)
<10	433.27	<5	1149.15	20-40	105.86
10-20	775.88	5-10	274.80	40-60	401.62
20-30	304.01	10-20	489.20	60-80	307.30
30-40	83.42	20-30	137.36	80-100	1091.93
40-50	18.47	30-40	53.07	100-120	118.99
50-60	7.69	40-50	17.24		
60-70	1.49	50-60	3.97		
		60-70	0.93		

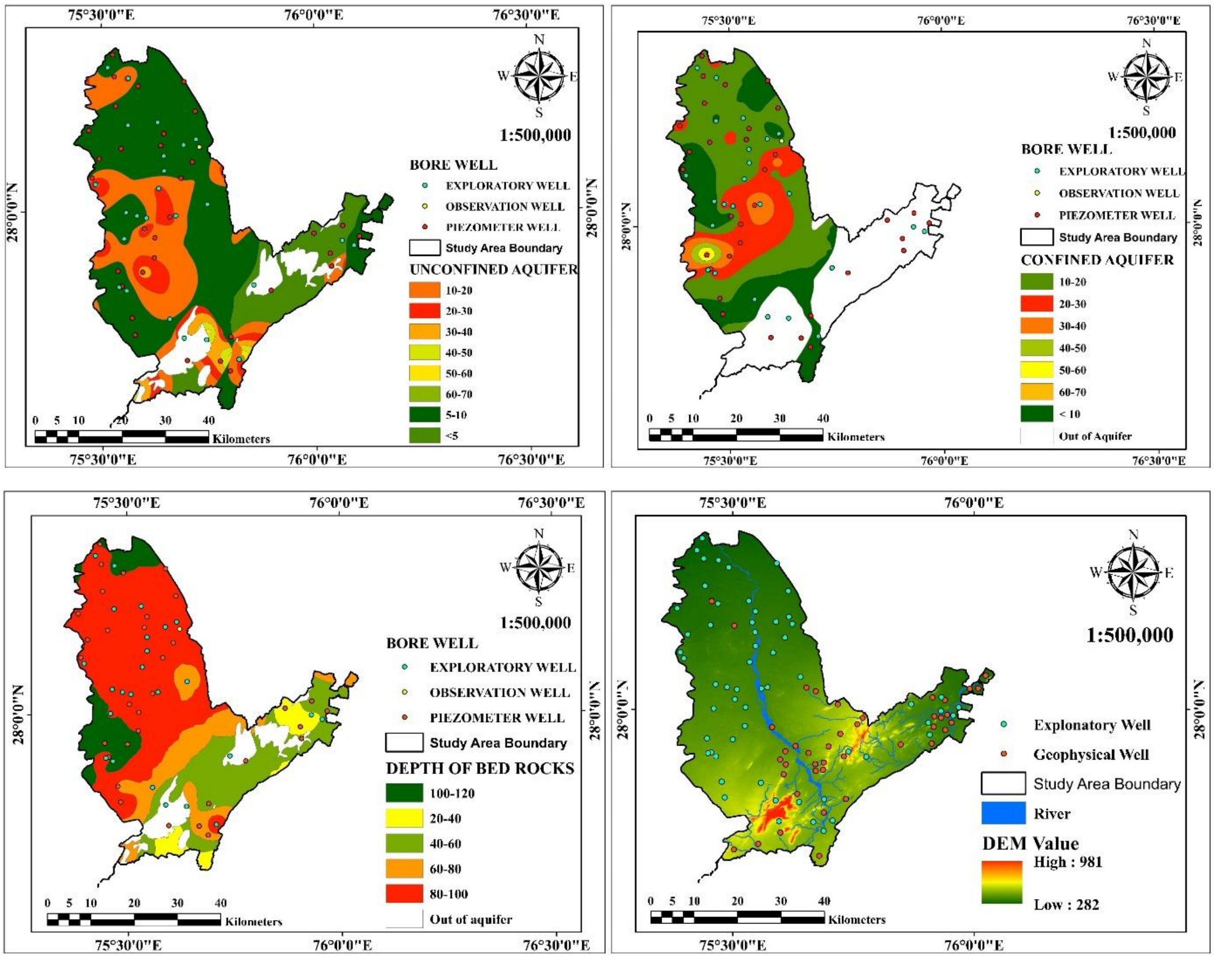


Fig. 3 Hydrogeological map of the study area, (a) unconfined aquifer, (b) confined aquifer, (c) depth of bedrock and (d) well with DEM

Methodology

In the present investigation, various parameters have been used to identify the suitable areas for groundwater prospective zones; viz. (1) Geology, (2) Geomorphology, (3) Soil, (4) Land Use and Land Cover, (5) Drainage, (6) Slope and (7) Lineament. The drainage and channel layers are generated from the survey of India toposheet in 1:50000 scale. The output layers have been updated with Landsat-4, Landsat-5, Landsat-7 and Landsat-8 satellite imagery. The vector files have been created to digitize and analyze the raster image (Strahler, 1964). The order of every stream is very systematically and sequentially observed in the study area. The digital elevation model (DEM) has been developed and used for elevation studies and comparative analysis of drainage patterns. The digitization and density mapping of all these layers have been prepared for the vector data analysis. It has been done by weighted overlay analysis with the help of ArcGIS software. This map has been scientifically used for the interpretation of groundwater occurrence in the study area and to identify the additional recharge structure. Field observation has been undertaken to validate the map (Ibrahim et al., 1997; Abu El-Ela et al., 1997; Krishnamurthy et al. 1996; Ganapuram et al.2009). The borehole data is taken directly from the field with the help of the instrument and its validation accuracy is used to identify the groundwater potential zone. A base map of the study area is prepared with the help of Landsat series of TM, MSS, and ETM+, etc. The ERDAS Imagine 2014, Intergraph software was used for digital image processing. SRTM data (Shuttle Radar Topography Mission) of the study area were obtained and processed to construct a continuous DEM. The methodology adopted in the study area to locate the groundwater potential zone is depicted in Figure 4.

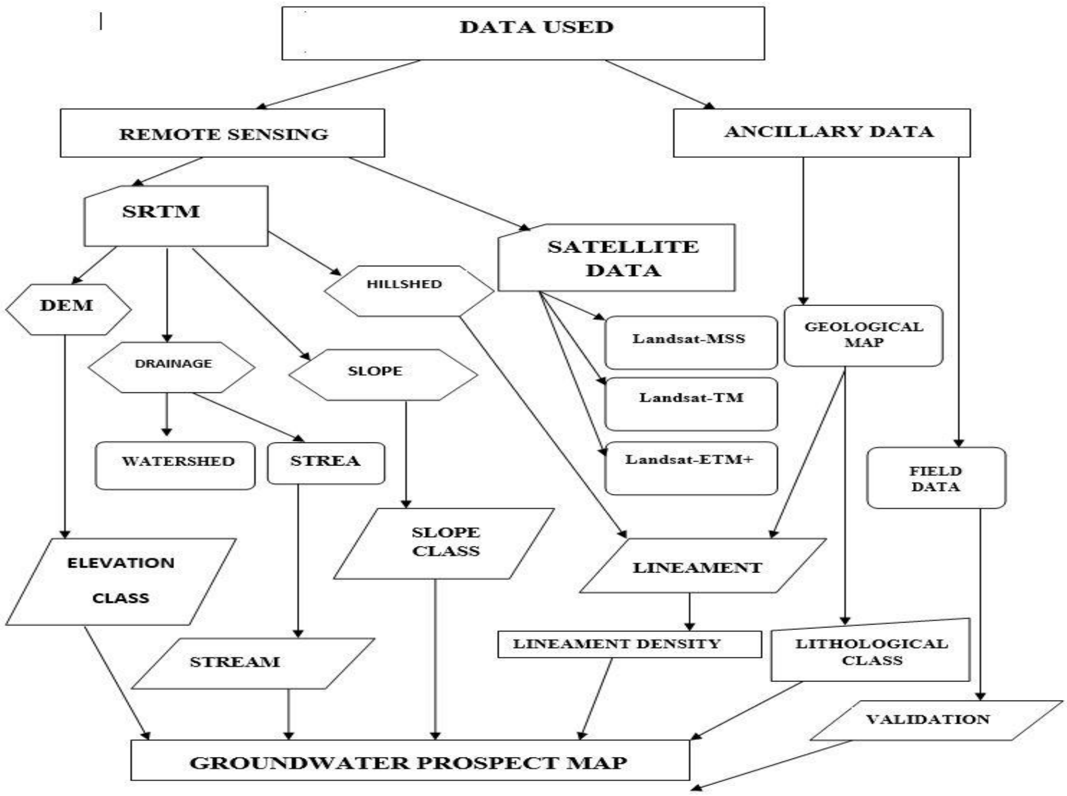


Fig. 4 Flow chart of the study area

Results and Discussions

Topographical and geological maps have been used to delineate the groundwater potential zones in the study area. The groundwater level in the study area depends on the following important factors:

(1) Slope variation which controls the runoff of the rainwater, as a gentle slope increases the rate of infiltration of the surface water whereas a steep slope enhances the surface runoff;

(2) Stream network which affects runoff and groundwater recharge;

(3) Lineament as it is significantly enhancing the permeability and porosity of the rocks and affects the vertical percolation of water to recharge the local aquifers;

(4) Lithology which determines the penetration capacity of soils and opens the rock layers that manage the runoff and storage of groundwater;

(5) Topography

Each of the topographic layers is divided into different classes that are controlled by hydrogeological properties. The weighted over-analysis is done based on the relative importance of the potential of the groundwater level. The weighted over-analysis is performed by GIS for the preparation of the final groundwater potential map (Eastman et al., 1995; Voogd, 1983).

Topography Elevation

A topographical map of the study area has been created from SRTM DEM data. DEM map is depicted in Figure 5 to get an accurate idea of the surface elevation of the study area. The surface topography determines the direction of runoff over the surface. As per the DEM data, the lowest and highest elevation of the study area is 282 and 982 meters MSL respectively. Multiple irregular slopes are noticed in the study area. The slope of the northern part is relatively low and the amount of slope in the southern part is fairly high. The topographical maps are mainly classified into three numerical categories according to the characteristics of the slope (Fig. 6). The topographic features have explained the surface hydrology as well as the groundwater hydrological capabilities. The topographic elevation details are illustrated in Table 3.

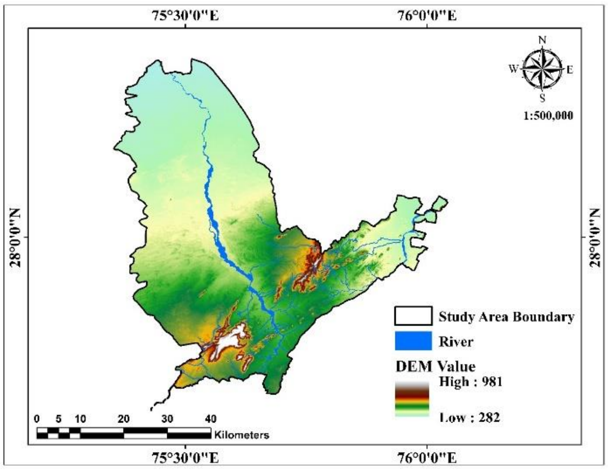


Fig. 5 Digital Elevation Model of the study area

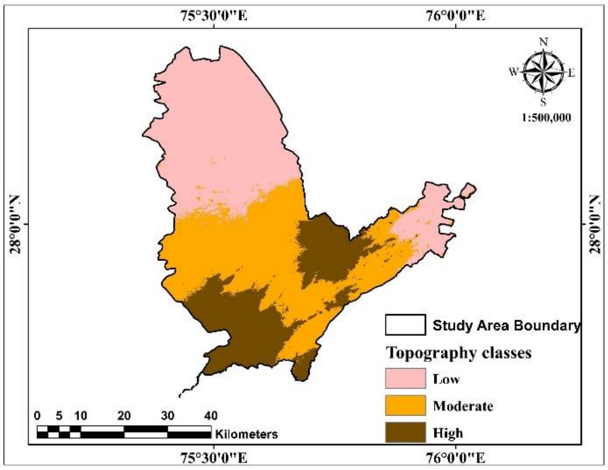


Fig. 6 DEM Topography of the study area

Slope

Critical analysis of slopes reveals the sources of groundwater infiltration and recharge and in turn enables to delineate groundwater potential zones (Dawoud et al., 2005; Vittala et al., 2005; Solomon and Quiel, 2006, Bagyaraj et al., 2013). A close contour indicates a steeper slope whereas a widely spaced contour specifies a gentle slope. A slope layer has been used to locate the groundwater potential zones (Sreedhar et al., 2009). The groundwater percolation is higher in the gentle and flat areas. In the case of steep slopes, the runoff of rainwater is high, and infiltration is low. The slope amount and numerical values of the slope are presented in Figures 7 and 8 respectively. The major part of the region (around 73-90%) is covered by a steep slope. Slope details of the area are depicted in Table 3.

Table 3 Details of various hydrological parameters

Parameter	Classes	Groundwater Prospect	Weight	Rank
Topography (Elevation M.)	282-359	Very High	10	5
	259-422	High		4
	422-517	Moderate		3
	517-687	Low		2
	687-981	Very Low		1
Slope	15%< Plain Region	Very Good	10	1
	15%-25% Undulating Region	Good		2
	25%-40% Pediment Region	Moderate		3
	40%-55% Plateau Region	Poor		4
	55%-90% Hilly Region	Very Poor		5
Drainage Density (km/km^2)	0.0-0.6	Very Good	20	1
	0.6-1.8	Good		2
	1.8-3.2	Moderate		3
	3.2-5.2	Low		4
	5.2-9.12	Very Low		5
LULC	Crop Land	Very Good	10	5
	Lake Pond, reservoir, Tanks, river, Stream, Drainage	Good		4
	Forest	Moderate		3
	Core urban, Gullied, Hamlets Household, Peri Urban, Scrub land	Poor		2
	Barren Rocky	Very Poor		1
Geomorphology	Pediment	Very Good	10	5
	Structural/ Linear denudation, Interdunal Depression.	Good		4
	Waterbody, River, Pond, Reservoir, Plain area.	Moderate		3
	Intermontane Valley, fill valley.	Poor		2
	Obstacle Dune	Very Poor		1
Geology	Alwar groups	Very Good	20	5
	Ajabgarh groups	Very Good		5
	Malani Plutonic	Good		4
	Alluvium and windblown Sand	Moderate		3
Soil	Clay loam	Very Good	10	5
	Fine Sand	Moderate		3
	Loam	Moderate		2
	Sandy Loam	Poor		2
Lineament Density (km/km^2)	0.0-0.32	Very Good	10	1
	0.33-0.64	Good		2
	0.65-0.95	Moderate		3
	0.96-1.27	Poor		4
	1.28-1.59	Very Poor		5

Geomorphology

In the study area, twelve geomorphic units have been identified with the help of remote sensing and Landsat ETM+ satellite imagery. The plain area is about 1463.98 km^2 (63.35%)

of the investigated terrain. All the geomorphic units are shown in Table 4. Since the study area is part of the semi-desert region, the predominance of sandy plain lands has been observed. The geomorphic categories and geomorphic numerical values are depicted in Figures 9 and 10 respectively. Groundwater scarcity is noticed in the sandy plains. The geomorphic units like plains, valleys, pediments, and structural hills yield moderate groundwater.

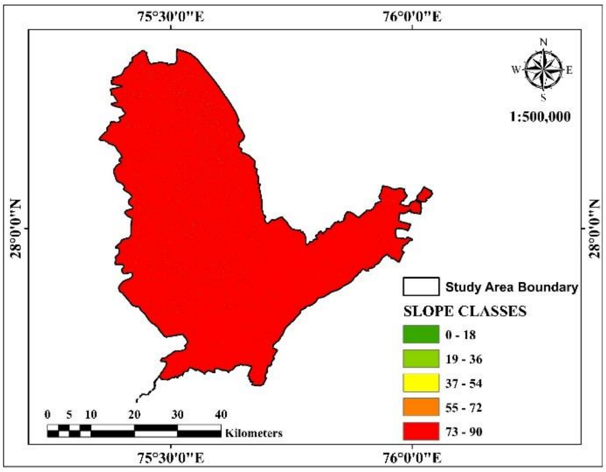


Fig. 7 Map depicting different slope classes

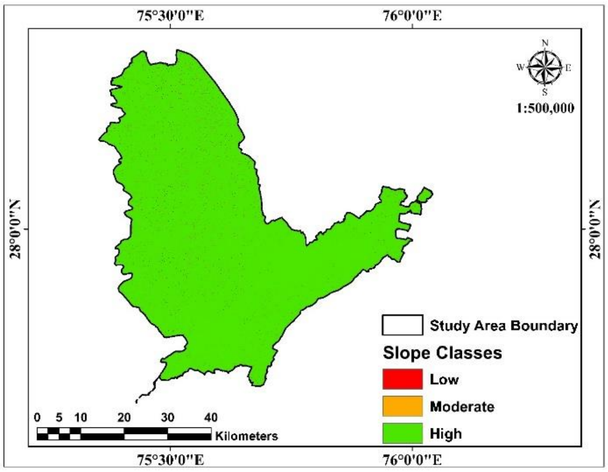


Fig. 8 Map showing slope zoning (numerical value)

Table 4 Geomorphic units and their areal extension in the study area

Geomorphology Category Description	Area sq.km	Area (%)
Alluvial Plain	538.73	23.34
Buried Pediment	305.37	13.21
Aeolian Plain	65.55	2.8
Flood Plain	21.28	0.9
Interdunal Depression	149.82	6.52
Intermontane Valley	28.89	1.2
Obstacle Dune	53.51	2.3
Pediment	30.43	1.3
River/Pond/Reservoir	45.48	2
Sandy Plain	860.70	37.21
Structural/Linear/Denudational	197.91	8.55
Valley Fill	15.52	0.67
Total Area	**2313.20**	**100**

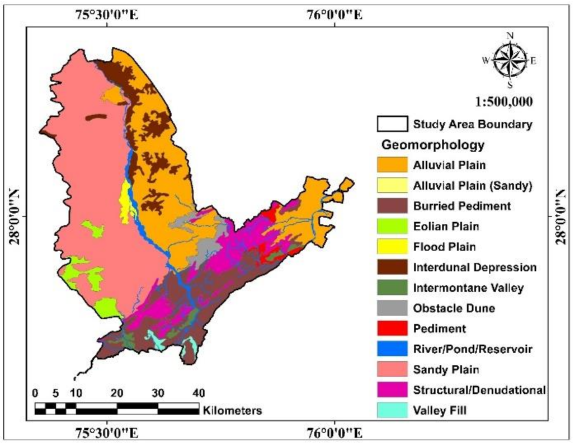


Fig. 9 Map showing different geomorphological types

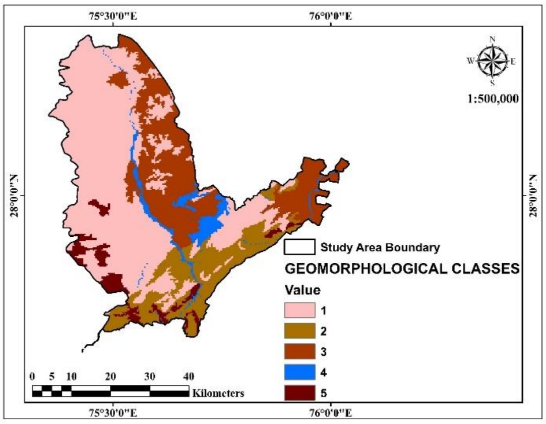


Fig. 10 Map showing various geomorphological classes

Geology

The occurrence and movement of groundwater depend on the porosity and permeability of the rocks that are closely associated with geology (Sreedhar et al., 2009). The Quaternary and Precambrian deposition are found in the study area. The geology and numerical value of the litho units are depicted in Figures 11 and 12 respectively. There are many pediments and structural areas between the Ajabgarh group and its adjoining areas. Groundwater has existed in fractured and weathered Precambrian rocks in the study area.

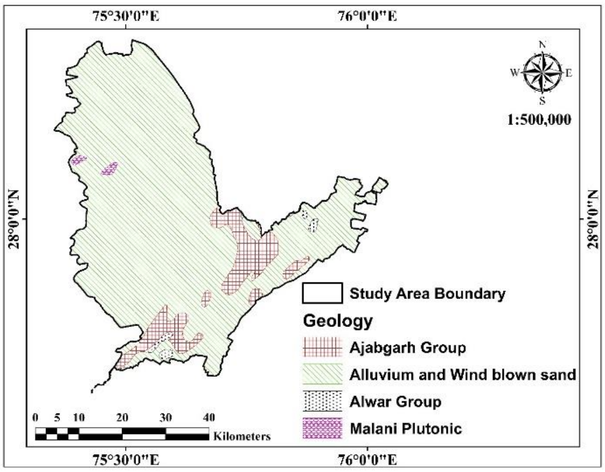


Fig. 11 Geological map of the study area

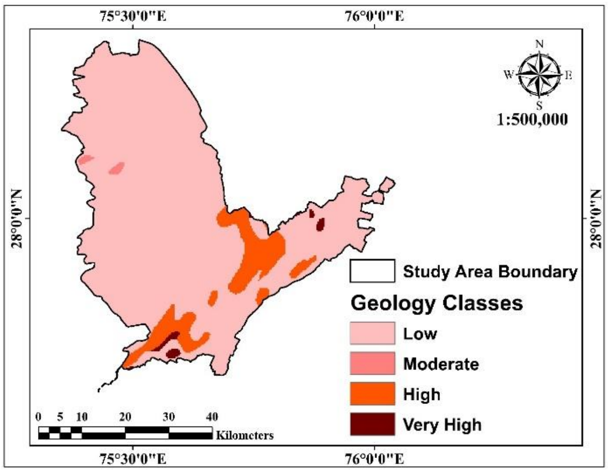
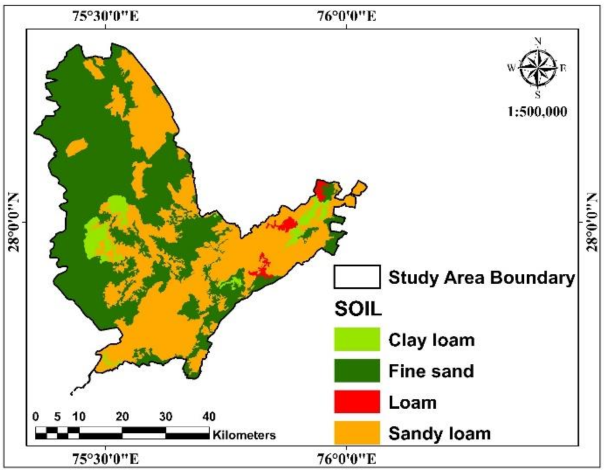


Fig. 12 Map depicting geological classes

Soil

The role of soil is important in groundwater research. Low permeability and limited water infiltration are observed in fine-grained soils. Four major soil units were observed in the study area: Clay loam soils (92.53 km^2, 4.0%), Fine sand soils (1201.29 km^2, 51.9%), Loamy soils (25.52 km^2, 1.1%), and Sandy loam soils (994.20 km^2, 43 %). Soil map of the study area and map showing soil classes are depicted in Figures 13 and 14. Soil data from the study area is presented in Table 5. Soil data reveals that there is inadequate water holding capacity and a shortage of groundwater storage as a larger part of the study area is covered by sandy soils.



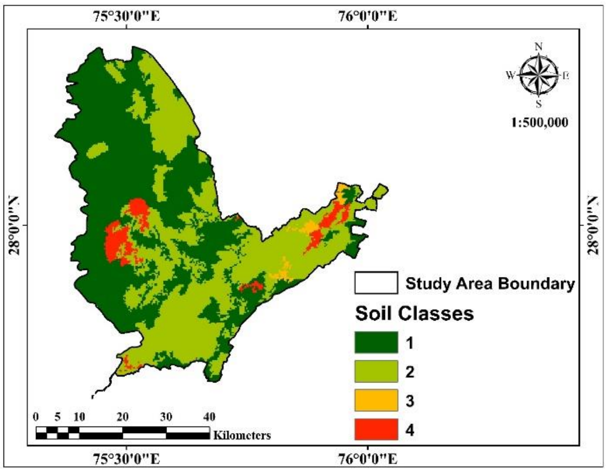


Fig. 13 Soil map of the study area

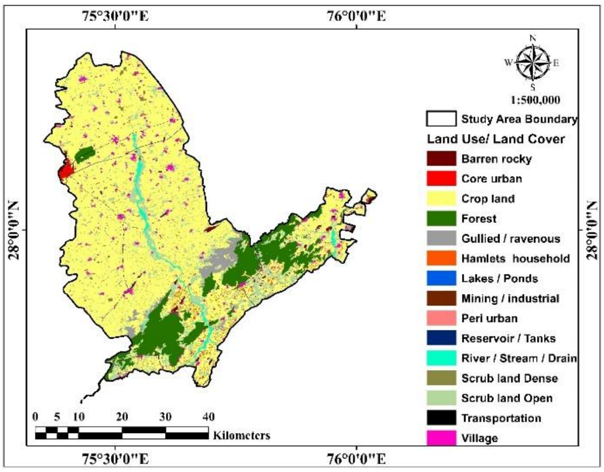
Fig. 14 Map showing soil classes

Table 5 Distribution of Soil in the study area

SOIL Category Description	Area sq.km	Area (%)
Clay loam	92.53	4.0
Fine sand	1201.29	51.9
Loam	25.52	1.1
Sandy loam	994.20	43.0
Grand Total	**2313.20**	**100.0**

LULC

Land use land cover mapping has an immense role in delineating the groundwater potential zone as hydrogeological processes are particularly controlled by land use and land cover. Generally, forest areas have high infiltration and runoff is very low. Table 6 demonstrates that the forest land is around 253.04 km^2 (10.93 %) where there is more infiltration; cropland spreads around 1610.31 km^2 (69.61%), where infiltration is moderate. Similarly, scrub land spreads over an area of 255.12 km^2 (11.02%), where infiltration is moderate to low (Figs. 15, 16).



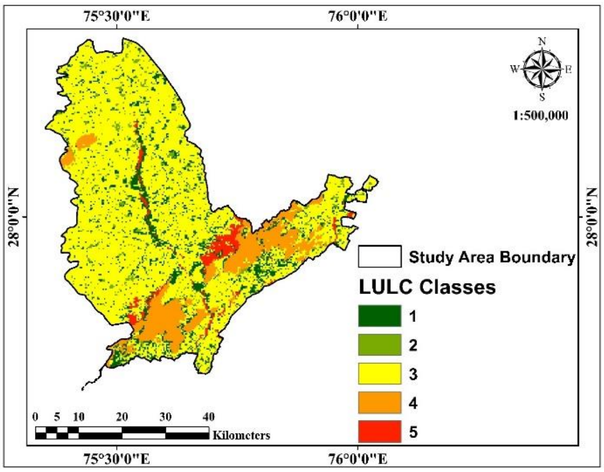


Fig. 15 LULC map of the study area

Fig. 16 Map showing LULC classes

Table 6 Land use /Land cover distribution of the study area

LULC Category Description	Area sq.km	Area (%)
Barren rocky	10.43	0.45
Core urban	8.00	0.35
Crop land	1610.31	69.61
Forest	253.04	10.93
Gullied / ravenous	51.31	2.21
Hamlets and dispersed household	29.50	1.27
Lakes / Ponds	0.20	0.008
Mining / industrial	7.10	0.306
Peri urban	0.40	0.017
Reservoir / Tanks	0.08	0.003
River / Stream / Drain	24.40	1.054
Scrub land Dense	8.30	0.358
Scrub land Open	255.12	11.028
Transportation	2.21	0.095
Village	52.80	2.28
Grand Total	**2313.20**	**100**

Pre and Post monsoon Groundwater depth

The groundwater level in the Indian subcontinent is controlled by monsoon rainfall. The variation of groundwater depth is observed between the pre-monsoon and post-monsoon periods. Groundwater recharge is good after post-monsoon periods. The aquifer became rich in the later stage of monsoon rainfall. The pre-monsoon and post-monsoon groundwater depth and the numerical value of the groundwater level are depicted in Figures 17, 18, 19 and 20.

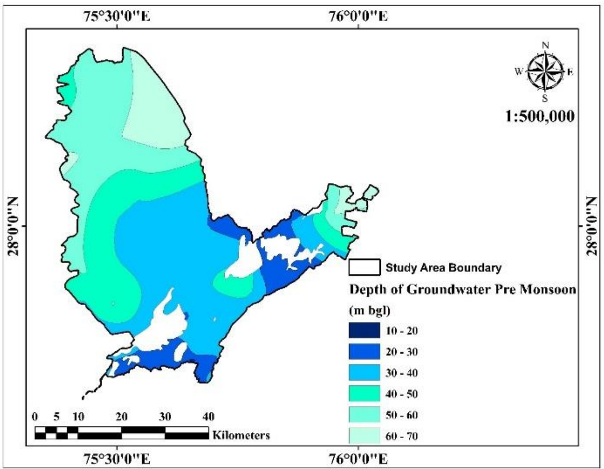


Fig. 17 Groundwater depth of pre-monsoon map

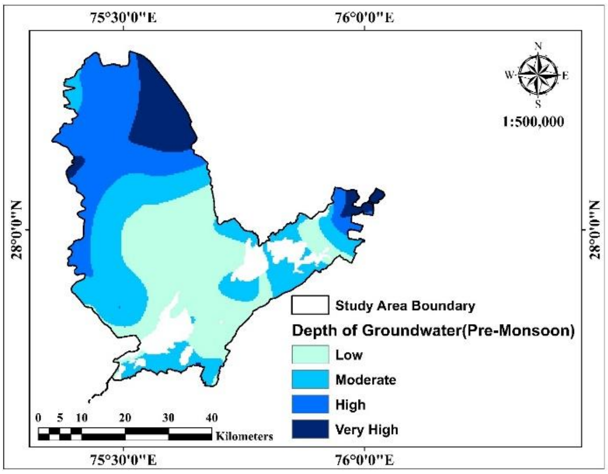


Fig. 18 Map showing groundwater depth classes of pre-monsoon

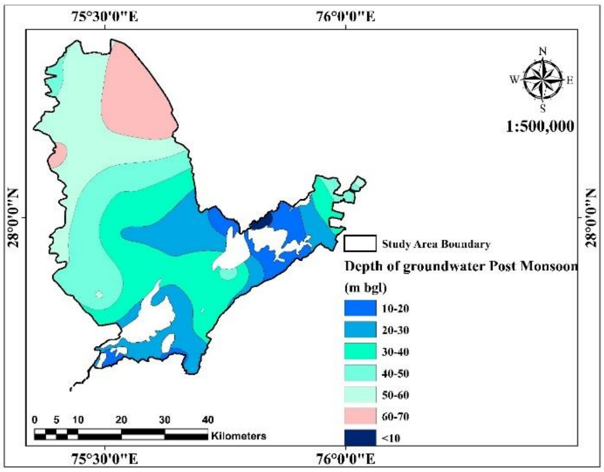


Fig. 19 Groundwater depth of the post-monsoon map

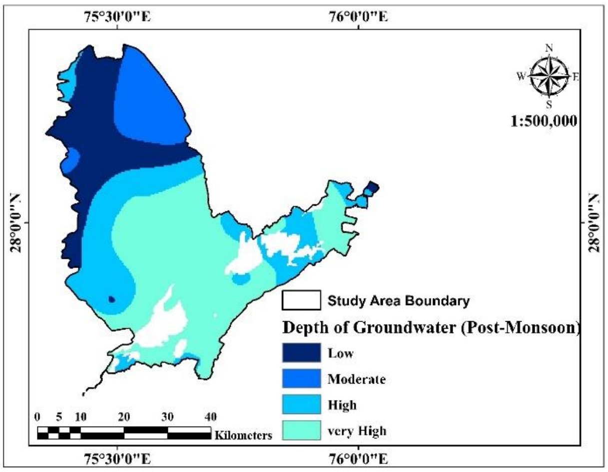


Fig. 20 Map showing groundwater depth classes of post-monsoon

Rainfall

Rainfall directly recharges the groundwater. The isohyet line of maximum rainfall was detected in the north-eastern and south-western parts of the study area. The rainfall distribution and rainfall numerical values of the study area are presented in Figures 21 and 22. The amount of annual rainfall in various weather monitoring stations located in the study area is presented in Table 7. The maximum amount of rainfall is in the Khetri block of Jhunjhunu district, Rajasthan.

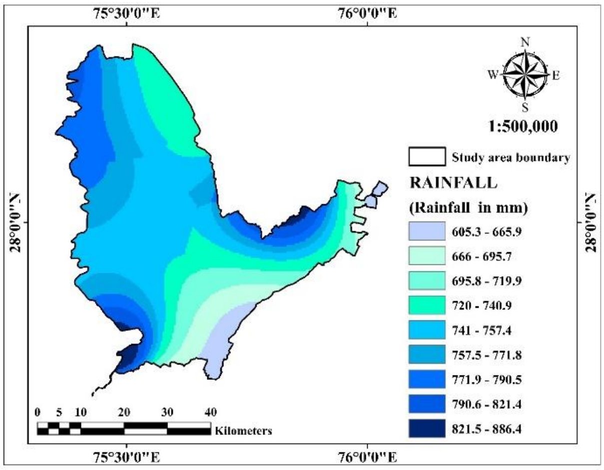


Fig. 21 Rainfall distribution map

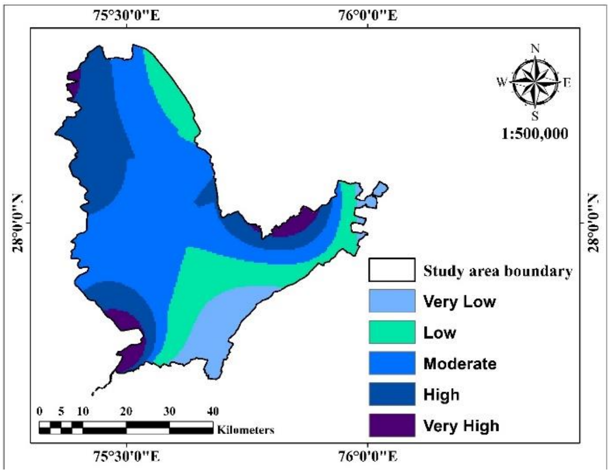


Fig. 22 Rainfall classes map

Table 7 Rainfall distribution and rainfall survey station.

District	Rainfall Station (Near the study area)	Rainfall (mm)
Jhunjhunu (Rajasthan)	Alsisar	854.7
Jhunjhunu (Rajasthan)	Buhana	650.5
Jhunjhunu (Rajasthan)	Chirawa	734
Jhunjhunu (Rajasthan)	Jhunjhunu	778.9
Jhunjhunu (Rajasthan)	Khetri	913.7
Jhunjhunu (Rajasthan)	Nawalgarh	740.7
Jhunjhunu (Rajasthan)	Surajgarh	617.5
Jhunjhunu (Rajasthan)	Udaipurwati	888
Churu (Rajasthan)	Rajgarh	700.3
Sikar (Rajasthan)	Khandela	414.25

Sikar (Rajasthan)	Neem Ka Thana	620.25
Mahendragarh (Haryana)	Narnaul	570

Drainage

Drainage plays an important role in groundwater storage and movement. The drainage density scientifically reveals the groundwater potential and recharge condition of the terrain (Prasad et al., 2008). The drainage pattern is depicted in Figure 23. The drainage density of the study area is presented in Figure 24. The maximum drainage density is located in the north-eastern region of the study area.

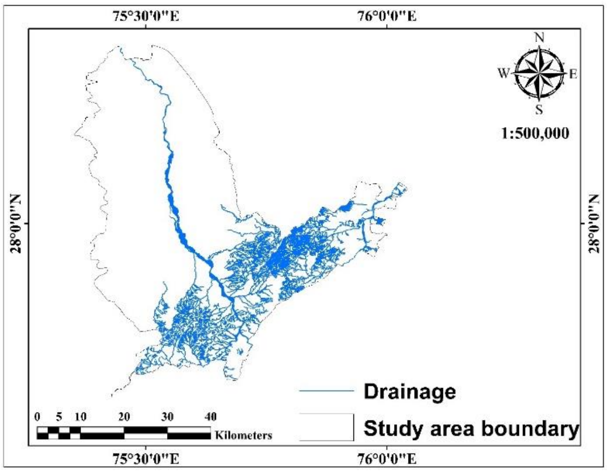


Fig. 23 Drainage map of the study area

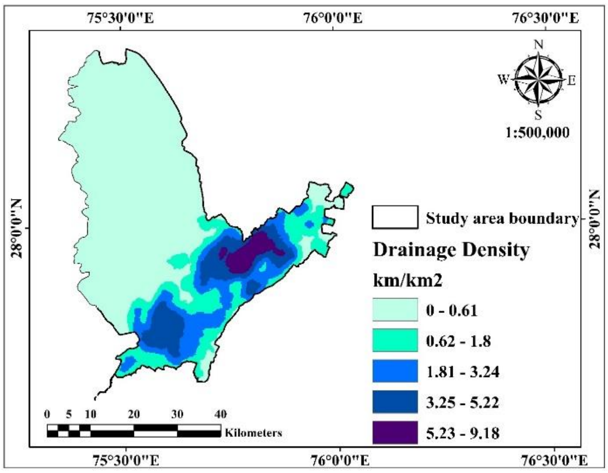


Fig. 24 Drainage Density map of the study area

Lineament

Lineament analysis reveals a close relationship between groundwater infiltration and fractured rocks. Groundwater occurrence and movement are governed by the fracture, joints, and lineament in the hard rock region. The source of lineament data is SRTM images. This layer provides important information about the fractured rocks, which control the movement and storage of groundwater (Pradeep, 1998; Sreedhar et al., 2009). Table 3 shows the lineament density of the study area, which is divided into five categories. The high lineament density region is the potential location for groundwater infiltration. Figures 25 and 26 show the location of the lineament area and the numerical value of lineament density.

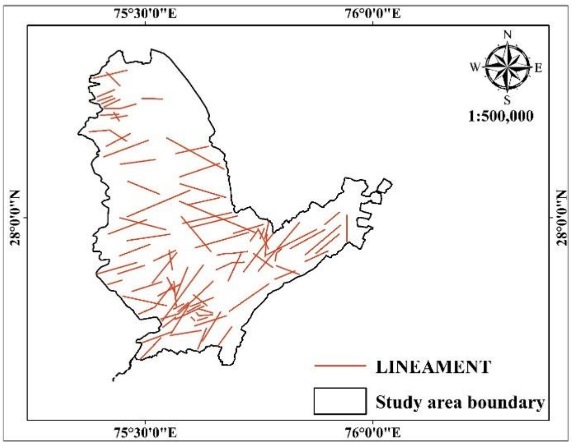


Fig. 25 Lineament map of the study area

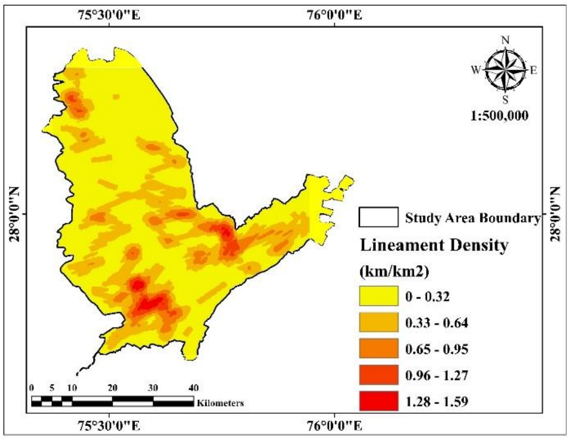


Fig. 26 Lineament Density map of the study area

Stream network

The morphometric analysis depends on the stream network. SRTM topographic data are mainly used for stream networks and for delineating watershed regions. Researchers have used stream networks to identify groundwater potential zones (Abdalla, 2012; Pradeep, 1998; Sreedhar et al., 2009; Adhikary et al. 2021). Stream network is mainly influenced by lithology, rock masses and lineament. The stream of a region refers to the main rivers, tributaries, and distributaries; and stream network refers to a watershed that flows in the direction of the river. Stream ordering has been done using the Strahler method. It is mainly divided into five numerical groups (Table 3) depending on the capability of runoff and infiltration. Figures 27 and 28 show the stream ordering and stream network density of the study area.

Groundwater Potential Zone

The groundwater potential zone has been obtained with the help of a thematic map of the overlay method of the spatial analysis tool of ArcGIS 10.2 software. Each map was created by a common UTM projection and WGS84 datum. The thematic map has been changed into a raster format. Groundwater potential zones are based on the drainage density, slope, land use/land cover, geomorphology, geology, lineament density, and topography data of the study area (Voogd, 1983; Sikdar et al., 2004; Abdalla, 2012). The output prospective map describes the potential groundwater zone. The Groundwater potential zone map of Kantli River Basin (upper part of the Skekhawati River Basin) is divided into five sections namely: very poor (1051.35 km^2, 45.45%), poor (544.76 km^2, 23.55%), moderate (460.33 km^2, 19.90%), high (175.34 km^2, 7.58%), very high (81.43 km^2, 3.52%) (Table 8). The largest area under the study belongs to the very poor groundwater potential zones, which cover 1051.35 km^2 (45.45%). The groundwater potential map of the study area is depicted in Figure 29.

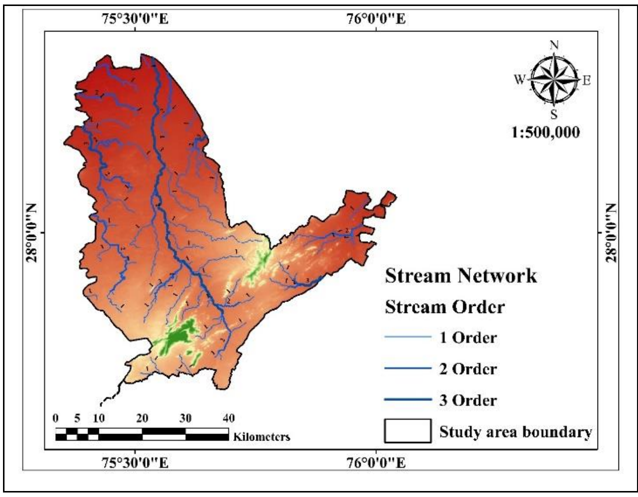


Fig. 27 Stream ordering map of the study area

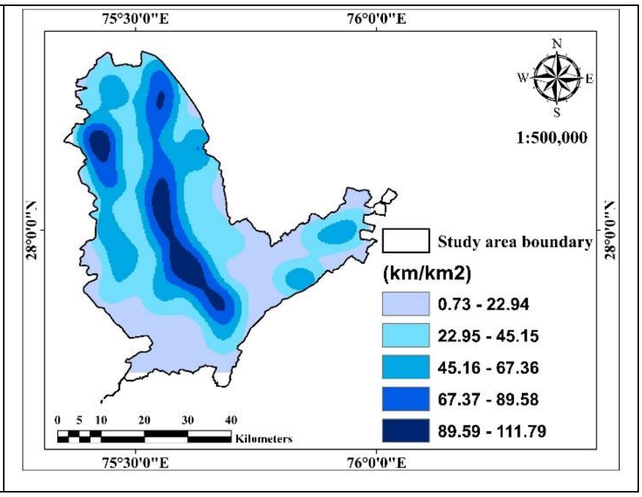


Fig. 28 Stream Network density map of the study area

Table 8 Various groundwater potential zones

Sl.no.	Value	Potential Zone	Area (km^2)	Area (%)
1	0-1	Very Poor	1051.35	45.45
2	1-2	Poor	544.76	23.55
3	2-4	Moderate	460.33	19.90
4	4-6	High	175.34	7.58
5	6-12	Very High	81.43	3.52

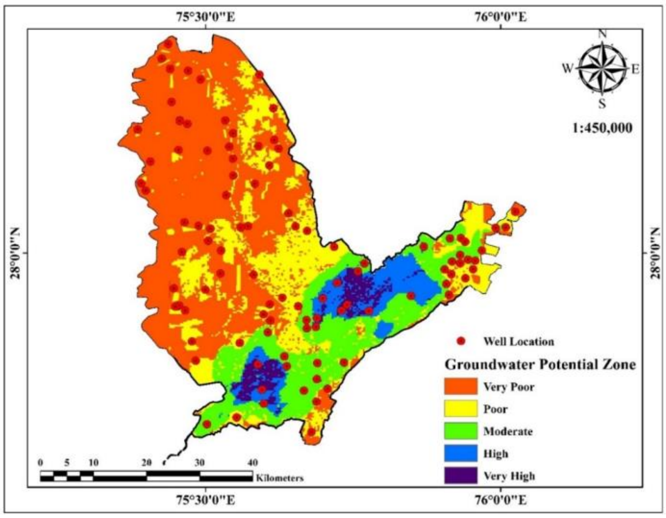


Fig. 29 Groundwater potential zone map of the study area

Results validation with borehole data

Two types of aquifers are commonly noticed in the region; confined and unconfined. The result obtained from the boreholes data is that the depth of the shallow unconfined aquifer is located at 8-70 m depth of the study area (27.1%). The confined aquifer is found in a large area, the depth of this well is above 70 meters (72.9%). The groundwater scarcity is found in most of the study area, which is derived from borewell data and pumping test data. Table 9 shows the boreholes (Geophysical Well, Exploratory Well, Observation Well, and Piezometer Well) types and depth of groundwater.

Table 9 Various borehole data of the study area

<table>
<tr><th>Types of Boreholes</th><th>Several Well no</th><th>Number of Borehole</th><th>Percentage of Well (%)</th><th>Depth (m)</th><th>Aquifer</th></tr>
<tr><td>Geophysical Well</td><td>15</td><td rowspan="4">29</td><td rowspan="4">27.1</td><td rowspan="4">8-70 M</td><td rowspan="4">Unconfined Shallow</td></tr>
<tr><td>Exploratory Well</td><td>01</td></tr>
<tr><td>Observation Well</td><td>00</td></tr>
<tr><td>Piezometer Well</td><td>13</td></tr>
<tr><td>Geophysical Well</td><td>33</td><td rowspan="4">78</td><td rowspan="4">72.9</td><td rowspan="4">70 M Above</td><td rowspan="4">Confined Deep</td></tr>
<tr><td>Exploratory Well</td><td>24</td></tr>
<tr><td>Observation Well</td><td>01</td></tr>
<tr><td>Piezometer Well</td><td>20</td></tr>
</table>

Conclusion

The present study reveals the delineation of potential groundwater zones in the Kantali Basin of Jhunjhunu District (upper Shekhawati basin). The various informative thematic map layers have been compiled to identify potential zones of groundwater (very poor, poor, moderate, high, very high). It is observed that only 11% of the total study area constitutes a very good to good groundwater potential zone. Sandy soil, low lineament density, medium to low rainfall, insignificant forest density, moderate to steeply slope have reduced the infiltration and increased the runoff, which has resulted in low and unhealthy groundwater prospective zone in the Kantali Basin. Steps may be taken to construct good numbers of check dam and water harvesting structures at the Government level. Moreover, extensive plantation programmes may also be undertaken in these areas by local bodies and NGOs. Hopefully, subsequently increased groundwater recharge will enhance the groundwater prospects and potentials of the area.

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Reference

Abdalla F (2012) Mapping of groundwater prospective zones using remote sensing and GIS techniques: A case study from the Central Eastern Desert, Egypt, Journal of African Earth Sciences 70:8-17

Abu El-Ela S, Ibrahim H, El-Hussaini A (1997) Geoelectrical and Hydrogeological Studies on the Sediments of the Main Trunk, Wadi El-Mathula Basin, Eastern Desert, International Desalination Association, Madrid, Spain 99-115

Adhikary PP, Shit PK, Santra P, Bhunia GS, Tiwari AK, Chaudhary BS (Eds.) (2021) Geostatistics and Geospatial Technologies for Groundwater Resources in India. Springer Nature

Agarwal R, Garg PK, Garg RD (2013) Remote sensing and GIS based approach for identification of artificial recharge sites. Water resources management 27(7):2671-2689

Anuradha CT, Prabhavathy S (2010) Water resources management for Virudhunagar District using remote sensing and GIS. International Journal of Earth Sciences and Engineering 3:55-61

Bagyaraj M, Ramkumar T, Venkatramanan S, Gurugnanam B (2013) Application of remote sensing and GIS analysis for identifying groundwater potential zone in parts of Kodaikanal Taluk, South India. Front. Earth Sci.7:65-75

Chowdhury A, Jha MK, Chowdary VM (2010) Delineation of groundwater recharge zones and identification of artificial recharge sites in West Medinipur district, West Bengal, using RS, GIS and MCDM techniques. Environmental Earth Sciences 59(6):1209-1222

Chowdhury A, Jha MK, Chowdary VM, Mal BC (2009) Integrated remote sensing and GIS-based approach for assessing groundwater potential in West Medinipur district, West Bengal, India. International Journal of Remote Sensing 30:231-250

Das PP, Mohapatra PP, Goswami S, Mishra M, Pattanaik JK (2020) A geospatial investigation of interlinkage between basement fault architecture and coastal aquifer hydrogeochemistry. Geoscience Frontiers11(4):1431-1440

Das PP, Mohapatra PP, Sahoo HK, Goswami S (2016) A geospatial analysis of fluoride contamination of groundwater in Paradeep area, Odisha, India. Environmental Geochemistry 19:11-14

Das R, Das M, Goswami S (2012) Groundwater Quality Assessment around Talabasta Area, Banki Sub-Division, Odisha, India. International journal of Earth science 5(6): 1609-1618

Das R, Das M, Goswami S (2013) Groundwater quality assessment for irrigation uses of Banki sub-division, Athgarh basin, Orissa, India. Journal of Applied Geochemistry 15: 88-97

Das R, Das M, Goswami S (2015) Groundwater quality assessment for drinking and industrial purpose of Rourkela, Sundergarh District, Odisha, India. Asian Journal of Water, Environment and Pollution 12(4):35-41

Das R, Das M, Pradhan AA, Goswami S (2010) Groundwater quality assessment of Banki subdivision, Cuttack district, Orissa. The Bioscan 35-42

Dasgupta SP (1968) The structural history of the Khetri copper belt, Jhunjhunu and Sikar districts, Rajasthan. Memoirs Geological Survey of India 98:243

Dawoud MA, Darwish MM, El-Kady MM (2005) GIS-based groundwater management model for western Nile delta. Water Resour Manage 19(5):585-604

Dinesh Kumar PK, Gopinath G Seralathan P (2007) Application of remote sensing and GIS for the demarcation of groundwater potential zones of a river basin in Kerala, southwest coast of India. International Journal of Remote Sensing 28(24): 5583-5601

Ganapuram S, Kumar GV, Krishna IM, Kahya E, Demirel MC (2009) Mapping of groundwater potential zones in the Musi basin using remote sensing data and GIS. Advances in Engineering Software 40(7):506-518

Goswami S, Pati P (2008) Physico-chemical characteristics of thermal water and soil of Tarabalo and Attri geothermal province, Orissa, India. Journal of ecophysiology and occupational health 8:83-88

Hota SR, Goswami S (2018) Hydrogeochemistry and groundwater quality assessment for drinking purpose in Saharpada block of Keonjhar district, Odisha, India: an empirical study. Environmental chemistry 21:43-47

Ibrahim HA, Abu El-Ella S, Attia M (1997) Application of Shallow Seismic Refraction Techniques to Hydrologic Investigations on the Main Trunk of Wadi El-Mutula, Eastern Desert, Egypt. International Desalination Association. Madrid, Spain 479-493

Jasrotia AS, Kumar R Saraf, AK (2007) Delineation of groundwater recharge sites using integrated remote sensing and GIS in Jammu district, India. International Journal of Remote Sensing 28(22):5019-5036

Jha MK, Chowdary VM, Chowdhury A (2010) Groundwater assessment in Salboni Block, West Bengal (India) using remote sensing, geographical information system and multi-criteria decision analysis techniques. Hydrogeology Journal 18(7):1713-1728

Khan MA, Narain P, Moharana PC (2006) Prospecting ground water resources using RS-GIS-a case study from arid western Rajasthan of India. Journal of the Indian Society of Remote Sensing 34(2):171-179

Krishnamurthy J, Mani A, Jayaraman V, Manivel M (2000) Groundwater resources development in hard rock terrain-an approach using remote sensing and GIS techniques. International journal of applied earth observation and geoinformation 2(3-4):204-215

Krishnamurthy J, Venkatesa Kumar N, Jayaraman V, Manivel M (1996) An approach to demarcate ground water potential zones through remote sensing and a geographical information system. International Journal of Remote Sensing 17(10):1867-1884

Kusky T, Gad S (2006) Lithological mapping in the Eastern Desert of Egypt, the Barramiya area, using Landsat thematic mapper (TM). Journal of African Earth Sciences 44:196-202

Mahanta N, Mishra I, Hatui A, Mahanta PS, Sahoo HK, Goswami S (2020) Geochemical appraisal of groundwater qualities and its uses in and around Maneswar Block of Sambalpur District, Odisha, India. Environmental Earth Sciences 79:1-13

Mohammed-Aslam M, Balasubramanian A (2010) History of river channel modifications-A review. Journal of Ecology and the Natural Environment 2(10): 207-212

Nandi D, Sahu PC, Goswami S (2017) Hydrogeomorphological study in Bamanghaty subdivision of Mayurbhanj District, Odisha an integrated remote sensing and GIS approach. International Journal of Geosciences 8(11):1361-1373

Pandey A, Chowdary VM, Mal BC, Dabral PP (2010) Remote sensing and GIS for identification of suitable sites for soil and water conservation structures. Land Degradation & Development 22(3):359-372

Patel SC, Khalkho R, Patel SK, Sheikh JM, Behera D, Chaudhari S, Prabhakar N (2014) Fluoride contamination of groundwater in parts of eastern India and a preliminary experimental study of fluoride adsorption by natural haematite iron ore and synthetic magnetite. Environmental earth sciences 72(6):2033-2049

Patra PK, Behera D, Naik SP, Goswami S (2021) Spatio-Temporal Variation of Vegetation and Urban Sprawl Using Remote Sensing and GIS: A Case Study of Cuttack City, Odisha, India. Journal of Geosciences Research 6(2):213-219

Pradeep R (1998) Remote sensing techniques to locate groundwater potential zones in upper Urmil River Basin, District Chhatarpur-Central India. Journal of the Indian Society of Remote Sensing 26:135-147

Prasad RK, Mondal NC, Banerjee P, Nandakumar MV, Singh VS (2008) Deciphering potential groundwater zone in hard rock through the application of GIS. Environ Geol 55(3):467-475

Roy AB, Jakhar SR (2002) Geology of Rajasthan (Northwest India) Precambrian to recent. Scientific Publishers

Sander P, Minor TB, Chesley MM (1997) Ground-water exploration based on lineament analysis and reproducibility tests. Groundwater 35(5):888-894

Sarkar SC, Dasgupta S (1980) Geologic setting, genesis and transformation of sulfide deposits in the northern part of Khetri copper belt, Rajasthan, India-an outline. Mineralium Deposita 15(2):117-137

Sikdar PK, Chakraborty S, Adhya E, Paul PK (2004) Land use/land cover changes and groundwater potential zoning in and around Raniganj coal mining area, Bardhaman District, West Bengal-a GIS and remote sensing approach. Journal of Spatial Hydrology 4(2):1-24

Singh AK, Prakash SR (2003) An integrated approach of remote sensing, geophysics and GIS to evaluate groundwater potentiality of Ojhala sub watershed Mirzapur district, UP. Remote Sensing Applications Centre, Uttar Pradesh, India

Singh S, Gautam·PK, Sarkar Tandrila, Taloor AK (2022) Characterization of the groundwater quality in Udham Singh Nagar of Kumaun Himalaya, Uttarakhand. Environmental Earth Sciences, 81(19), 1-13

Sinha-Roy S (1984) Precambrian crustal interaction in Rajasthan, NW India. In Proceeding of Seminar on Crustal Evolution of Indian Shield and it's Bearing on Metallogeny 84-91

Solomon S, Quiel F (2006) Groundwater study using remote sensing and geographic information systems (GIS) in the central highlands of Eritrea. Hydrogeol J 14(6): 1029-1041

Sreedhar G, Vijaya Kumar GT, Murali Krishna IV, Ercan K, Cuneyd DM (2009) Mapping of groundwater potential zones in the Musi basin using remote sensing data and GIS. Advances in Engineering Software 40:506-518

Strahler AN (1964) Quantitative geomorphology of drainage basins and channel networks, section 4II, In: Handbook of Applied Hydrology, edited by V.T. Chow, *McGraw-Hill*, 439

Vittala S, Govindaiah S, Gowda HH (2005) Evaluation of groundwater potential zones in the sub-watersheds of North Pennar River basin around Pavagada, Karnataka, India, using remote sensing and GIS techniques. J Indian Soc Remote Sens 33(4):483-493

Voogd H (1983) Multi-Ctiteria Evaluation for Urban and Regional Planning, Pion, London