Applications of GIS and Remote Sensing in Groundwater potential zoning of Srikakulam district in Andhra Pradesh

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Abstract

Groundwater supplies across the world are under tremendous strain due to overuse and noticeable climatic changes over time. The requirement to assess groundwater potential and aquifer productivity rises along with the global need for potable water for human consumption, agriculture, and industrial applications. Because they are quick and will give first-hand knowledge on the resource for future projects, geographic information system-based studies have recently become quite popular in groundwater exploration. With this in mind, the current work uses remote sensing and GIS techniques to select and define groundwater potential zones for the evaluation of groundwater availability in the Srikakulam district of Andhra Pradesh, India. In the current work, an analytical hierarchical process approach (AHP) was combined with a geographic information system. For the purpose of defining the groundwater potential zone, a total of 12 thematic layers, including slope, rainfall, curvature, soil, drainage density, lineament density, topographic wetness index, land surface temperature, elevation, land use & land cover, lithology, and groundwater fluctuation, were taken into consideration. According to their qualities and water potential capacity as determined by the AHP technique, weights are allocated to each class in all thematic maps. To determine the groundwater potential zones, overlay analysis was performed after the creation of all the maps. The resulting groundwater potential zone map, which had a groundwater potential index of 33, was divided into five classes which are ranging from very high to very low.

1. Introduction

The most precious and important natural resource is groundwater, which is more suited and consistently available than other resources. (Jha and Sinha 2010; Patle 2019). It is the zone of saturation present below the ground which is known as aquifer (Prakash Khedun et al. 2014). In order to give water to wells and springs, aquifers are often porous and permeable and act as underground reservoirs for groundwater storage (Ozha 2015; C. Abirami & Annadurai 2016). Groundwater can be easily extracted and renewed and is less contaminated (Bierkens and Wada 2019). Records show that groundwater usage for residential purposes is mostly used by rural residents (80%) and urban residents (50%) in the future (Patle 2019). So, in order to meet this demand, there is a need of groundwater recharge potential zones. Groundwater is a significant source of water in both humid and arid/semi-arid parts of the world due to its physical and chemical characteristics, as well as during emergencies such as droughts and earthquakes (Ozha 2015; C. Abirami & Annadurai 2016). The potential for groundwater in a location depends on several factors, and it changes from place to place depending on how those factors evolve. (Jhariya, Mondal, et al. 2021). This variation of groundwater potential has been observed (Dar, Sankar, and Dar 2010). In olden days people have used many methods for the identification of groundwater (Buckner et al. 2016; Kana et al. 2022). One of them is using coconut, people used this technique. It occurs when the force of groundwater increases then the gravitational force increases which leads in the change of direction of coconut which indicates that water is present in that area. This method is not scientifically proved by any of the researches but in ancient times due lack of technology people followed this technique. But now the
technology has improved and many methods were developed for the determining the potential for groundwater recharge (Barjasteh, Zeraatgar, and Javaheerian 2016; Adhikary et al. 2021).

A variety of artificial recharge techniques have been used to keep the water table in balance and limit the amount of surface run-off that is wasted (Yadav et al. 2012; Ozha 2015). An untapped natural resource that cannot be immediately accessed is groundwater. detected therefore, mapping of this resource is done (Gaonkar et al. 2019; Allafta, Opp, and Patra 2021). Researched have demonstrated that GIS and remote sensing are particularly effective tools for groundwater studies (Patle 2019). It is an easy and efficient method for investigating the groundwater potential zone (Ifediegwu 2022; Owolabi et al. 2020; Rajasekhar et al. 2022). For long-term resource management, it is essential to be able to determine the groundwater potential zone (Igwe, Ifediegwu, and Onwuka 2020; Ifediegwu 2022). By taking into account techniques like RS and GIS, the current study classified groundwater likely zones in and around the Srikakulam area and AHP techniques (Jhariya, Mondal, et al. 2021). Remote sensing is a method used for collecting physical data from the objects on earth without any physical contact and that data is to be integrated in GIS (Chawla et al. 2020). Groundwater studies frequently employ high-resolution satellite images because of their excellent spectral and spatial resolution (Golekar et al. 2015; Suganthi, Elango, and Subramanian 2013). This study mainly emphasizes the application of slope, rainfall, drainage density, lineament density, topographic wetness index, soil texture, land use and landcover, lithology, land surface temperature, curvature, elevation, groundwater depth were combined by the weighted index analytical hierarchy process (AHP) method to produce the groundwater potential zones (Jhariya, Mondal, et al. 2021; Ifediegwu 2022; Igwe, Ifediegwu, and Onwuka 2020). AHP is a method with several applicability across various industries. It is mostly employed to address difficult issues (Jhariya, Mondal, et al. 2021). Thomas L. Saaty created and released the approach in 1977. (Saaty 1997). The AHP (Saaty and Vargas 1980) is a standard for quantitative analysis used all around the world. It is a reliable method for making decisions about issues including several factors that may also be utilised to assess the potential groundwater occurrence zones selected for this study (Jhariya, Mondal, et al. 2021). With the use of AHP, the pairwise comparison is transformed into a collection of numbers that are then ranked according to their relative importance (Jhariya, Mondal, et al. 2021). Hence, the overlay analysis is done for mapping of groundwater potential zones in Srikakulam district of Andhra Pradesh (Rajesh et al. 2021; Melese and Belay 2022; Doke et al. 2021).

2. Study Area

District of Srikakulam located in the north-east portion of the state Andhra Pradesh, India shown in Fig. 1. Srikakulam is surrounded by Bay of Bengal in the east and south, Odissa state in the north and Vizianagaram and some portion of Odissa state in the west. The study area falls under latitudes of 18°5'52.8" to 19°7'11.6184" and longitudes of 83°36'42.552" to 84°47'25.3896". the total area of srikakulam district is 5837 km². Srikakulam District has a undulating terrain with such a hill towards Palakonda and Pathapatnam Constituency and Tekkali region. Some of the areas of Srikakulam district is drained by vamsadhara river, nagavali and bahuda rivers from the North to South. And also,
Srikakulam is also one of the districts in Coastal region of Andhra Pradesh with a 193 kms. The avg maximum temperatures vary between 25° C to 32°C. The rainy Season starts from June. And the avg rainfall of this district is 1067 mm.

3. Methodology

Underlying lithology, soil properties, lineaments, and drainage densities are principally responsible for controlling the occurrence and flow of groundwater (Jhariya, Mondal, et al. 2021). While recharge is regulated by rainfall, land use & land cover type (Jhariya, Mondal, et al. 2021). The current study developed and combined a total of twelve thematic layers like (slope, rainfall, curvature, soil, drainage density, lineament density, temperature of the ground surface, the topographic moisture index, elevation, land use & land cover, lithology, and groundwater fluctuation) using ArcGIS 10.3 software (Jhariya, Mondal, et al. 2021).

3.1 Data collection and processing in geographic information system (GIS)

The twelve thematic maps a GIS platform was used to create the data necessary to make the GWPZs map (ArcMap 10.3 software) (Jhariya, Mondal, et al. 2021). The Curvature, slope, Drainage density, Topographic wetness index and Elevation thematic maps were created using the Shuttle Radar Topography Mission (SRTM) Digital Elevation Model (Dem) with a 30 m spatial resolution (Dingle et al. 2018; Stewart 2017). The soil map and the Lithology map of the research area were extracted FAO Indian Soil map and USGS world geologic maps respectively (Thilagavathi et al. 2015). Lineaments were manually produced in the study region from the spatial analyst tool utilizing the equation below (Jhariya, Mondal, et al. 2021; Dingle et al. 2018; Stewart 2017).

\[ Ld = \sum_{i=1}^{n} Li / A \]

Where Li is the length each lineament and A is the study area to be considered.

Land sat 8 data was used to create the LULC map of the research region, which was created using supervised classification of a composite of the band 5, 6, and 4 in GIS software (Jhariya, Mondal, et al. 2021). To assess the spatial rainfall pattern of the research region, the average annual rainfall over a 10-year period was calculated using information from the Andhra Pradesh State Development and Planning Society (APSDPS) (Jhariya, Mondal, et al. 2021). For Land surface Temperature, data from USGS earth Explorer Land sat 8 collected and it is processed. Groundwater depth data was collected from India Water Resources Information System. All the shape files and non-spatial data by using the analytic hierarchy approach, maps were converted to raster format and the proper weights were assigned in order of their hierarchy in groundwater potentiality (AHP) (Jhariya, Mondal, et al. 2021).

3.2 Role of GIS and Analytic Hierarchy process
For ranking the numerous factors taken into consideration in this study, a combination of the Analytical Hierarchy Process (AHP) approach and Multi-Criteria Decision-Making Analysis (MCDM) is used (Sivakumar, Radha Krishnappa, and Nallanathel 2021). The weighted layers are then statistically evaluated using GIS to create the drought vulnerability assessment map. The analytical hierarchy process (AHP) and geographic information system (GIS) work well together to monitor groundwater, map disasters like landslides, floods, and droughts, and even determine if a piece of land is suitable for farming. AHP is employed to resolve a variety of issues where decision-making based on a number of factors necessitates weighting of the parameters based on their significance for the given condition on a pair-wise comparison means for each of the parameters under consideration investigation. Consequently, in the AHP, the grading is done in accordance with Saaty’s idea and scored from 1 to 9, where 1 means the least contribution and 9 represents the most contribution, as shown in Table 1. (Jhariya, Mondal, et al. 2021; Sivakumar, Radha Krishnappa, and Nallanathel 2021). A pairwise comparison matrix is also included in the table 2(Jhariya, Mondal, et al. 2021).

Table 2  Random index (RI)(Penki, Basina, and Tanniru 2022; Ramu, Sai Santosh, and Chalapathi 2022; Ramu et al. 2020; Ravinder, Ramu, and Srinivasarao 2020)

<table>
<thead>
<tr>
<th>N</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
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</thead>
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</table>

Table 3 Pair wise comparison matrix(Das et al. 2018)

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<th>4</th>
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<td>0.125</td>
<td>0.33</td>
<td>0.5</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Note: 1=curvature, 2=drainage density, 3=elevation, 4=land surface temperature, 5=lineament density, 6=LULC, 7=lithology, 8=Rainfall, 9=Slope, 10=Soil, 11=Topographic wetness index, 12=Groundwater fluctuation.

The based on prior work completed and material readily available on the research, the user’s knowledge, skill, and acumen are used to rate the criteria, finalise them, and make decisions. Therefore, using this subjective procedure, a rational strategy to finalising the components and ranks is needed. In this study, groundwater potential zoning for the Srikakulam district of Andhra Pradesh, India, was spatially
analysed using geographic information systems (GIS). AHP was used to create pair-wise comparison matrices and to calculate the weightage factors of each parameter (Sivakumar, Radha Krishnappa, and Nallanathel 2021). The final step of the AHP process is to calculate the consistency of the normalized criteria weights. The weights must have a consistency ratio (CR) value less than 0.10 to be considered consistent. (Jhariya, Mondal, et al. 2021). The pair-wise comparisons must be re-calculated if the Consistency ratio values are more than 0.10. The formula for calculation of Consistency ratio is shown below (Jhariya, Mondal, et al. 2021).

\[
CR = \frac{CI}{RI} - 2
\]

Where CR is consistency ratio and the CI is the consistency index developed by the following equation (Aliyev, Temizkan, and Aliyev 2020).

\[
CI = \frac{\text{max} - n}{n-1} - 3
\]

Where max denotes the maximum Eigen value of the judgment matrix,

\[
\text{max} = (1/n)\sum_{i=1}^{n} (A^w)i/W_i - 4
\]

And the groundwater potential zone equation shown below,

\[
GWPZ = \sum_{I=1}^{n} W_i^*r_i - 5
\]

Where \(W_i\) is the relative weights of the criterion i and \(r_i\) denotes the criterion's standardized score (Raj et al. 2022).

When there are several criteria and options accessible, MCDM is utilized to select the optimal option while preventing conflicts. Numerous MCDM methodologies are already in use, and the core of MCDM investigations is the integration of geospatial technology. GIS with AHP significantly lowers the confusion in the decision-making process since MCDM is very complicated in nature owing to the volume of a variety of dependent and independent elements discovered and taken into consideration. Using many criteria and geographic information, a decision is made using a procedure called spatial multi-criteria decision-making (MCDM). Consequently, several data layers must be processed in a multi-criteria evaluation to arrive at the ground water potential zones, it is easily accomplished with the use of GIS. As a result, to solve the issue with factor identification and selection in the study, ground water potential regions were determined using MCDM, AHP, and GIS (Sivakumar, Radha Krishnappa, and Nallanathel 2021).
Table 4
Ground water potential Mapping and subclasses of different categories based on weights (Penki, Basina, and Tanniru 2022)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Sub-Class</th>
<th>Rank</th>
<th>Parameter weight</th>
<th>Sub-Class weight (%)</th>
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<td></td>
<td>8.6–17</td>
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<td>17–26</td>
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<td>11</td>
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<td></td>
<td>26–71</td>
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<td>Undivided Precambrian rocks</td>
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<td>Loam</td>
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<td>34</td>
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<td>Sandy clay loam</td>
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<td>5</td>
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<td>943.44–1006.17</td>
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<td>1006.18–1068.92</td>
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<td>1131.65–1194.39</td>
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<td>Ground water Fluctuations</td>
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<td>4</td>
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<td>11</td>
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<td>5.2–6.4</td>
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</table>
4. Results And Discussion

The effective elements listed in Table 4 and the weights for the AHP criteria were used to create the Ground Water Potential map(%). The findings are addressed further below (Penki, Basina, and Tanniru 2022).

4.1 Slope: The slope is an important terrain feature that expresses the steepness of the ground surface. Slope provides critical information about the nature of the geology process and how it operates on a regional scale (Arulbalaji, Padmalal, and Sreelash 2019). A steeper slope causes faster runoff and erosion, as well as a lower recharge potential (Dashti Barmaki, Rezaei, and Madadi 2020). If the slope is less steep, there is less runoff, which results in a higher infiltration rate and is good for groundwater storage (Magesh, Chandrasekar, and Soundranayagam 2012). Slope is given a weight of 0.127 based on its relative influence on the identification of groundwater potential zones among the parameters used in this study (Jhariya, Mondal, et al. 2021). Srikakulam district’s slope was classified into five classes, including 0° – 3° as very good and 3° – 8.6° as good and 8.6° – 17° as moderate and 17° – 26° as poor and 26° – 71° as very poor, shown in Fig. 2 (Ifediegwu 2022; Igwe, Ifediegwu, and Onwuka 2020).

4.2 Rainfall: Rainfall distribution has a direct impact on runoff water infiltration. As a result, the possibility of groundwater potential zones grows (Sar et al. 2015). The district receives 1067 mm of rain per year. The south-west monsoon is the main source of rainfall for the study area, accounting for 80–85% of total rainfall from July to September (Kumar, Jain, and Singh 2010). Because rainfall is the primary source of groundwater, it plays an important role in mapping groundwater potential zones (C. Abirami & Annadurai 2016). Among the rainfall is the most significant variable used in this study to create GWPZs, with a weighting value of 0.304. (Jhariya, Mondal, et al. 2021). The total rainfall in Srikakulam district was divided into five subgroups. 1131.65mm-1194.39mm is excellent, as is 1068.93mm-1131.65mm. The 1006.18mm-1068.92mm range is regarded as moderate, while.

4.3 Curvature: If the curvature is more than the rate runoff is less (Arulbalaji, Padmalal, and Sreelash 2019). So, there is a sufficient time to infiltrate the water into ground. The curvature of the Srikakulam was further classified into five categories. <-1.10 is classified as very poor and <-1.10 to -0.28 classified as poor and - 0.28 to 0.28 as moderate and 0.2.8 to 2.9 as good and 2.9 to 23.18 as very good, Curvature, which can be concave or convex, is a quantitative representation of the characteristics of a surface profile. Water tends to slow down and accumulate in convex and concave profiles, respectively (Arulbalaji, Padmalal, and Sreelash 2019) shown in Fig. 2.

4.4 Soil: Water infiltration is greatly influenced by soil characteristics. Infiltration capacity is heavily influenced by soil texture, porosity, and permeability, all of which are influenced by texture. Because of porosity and permeability, fine-grained soil has lower infiltration than coarse-grained soil. (Patle 2019). The soil which has high infiltration capacity are considered as most potential zone due to high sand content in it. It is the factor which influences the infiltration rate (Adhikary et al. 2021). The study area is predominantly consisting of three types soil namely Loam, Sandy clay loam and Sandy loam (Olatona 2018). In the study area the areas which come under sandy loam soil are considered as good water potential zones, because when compared to other two soil types sandy loam is good for water drainage.
Sandy loam consists of sand with varying amounts of silts and clay. If it is sandy clay loam then it is considered as low zone and if it is loamy soil, it is considered as moderate zones, when compare to other two soil types, shown in Fig. 2.

4.5 Drainage density: Low drainage density indicates greater infiltration and less runoff. Zones with low to moderate drainage density are regarded as having high groundwater potential (Golekar et al. 2015). Areas with a high drainage density represent impermeable rock land, while areas with a low drainage density represent a permeable basement. High infiltration rates and low drainage density regions can be used to locate possible groundwater occurrence zones (Jhariya, Khan, et al. 2021). Based on its relative significance in establishing groundwater potential zones, drainage density is weighted at 0.029 (Jhariya, Mondal, et al. 2021). The drainage density has been divided into four categories. 0–4.5 is considered good, 4.5–9 is considered moderate, 9–13.5 is considered low, and > 13.5 is considered extremely low.

4.6 Lineament density: The factors that eventually influence permeability are characteristics of the lineament (Jhariya, Mondal, et al. 2021). Less lineament is beneficial for groundwater recharge because it functions as a pavement for water infiltration (Ozha 2015). According to the weighting value of 0.054 among the characteristics used to define groundwater potential zones in the current study, the class has been given based on its significance to potentiality for groundwater storage. From 0 to 0.96 km/km², the lineament density was present (Kumar, Jain, and Singh 2010). It is classified as very good, good, moderate and low. 0–0.09 km/km² is very good, 0.09–0.26 km/km² is good, 0.26–0.52 km/km² is moderate and 0.52–0.96 km/km² is low. Highest lineament values are occurred on north west and north east direction of the Research area (Prajapati et al. 2021).

4.7 Topographic wetness index: Also known as compound wetness index. It is frequently used to measure the influence of topography on hydrological processes. According to Srensen, Zinko, and Seibert (2006), the index depends on the slope as well as the upstream contributing area per unit width orthogonal to the flow direction. Due to the effect of the hillslope factor, low TWI regions are more likely to create an overland flow than allow for groundwater recharging. Meanwhile, because to the propensity for soil moisture buildup, high TWI in the foothills of low TWI is more likely to facilitate groundwater recharge (Owolabi et al. 2020). The topographic wetness index of the research area is ranges from 2.5 to 23 and classified as very good, good, moderate, low and very low (Harish and Haseena 2020). 2.5–6.6 is very low, 6.6–8.5 is low, 8.5–11 is classified as moderate, 11–14.3 is classified into good and very good portion ranges from > 14.3. TWI is assigned with a weighting value of 0.039 among parameters utilized to establish groundwater potentials zones in present study (Jhariya, Mondal, et al. 2021).

4.8 Land surface temperature (LST): LST identifies areas with low saturation thickness, high evapotranspiration, and evaporation when semi-aridity is severed in the research region. Therefore, if LST is higher, groundwater potential is lower there. High evaporation rates are found in regions with high temperatures. High temperature regions receive the lowest ranking, while low temperature regions receive the best ranking. In the current study, LST was given a weighted value of 0.117 among the criteria used to create groundwater potential zones in present study (Jhariya, Mondal, et al. 2021). The average land surface temperature of the Research area throughout the year is ranges from 8.0852°C to 28.1738°C and
classified into five categories as very good, good, moderate, low and very low (Rao 2013). LST ranges from 8°C-17°C is very good, 17°C-19°C is good, 19°C-20°C is moderate, 20°C-21°C is low and 21°C-28°C is very low.

4.9 Elevation: A location’s elevation is its height above or below a constant reference point (Wu, Xie, and Wang 2022). Always water runs from higher elevation to lower elevation. Water can store at lower elevations only when compared to higher elevations. So, there is no sufficient time to infiltrate the water in the higher elevations. So possible time is there to infiltrate the water into ground in lower elevation. So, when the elevation is low, it is good for groundwater potential. Elevation map is assigned with a weight of 0.086 and it is classified as four classes. Less than 67m is classified as good, 67-194m is categorized as moderate, 194-411m is classed as poor and 411-1033m is classed as very poor.

4.10 Land use & land cover: Use of Land Groundwater occurrence and development are influenced by land cover (Hassan et al. 2016). Land use refers to man’s activities on land for various purposes, whereas land cover refers to natural vegetation, water bodies, rocks, and so on (Hassan et al. 2016). A weight of 0.055 has been assigned to the land use/land cover map. Water bodies, bare land, forest area, built-up area, and agriculture comprise the total area (Goitsemang et al. 2020). The amount of recharge, evapotranspiration, and runoff were all considered when weighting and ranking LULC types (Jhariya, Mondal, et al. 2021).

4.11 Lithology: It has an impact on the ground surface’s infiltration capacity (C. Abirami & Annadurai 2016). This is determined by the type of rock and the general physical characteristics of the rock, as well as hydraulic conductivity, which is one of the aquifer properties that determines groundwater recharge (Jhariya, Mondal, et al. 2021). In the current study, Precambrian rocks cover 70% of the area. Dolomite, quartzite, and volcanic rocks are examples of these rocks. If the hydraulic conductivity of rocks is high, it is considered crucial for groundwater storage (Jhariya, Mondal, et al. 2021). The current study area’s total area was divided into two categories. The first is water, and the second is undivided Precambrian rocks. All other parameters have a weight of 0.048 on the lithology map.

4.12 Groundwater fluctuations: Groundwater is defined as water found underground in saturated zones beneath the land surface (Sharan, Lal, and Datta 2021). The groundwater fluctuation map has a weight of 0.031. Groundwater levels in dug wells deplete for a variety of reasons, including variations in rainfall, groundwater withdrawal during the rainy season (prolonged dry spell) for irrigating rain-fed crops, an increase in demand, and hydraulic connectivity with deeper confined aquifers. The fluctuation of groundwater levels is proportional to the GEP (Zagade and Umrikar 2021). The average fluctuation of groundwater levels in the area is classified into five categories: very good, good, moderate, low, and very low (Kana et al. 2022; Zagade and Umrikar 2021). The values 0.25–1.5 are considered very good, 1.5–2.7 are considered good, and 2.7–3.9 are considered excellent.

The final ground water potential map was created using the AHP method and was separated into five large groups with water potentialities ranging from extremely low to very high shown in Fig. 5. According to ground water potential studies, high-class outlined regions have a high Potentiality to ground water. According to this study, Rainfall and slope are the most important factor in ground water potentiality.
Since severe rain increases the amount of infiltration with directly influences and results in increase of ground water (Penki, Basina, and Tanniru 2022).

5. Conclusions

This paper highlights the application of integrated RS, GIS technologies with AHP technique in groundwater exploration and assessment. The present study put emphasis on following points:

- Assessing groundwater potential is a critical step in using and managing resources effectively and efficiently. GIS, remote sensing, and AHP techniques were used in this study to delineate GWPI such as slope, rainfall, curvature, soil, drainage density, lineament density, topographic wetness index, land surface temperature, elevation, land use & land cover, lithology, and groundwater fluctuation. The weight of thematic layers of groundwater prospect was determined by the results of the AHP process.

- In some areas of the Srikakulam district, groundwater potential has been identified using geographic information systems and remote sensing, which has shown to be a successful and economical technology. The integration of twelve thematic maps, including those on drainage density, slope, geology, geomorphology, lineament density, and land use/land cover, the research claims, gives local planners and authorities first-hand knowledge of locations that are suited for groundwater investigation.

- The approach is more practical and affordable for emerging and low-income nations where there is a frequent shortage of appropriate and high-quality hydro-geologic data for groundwater assessment using data-intensive approaches.

- The number and type of thematic layers used by researchers vary from study to study, and their selection is also arbitrary.

- A more robust ground water potential map can be produced by incorporating socioeconomic factors, resilience indexes, and public opinions into the framework.

Declarations

Ethical approval: Not applicable

Consent to participate: Not applicable

Consent to publish: Not applicable

Author Contributions: All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by RAMU PENKI, SAI SANTOSH BASINA and PRIYANKA NYAYAPATHI. The first draft of the manuscript was written by SAI SANTOSH BASINA and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.
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**Competing Interests:** The authors have no relevant financial or non-financial interests to disclose.

**Availability of data and materials:** Not applicable

**References**


Table 1

Table 1 is available in the Supplementary Files section.

Figures
Figure 1

Study area location map
Figure 2

Parameters used for AHP modeling. (a) Slope. (b) Rainfall. (c) Curvature. (d) Soil (Penki, Basina, and Tanniru 2022).
Figure 3

The variables utilized in AHP modelling. (a) Drainage Density (DD). (b) Lineament Density (LD). (c) Topographic wetness index (TWI). (d) Land surface temperature (LST)(Penki, Basina, and Tanniru 2022; Owolabi et al. 2020).
Figure 4

Parameters used for AHP modeling. (a) Elevation. (b) Land Use & Land Cover (LULC). (c) Lithology. (d) Ground water Fluctuation (Shit et al. 2015).
Figure 5

Ground water potential zoning of the study area

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Table1.docx