



Deciphering groundwater potential zones using AHP and geospatial modelling approaches: a case study from YSR district, Andhra Pradesh, India

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Abstract

Groundwater contamination has increased in recent years due to an escalation in the use of groundwater and increasing agricultural activities. The growing demand for groundwater has improved that it is necessary to identify zones in an environment where groundwater reserves are most probable to be accessible. The present study was carried out in the Kadapa region in Andhra Pradesh in India where extreme groundwater use for irrigation mainly has caused groundwater levels to decline. An AHP approach was used to assemble a groundwater potential zones (GWPZs) map for the study area. The map was compiled using ten thematic layers including: geomorphology (GM), lineament density (LD), geology, soil, slope, land use/land cover (LULC), drainage density (DD) and pre- and post-monsoon water level fluctuations. The groundwater fluctuation data were used to verify the GWPZ map, which was then associated with agricultural reliance on groundwater. The final map obtained divided the regions into five groups. These are areas with a very poor, poor, moderate, good, and very good prospectively. The area falling in the ‘very good’ zone is about 7.61 km² (2.59%), which encompasses major in central portions of the study area. The northeast and central portions along with average patches fall in the ‘good’ zone, which encompasses an area of 78.34 km² (26.68%). The ‘moderate’ zone is dominant in the study area which covers an area of 123.12 km² (40.93%). The southwestern and north-western parts of eastern and southwest and central portions of the study area are characterised as having ‘poor’ 78.05 km² (26.58%) and ‘very poor’ 6.52 km² (2.22%) groundwater potential zones. The groundwater potential map was finally verified using the well yield data of 39 pumping wells, and the result was found satisfactory. Together, it is possible to define a practical method for explaining the potential for groundwater accessibility which finally allows for improved development and management of groundwater sources. Since the current technique is based on logical criteria and reasoning, it may be successfully used elsewhere with minor changes. Thus, the capabilities of remote sensing and GIS in delineating different ground water potential zones have been convincingly proven in the above study, particularly in such a diversified geological setting.

Keywords Analytical hierarchy process · Geographical information system · Groundwater potential zones · Remote sensing · Sustainable development

Introduction

Groundwater demand has increased in recent years in developed and emerging countries to meet agricultural, residential, and industrial water requirements (Todd & Mays, 2005). Thus, it is vital to understand an efficient strategy

for designating groundwater potential zones and managing this critical resource on both a regional and local scale to ensure sustainable lives. Due to India’s complex topographical, geological, and climatological characteristics, groundwater distribution is extremely uneven. In hard-rock terrains, groundwater is predominantly targeted by shallow unconfined aquifers in weathered residuum and deeper cracks and joints under semi-confined conditions. Water consumption growth has damaged both groundwater and surface water supplies, posing the possibility of an emergency water catastrophe (Thakur et al., 2011). Groundwater development and management on a sustainable basis require

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an accurate quantitative assessment based on scientific principles and contemporary technology (Agarwal et al., 2013). Remote sensing and geographic information system (GIS) technology have opened up new options for the research of groundwater resources (Jasrotia et al., 2013). Remote sensing technology advancements and its spatially precise performance in georeferenced processes make it easier to determine the factors influencing groundwater potential zonation on a broad scale. Mapping groundwater potential zonation has become easier and faster in recent years as a result of the evolution of more complex geographic information systems (GIS) (Adji & Sejati, 2014). One of the most notable advantages of using remote sensing and GIS for hydrological research and monitoring is their ability to generate spatial and temporal domain data, which is necessary for successful analysis, prediction, and validation (Sarma & Saraf, 2002).

GIS-based AHP approach was utilised to demarcate groundwater potential zones in any location, which made time management easier. Lithology, land use, geomorphology, drainage pattern, lineament density, soil, and topographic slope are the thematic layers that are frequently employed to analyse groundwater potential. Numerous researches have indicated that the number of hydrologic thematic levels varies. In most of the research, weights were allocated to various thematic levels and their characteristics based on personal judgement or expert opinion. Over the last 2 decades, efficient use of multi-criteria decision analysis (MCDA) has been developed for water management, allowing judgments to incorporate structure, appropriateness, transparency, and rigour (Dunning et al., 2000; Machiwal

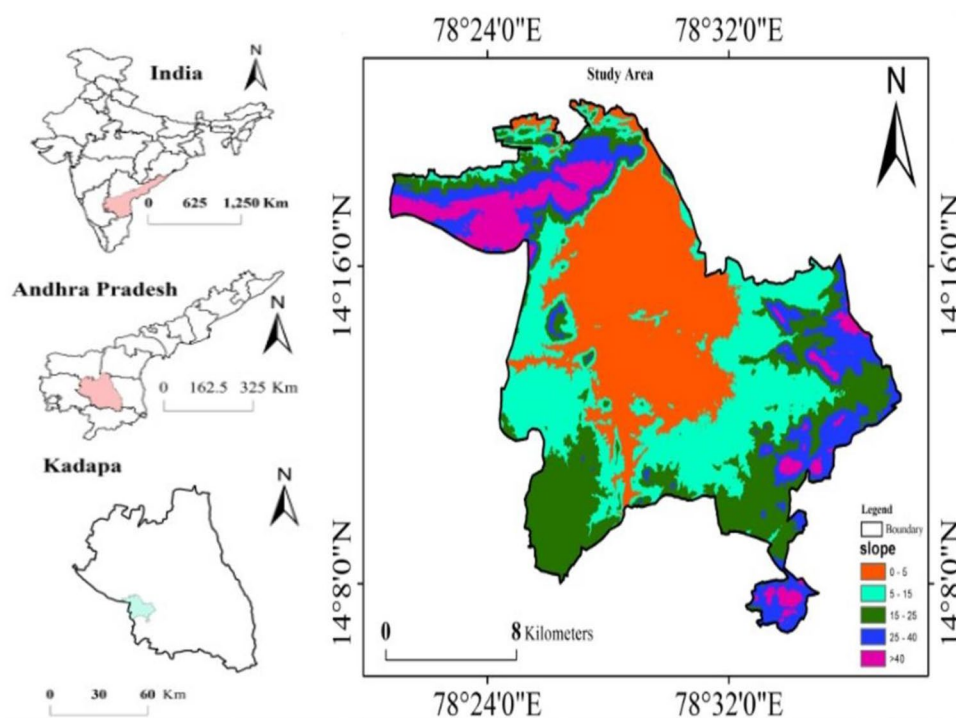
et al., 2011; Rajasekhar et al., 2020a, 2020b). The AHP approach was used to map the groundwater potential in this study. The AHP is the most extensively used and approved MCDA model, which may also be utilised for environmental management (Kadam et al., 2020; Rajasekhar et al., 2019). It emphasises the building of decision problems incorporating criteria and choice possibilities. The integration of geospatial technology for the preparation of various thematic layers, including geology, land use/land cover, elevation, drainage density, lineament density, soil depth, soil moisture, and rainfall, as well as the proper assignment of weights using the AHP technique, aids in the identification of GWPZs regions. The main objective of this study is to construct new groundwater potential map of the water scarcity for drinking and agriculture sedimentary rock terrain of YSR Kadapa district, South India. This study aims to spatially analyse the relationship between groundwater potential and terrain and hydrological and remote sensing parameters to control groundwater accumulation.

Materials and methods

Study area

The study area (293.64 km²) is in western part of the Kadapa district, Andhra Pradesh, India, entangling 78° 24' 00" E–78° 40' 00" E and 14° 08' 00" and 14° 16' 00" N (Fig. 1). This region is portrayed by hard-rock terrain of semiarid climatic conditions with potential of direct run-off

Fig. 1 Location map



and high evapotranspiration. Various lithological formations are formed they are granite, dolomite, quartzite, Vempalli formations, quartzite and volcanic flows were used in the observation site. The average annual rainfall is 389.4 mm, with wet days prevailing in subtropical weather. The area has a variety of geomorphological capabilities, formed and more in pediment–pediplain complex in the present study. The available water is suitable during the initial quantity of the cold weather period; later, the water table fluctuates promptly, and by summertime, many surface wells tapping the upper unconfined aquifers are either dry or do not adequately satisfy the critical. In those lines, even though there is a lot of ground water, there is a huge inefficiency of water in the summer. Consequently, it could be important to define areas where explicit artificial recharge techniques may be applied to improve water availability.

Methodology

This aspect has been collected using current hydro-geological and pertinent statistical data on soils, structural capabilities, and climatic conditions in the study region. Understanding of hydro-geological conditions of the study of interest to delineate the groundwater potential zones depends on a number of factors, such as drainage density, geomorphology, slope, lineament density, geology, soils and water levels fluctuations pre and post monsoons. The identification of GWPZs is carried out utilising a variety of data sets, including the SRTM DEM satellite image acquired by the USGS Earth Explorer with a spatial resolution of 90 m. The

geological map was obtained on a 1:250,000 scale from the Geological Survey of India (GSI), the soil map was obtained on a 1:250,000 scale from the National Bureau of Soil Survey and Land Use Planning (NBSS&LUP), and station-wise water level data were obtained from the district groundwater department of Kadapa, Andhra Pradesh, India. The data were interpolated using the Inverse Distance Weighted (IDW) method of the spatial analyst tool in ArcGIS software. The slope and drainage density maps were created using the spatial analyst tool in ArcGIS software using the SRTM DEM. To create the lineaments, we used the NRSC Bhuvan website's lineament density and geomorphology maps. The eight thematic levels selected represent critical hydro-geological elements that are interrelated and have an effect on the occurrence and transport of groundwater. Following the creation of all theme layers, the AHP model is used to determine the weight of each element and its sub-classes based on their influence on the development of groundwater (Fig. 2).

AHP approach

The AHP simplifies the parameters of the Pairwise Comparison Matrix (PCM) and is dependent on the assigning of experts about the significance of the influencing factors. AHP is one of the most common approaches in the decision-making analysis. This process also can analyse proportionally various thematic layers through the PCM analysis of each parameter and flexibility in the situation of intentions (Kumar et al., 2016; Rajasekhar et al., 2018; Shailaja et al., 2018). Saaty (1980) initially carried out this systematic

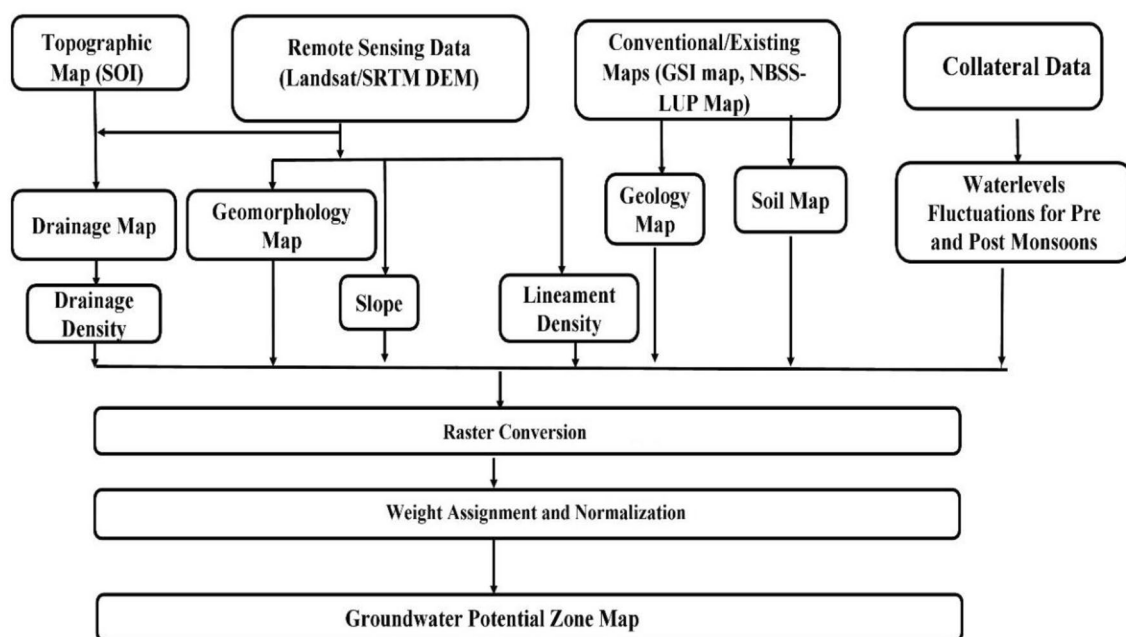


Fig. 2 Methodology

exercise to show sustainability and the consequences in a multilateral decision-making system. The matrix structure of AHP offers the possibility to quantify and synthesise different features of the multilateral decision-making process hierarchically.

In this study, AHP is used to estimate the weight of all relevant parameters that influence the potential of groundwater recharge in the study region. AHP implies an assessment of the significance between the parameters, the normalisation, and calculating the consistency ratio (CR). Depending on the hierarchical order constructed, it is decided that the priority of the influencing factors recognises the significance of the features at various levels of the hierarchy (Kaliraj et al., 2013). To obtain qualitative data, the factors that influence each level are compared in pairs. The Saaty scale from 1 to 9 (Table 1) is used to measure the relative importance of the factor (Saaty, 2008).

Pairwise comparison matrix (PCM)

By arranging the values in the upper triangle and using their reciprocal values to fill the triangular matrix in this manner, a diagonal matrix is created. PCM was determined based on the expert’s opinion (Zolekar & Bhagat, 2015). In addition, the relative weights have been adjusted. The normalised primary eigenvector is obtained by averaging the order of the priority vector to ensure its consistency. The primary eigenvalue is obtained by summing the products

of each eigenvector component and the summation of the mutual matrix’s columns (Table 2). Through an analysis of the consistency ratio (CR), this fundamental eigenvalue is utilised to determine the degree of consistency of thoughts (Saaty 1990). A CR value less than 0.1 can be interpreted as less uncertain weight determination judgments (Kadam et al., 2020; Rajasekhar et al., 2019, 2020a, 2020b). The Consistency Index (CI) is calculated by comparing all parameters used to calculate the CR using the following formulae and comparison matrix:

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

where λ_{max} is the average number of consistency vector and n is the number of criteria or factors.

The CR has been computed using the following equation:

$$CR = \frac{CI}{RCI}, \tag{2}$$

where RCI is the random consistency index, provided by Saaty (2008) (Table 3).

Table 1 AHP scale (Saaty 2008)

| | | | | | | | | | |
|------------|-------|------|----------|---------------|--------|-------------|-------------|-------------------|---------|
| Scale | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Importance | Equal | Weak | Moderate | Moderate plus | Strong | Strong plus | Very strong | Very, very strong | Extreme |

Table 2 Pairwise comparison matrix

| Criteria | Geology | GM | LULC | DD | LD | Pre-monsoon | Slopes | Post-monsoon | Normalised weight |
|--------------|---------|------|------|------|------|-------------|--------|--------------|-------------------|
| Geology | 1.00 | 0.50 | 0.50 | 4.00 | 4.00 | 0.50 | 1.00 | 0.20 | 0.11 |
| GM | 2.00 | 1.00 | 0.25 | 4.00 | 1.00 | 0.50 | 0.50 | 3.00 | 0.13 |
| Soils | 2.00 | 4.00 | 1.00 | 5.00 | 2.00 | 0.33 | 3.00 | 0.25 | 0.16 |
| DD | 0.20 | 0.25 | 0.20 | 1.00 | 0.33 | 0.25 | 0.20 | 0.33 | 0.03 |
| LD | 0.20 | 1.00 | 0.50 | 3.00 | 1.00 | 0.33 | 2.00 | 1.00 | 0.09 |
| Pre-monsoon | 2.00 | 0.50 | 3.00 | 4.00 | 3.00 | 1.00 | 3.00 | 2.00 | 0.20 |
| Slope | 1.00 | 2.00 | 0.33 | 5.00 | 0.50 | 0.33 | 1.00 | 0.20 | 0.08 |
| Post-monsoon | 5.00 | 0.33 | 4.00 | 3.00 | 1.00 | 0.50 | 5.00 | 1.00 | 0.20 |

Table 3 Random index values

| N | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|-----|---|---|------|------|------|------|------|------|------|------|
| RCI | 0 | 0 | 0.58 | 0.89 | 1.12 | 1.24 | 1.32 | 1.41 | 1.45 | 1.49 |

Results and discussion

Geology

The geological map was prepared using the ArcGIS environment and a 1:50,000 scale lithological map of Andhra Pradesh created by the GSI (Geological Survey of India). Volcanic flows known as dolomite cut through these shale strata. A solitary patch of dolomite forms in the northern half of the area. According to the pairwise comparison matrix of geology maps, the significance of aquifer type in terms of groundwater conservation was determined. The research region was divided into distinct lithologies based on their aquifer qualities, with a higher proportion of dolomites storing water in shale tuff with quartzites and a lower proportion of dolomites storing water in volcanic flows (Fig. 3). There was a moderate response to the importance of aquifers formed in the groundwater according to the PCM of the lithology layer. In general, the older alluvial deposits are compositionally like the younger deposits but are more consolidated and less transmissive. Therefore, older alluvium deposits are less favourable for groundwater occurrence compared to younger alluvium. The area, having a geology class of Vempalli dolomites with good porous nature, is characterised as a good zone for groundwater potential. The area has gently undulating topography and less vegetation. Primary quartzite and granites having hard-rock nature type of geology are found in the eastern and central parts of the study area with moderate groundwater potential.

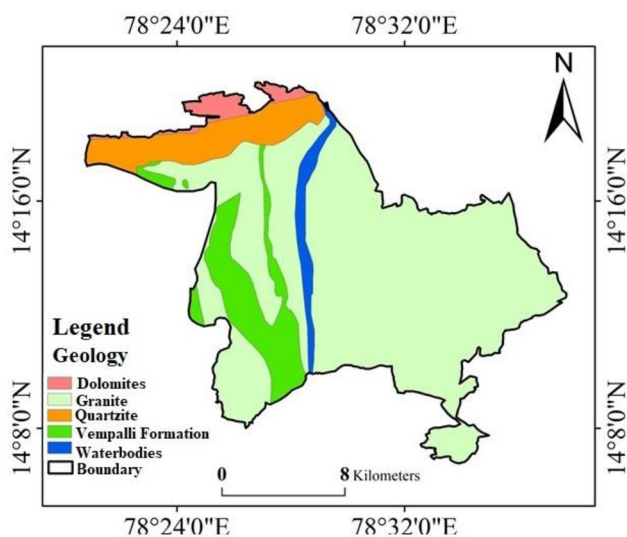


Fig. 3 Geology

Geomorphology

Geomorphology map was important element in evaluating the groundwater capability prospects due to the fact its faraway control of the subsurface motion of natural resources. The nature of the look at place is characterised using dominantly with the aid of a few degrees' hydrological backgrounds the geomorphology of any province was an important component in explaining the ground water capacity and dependent on the lithography and shape of the basic formations (Kumar et al., 2017). The geomorphological area may be categorised into 10 types, i.e. river/water body, fluvial origin, active quarry, aeolian origin, floodplain, pediment, pediplain, structural origin, denudational origin and dyke's/sill ridges (Fig. 4). The geomorphology of have a look at place is a dominance of porous sedimentary rock spatial quantity of the ground water bodies such as river become protecting 2.85% of the observe location, which act as recharge sector regarding the groundwater capability. The pediment type of geomorphology occurs as moderate patches in the central portion of the study area. It is very poor for groundwater occurrence. The overall topography in the pedimented area is mainly gently undulating and the soil is mainly granitic and not very good for agricultural production. A small part in the eastern portion of the study area has pediplain outcrop type geomorphology, which is completely weathered surface and here the availability of groundwater is moderate to good potential in the study area (Table 4).

Lineament density (LD)

The term “lineament density” (LD) refers to the total length of lineaments per unit extent. It provides numerous valuable

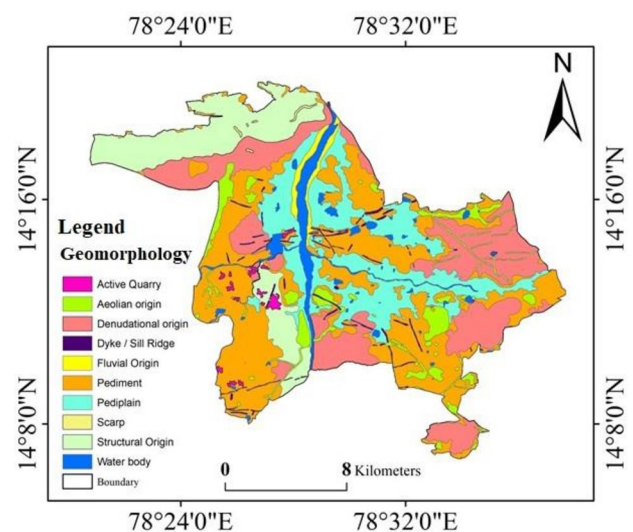
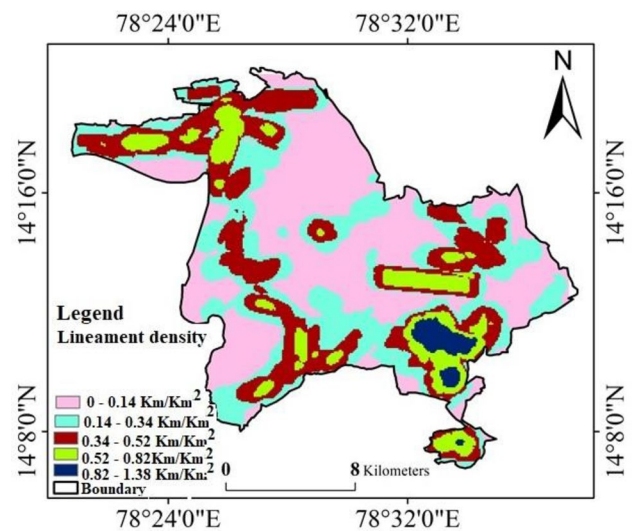


Fig. 4 Geomorphology

Table 4 Assigned and normalised weights to criteria

| Criteria | AHP weights | Normalised weight | Sub-criteria | | | |
|-------------------------------|-------------|-------------------|--------------------------------|---|-----|------------------------------|
| Geology | 11 | 0.11 | Dolomite | | | |
| | | | Granite | | | |
| | | | Quartzite | | | |
| | | | Vempalli formation | | | |
| | | | Waterbodies | | | |
| Geomorphology | 13 | 0.13 | Aeolian origin | | | |
| | | | Active quarry | | | |
| | | | Denudational origin | | | |
| | | | Dyke/sill ridges | | | |
| | | | Fluvial origin | | | |
| | | | Pediments | | | |
| | | | Pediaplains | | | |
| | | | Scrap | | | |
| | | | Structural origin | | | |
| | | | Waterbodies | | | |
| | | | Drainage density | 3 | 0.3 | 0–1.30 km/km ² |
| | | | | | | 1.30–3.10 km/km ² |
| | | | | | | 3.10–5.15 km/km ² |
| 5.15–7.80 km/km ² | | | | | | |
| 7.80–12.75 km/km ² | | | | | | |
| Lineament density | 9 | 0.9 | 0–0.014 km/km ² | | | |
| | | | 0.014–0.034 km/km ² | | | |
| | | | 0.034–0.052 km/km ² | | | |
| | | | 0.052–0.082 km/km ² | | | |
| | | | 0.082–0.132 km/km ² | | | |
| Soils | 16 | 0.16 | Dark brown soil | | | |
| | | | Dark reddish soil | | | |
| WLF pre-monsoon | 20 | 0.2 | 0.74 to 1.31 m | | | |
| | | | 1.31 to 1.71 m | | | |
| | | | 1.71 to 2.11 m | | | |
| | | | 2.11 to 2.54 m | | | |
| | | | 2.54 to 2.92 m | | | |
| WLF post-monsoon | 20 | 0.2 | – 9.44 to – 6.78 m | | | |
| | | | – 6.78 to – 4.33 m | | | |
| | | | – 4.33 to – 2.01 m | | | |
| | | | – 2.01 to 0.11 m | | | |
| | | | 0.11 to 1.78 m | | | |
| Slope (degrees) | 8 | 0.08 | 0–5 | | | |
| | | | 5–15 | | | |
| | | | 15–25 | | | |
| | | | 25–40 | | | |
| | | | > 40 | | | |

geological facts concerning the tectonic distortion's great strength, rock fracturing and shearing, and groundwater possibilities (Rajasekhar et al., 2018a, 2018b). The LD map represents a percentage of the computed length of the direct

**Fig. 5** Lineament density

component given in the grid (Shekhar and Pandey, 2015). The LD of a region indirectly reveals the territory's groundwater capabilities, as the proximity of lineaments generally indicates a pervious zone. Areas with a higher LD value are advantageous for groundwater conservation. LD changes from 0.82 to 1.38 km/km² in most of the research region, which is limited to the area. The lineament trends are predominantly along NW–SE and NE–SW directions. The minimum lineament density was found to be 0 m/km² in cells of no lineament, while the maximum was 1.38 m/km² (Fig. 5). Polygons with higher values of lineament density will have more recharge and hence better prospects of groundwater. The highest ranking was assigned to the highest lineament density interval.

Drainage density

Drainage density (DD) defines length of all order flow segments per unit area. DD is the inverse function of permeability. Lower DD has higher recharge rates and higher DD has lower recharge rates (Rajaveni et al., 2016). Drainage density is one of the parameters affecting the groundwater potential index. In river flows, DD is low in areas with low infiltration. Where drainage density is small, infiltration occurs at a higher speed because the flow is slow. Hence, the performance coefficient of ratios with low drainage density was taken as a higher value. DD is generally low in the river basin. The main factors affecting the availability of groundwater in a particular area and the DD classes are classified into 5 types of values 0–1.30 km/km², 1.30–3.10 km/km², 3.10–5.15 km/km², 5.15–7.80 km/km² and 7.80–12.75 km/km² (Fig. 6). High ranks are, therefore, assigned to low drainage density area and vice versa. The

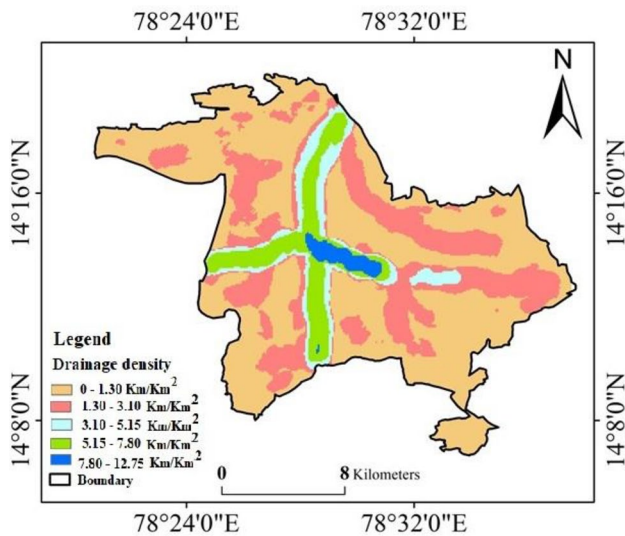


Fig. 6 Drainage density

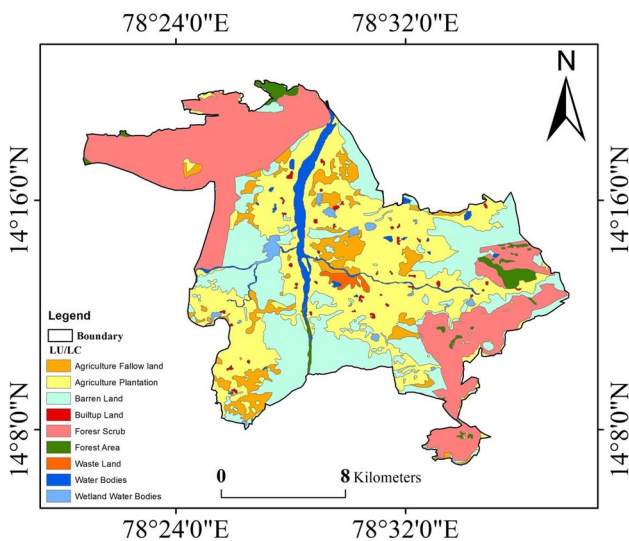


Fig. 7 Land use and land cover

maximum drainage density was found to be 12.75 km/km². A low drainage density region causes more infiltration and results in good groundwater potential zones as compared to a high drainage density region. Higher rankings were given to low drainage density regions and lower rankings to high drainage density areas as shown in Table 3.

Land use/land cover

Land use/land cover classification (LULC) was performed using the ERDAS Imagine 2014 software, which includes a supervised classification technique that maximum likelihood of categorisation (Fig. 7). Probabilities correspond

to all classes and the normal transmission of input bands. However, because this method is dependent on the normal distribution of data in each input band, it frequently exceeds the limits (Basha et al., 2018; Marhaento et al., 2018; Singh et al., 2018; Rajasekhar et al., 2018a, 2018b). Six LULC types have been identified in the study region based on the signatures: (i) forest, (ii) irrigated and fallow agricultural land, (iii) wastelands, (iv) built-up areas, (v) barren lands, and (vi) water bodies. Agricultural land and grasslands have high groundwater potentiality (Ghosh et al., 2020; Patra et al., 2018). Plantations have been assigned moderately high weightage since these slow down the surface run-off flow and increase the rate of infiltration (Bhattacharya et al., 2020). The wetlands and water bodies aid in groundwater recharge in wet seasons, however during the dry seasons these act as discharge features, so, these have moderately low groundwater potentiality (Saranya & Saravanan, 2020). Low groundwater potentiality has been assigning to the settlement zone for their low rate of infiltration.

Soils

Soil is also one of the key factors in identifying potential groundwater areas (Pankaj et al., 2016). Several types of soil have been identified and classified as dark brown and reddish soil, deep dark brown and red soil, settlement, deep reddish-brown soil, shallow dark brown soil and water bodies. Soil is an important factor in identifying areas of potential groundwater zones. According to the soil type analysis, the study area is mainly covered with offshore wetland with clay and offshore loamy soil (river floodplains), as shown by recharge capacity. Soils have been assigned ranks based on the source of their infiltration rate. These are very deep and well-drained soils that have a coarse loamy texture. These characteristics make this soil types suitable for groundwater recharge as these materials have an infiltration rate that exceeds the run-off rate. Since loamy calcareous soil has a high infiltration rate, it is given greater significance, but clayey soil has a low infiltration rate, it is given less significance. (Fig. 8).

Slope

The slope aspect plays an important role in identifying possible zones for groundwater. Higher slope levels lead to rapid run-off and higher erosion rates with low recharge potential (Magesh et al., 2012). Slope moves the drainage thickness, and it produces variances from place to place. In terms of groundwater recharge, the areas with flat terrain topography fall into the ‘very good’ category with relatively high infiltration rate, whereas the areas having moderate slope are considered as ‘good’ for groundwater storage due to slightly undulating topography with some

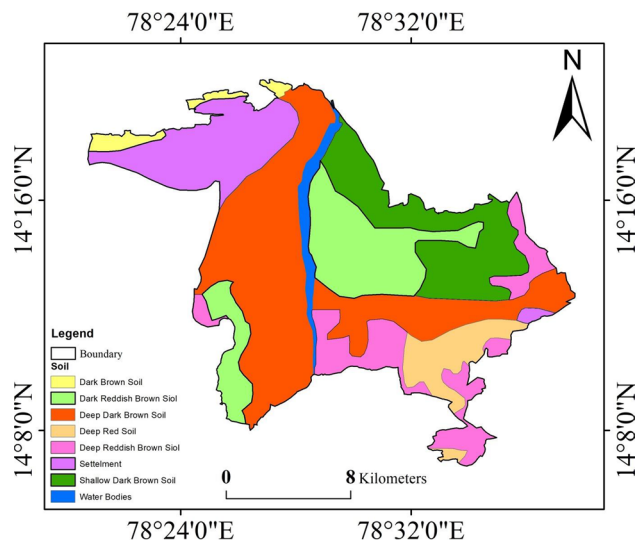


Fig. 8 Soils

run-off. The areas having steeper slope cause relatively high run-off and low infiltration, and hence are categorised as ‘poor’ and have less groundwater accumulation (Magesh et al., 2012). In this study, the slope map of the study area (Fig. 6) was generated from ASTER DEM and was categorised into 5 classes: specifically, 0–5°, 5–15°, 15–25°, 25–40°, and > 40° (Fig. 9). It is observed that the lowest slope (0–5°) indicating flat topography is present in the central region of the study area and the slopes above > 25° is observed over the hilly region present in the eastern and north-western regions. Classes having gentle slope was assigned higher rank due to the flat terrain which will allow more groundwater retention and less run-off,

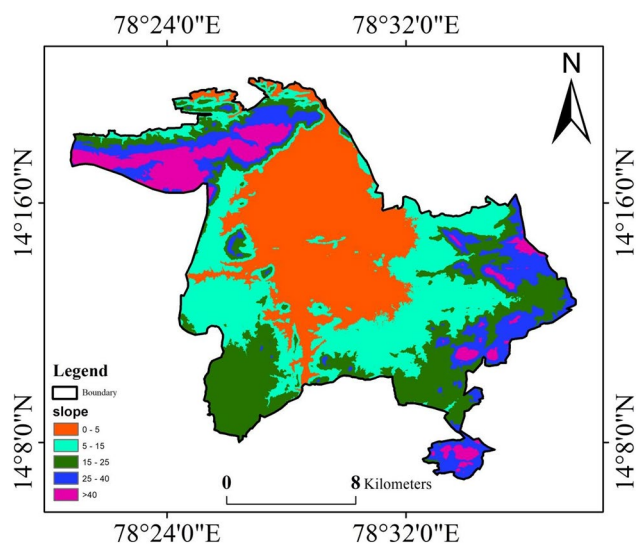


Fig. 9 Slope

while the steeper slopes were assigned lesser rank because of more run-off and less infiltration (Nag & Ghosh, 2013).

Groundwater level fluctuations (GWL): pre- and post-monsoon seasons

Water flows in aquifers reflect an energetic balance amongst groundwater recharge, storage, and discharge. If recharging exceeds discharge, the extent of water will grow; if discharge exceeds recharge, the capacity of water tiers will fall. Since they may not be allotted consistently in space and time, groundwater tiers are continuously growing or falling to the ensuing differences. Water degrees in wells reflect those modifications and offer the most important method of following modifications in groundwater ranges. High water stages get up inside the wet season recharging from precipitation exceeds discharge; the fundamental elements that infusion groundwater stages are precipitation, motion level, nicely pump age and inoculation. There is version within the water levels throughout the post and pre-monsoon period due to recharge and discharge of groundwater. The average fluctuations in groundwater levels in the pre–post-monsoon in the study region generally differ from – 9.44 to 2.92 m below the soil surface (m bgl), with much of the region with a depth of bgs of 6.5 at 10 m (Figs. 10 and 11). In the northeast of the region, the average depth of groundwater before the monsoons varies from 0.74 to 2.92 m. The spatial distribution post-monsoon level data varies in – 0.9.44 to 1.78 m, with most of the average monsoon groundwater level varying from 4.5 to 7 m.

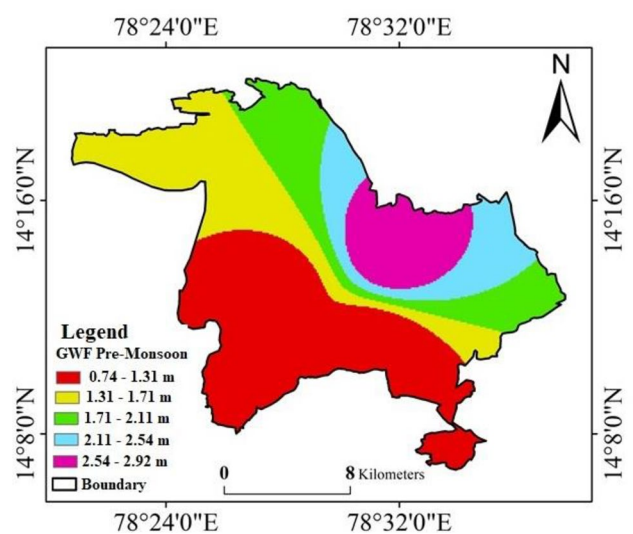


Fig. 10 Ground water fluctuations: pre-monsoon

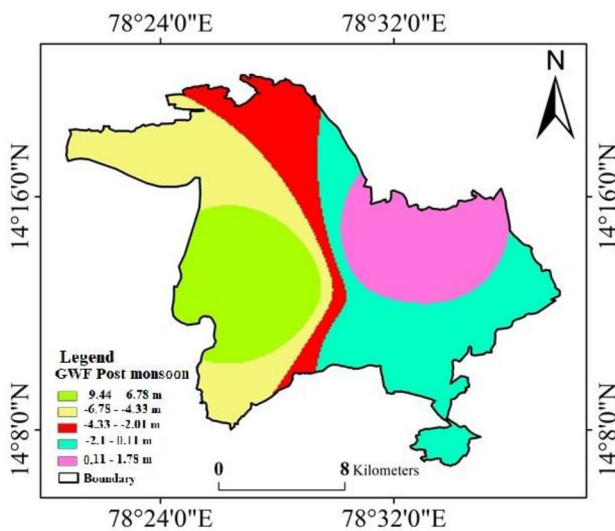


Fig. 11 Ground water fluctuations: post-monsoon

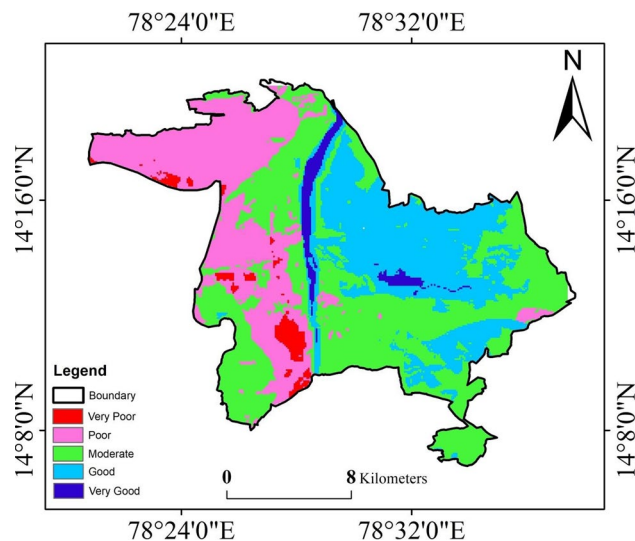


Fig. 12 Ground water potential zones

Groundwater potential zones

The achieve groundwater potential zones (GWPZ) map through GIS method and overlay weighted method separated to the study part into five classes, viz., very poor, poor, moderate, good and very good zones contributing to 6.52 sq km (2.22%), 78.05 sq km (26.58%), 123.12 sq km (41.93%), 78.34 sq km (26.68%) and 7.61 sq km (2.59%) (Fig. 11). For validation the reliability of concluding result, well inventory survey may be conducted on various locations of the study part as shown in (Fig. 12). The GWPZs were evaluated on the basis of the normalised weights of the separate features in the thematic maps (Table 4). There

were five types of GWP: very poor, poor, moderate, good, and very good (Fig. 12). The loamy calcareous soils showed moderate to strong GWP from the northwest sections. The analysis reveals that only 7.61 km² (2.59%) of the study area shows very good GWP, 78.34 km² (26.68%) shows good GWP, though 123.12 km² (41.93%) and 78.05 km² (26.58%) area show moderate and poor GWP, respectively. The good potentials weathered granite were included, with DD ranging from 0–1.30 to 7.80–12.75 km/km². Due to the gentle slopes and medium porosity of loamy calcareous soils, the weathered surface located within the southern and central part of the present study region has moderate GWP. A careful view of the GWPZ map indicates that the groundwater arrangement is replications of the precipitation and geological formations beside slope (Kumar and Yadav 2015; Mallik et al., 2014; Shankar and Mohan, 2005). These prospective groundwater zones can provide a basis for the detailed hydrogeologic and/or geophysical investigations needed for well siting and proper management of scarce groundwater resources.

Conclusion

The study showed that the use of remote sensing and GIS in combination with AHP technology is an effective technique in the study region of Kadapa district to locate areas of possible groundwater potential. The final map correlates to ground-truth evidence that the model is accurate. Planner involved in editing a water development plan to create an economically feasible plan by integrating geology, DD, LD, geomorphology, soil, slope, rainfall and LULC information basics are provided to the individual and the decision maker for identification of various categories of groundwater potential zones. The area falling in the ‘very good’ zone is about 7.61 km² (2.59%), which encompasses major in central portions of the study area. The northeast and central portions along with average patches fall in the ‘good’ zone, which encompasses an area of 78.34 km² (26.68%). The ‘moderate’ zone is dominant in the study area which covers an area of 123.12 km² (40.93%). The southwestern and north-western parts of eastern and southwest and central portions of the study area are characterised as having ‘poor’ 78.05 km² (26.58%) and ‘very poor’ 6.52 km² (2.22%) groundwater potential zones. The groundwater potential map was finally verified using the well yield data of 39 pumping wells, and the result was found satisfactory. Farmers in this area will also benefit from this type of explore to further locate the different areas of groundwater exploration. The saturated fractures or joints may yield a large quantity of water, and locating such potential fractures or joints is an extremely difficult task in the hard-rock terrain. Hence, remote sensing GIS and AHP both quantitative and qualitative analyses

gave information about the groundwater prospect zones for drilling borewell or dug wells for irrigation, drinking, and industrial supply.

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Data availability statement The raw data are obtained from NRSC Bhuvan and USGS website (<https://bhuvan.nrs.gov.in/> and <https://earthexplorer.usgs.gov/>) which is available free of cost and the findings of this study are available from the corresponding author, upon reasonable request.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

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