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Evaluation of Groundwater Potential Zones Using Remote Sensing and Geographic Information Systems in Bellampally, Mancherial District, Telangana

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ABSTRACT: Remote Sensing data GIS tool utilized for delineating potential groundwater zone in Bellampalli, Mancherial District, Telangana. Geologically the area is part of Gondwana Super group, composed of sandstone, shale, limestone and basalts in the western part of the area. Analysis of Remote Sensing data and integration of this in Geographic Information Systems (GIS) has a key role in evaluation of groundwater prospects. The study area was analyzed using six thematic layers: geomorphology, geology, LULC, Slope, drainage density and conduit density. These layers were integrated to identify potential groundwater zones. As a result, five different groundwater potential zones (GWPZ) were identified: very good, good, medium, poor and very poor. They cover an area of 40.38 km² for very good, 203.23 km² for good, 133.71 km² or moderate, 43.60 km² for poor and 4.08 km² for very poor. This study concludes that remote sensing and GIS are very fruitful and useful for evaluating potential groundwater zones.

KEYWORDS: Groundwater, Evaluation, Remote Sensing Data, Geographic Information Systems, Overlay analysis & Potential zones.

I. INTRODUCTION

Groundwater is extremely valuable because it helps to maintain human health, ecological diversity, and economic development. It possesses several essential qualities that make it an immensely important and reliable source of water supplies in all climatic conditions, including rural and urban areas of developed and developing countries[1], [2]. Groundwater is a precious resource that helps maintain human health, ecological diversity, and economic growth.

According to[3], groundwater is an essential resource of fresh water that can be used for a variety of purposes, including domestic, agricultural, animal husbandry, industrial, and other multipurpose operations. The groundwater table can become depleted when there is excessive usage of available groundwater resources without adequate management or recharge practises being put into place. The planning and management of groundwater resources become increasingly difficult as the climate continues to change.

According to[4], locating new locations with groundwater requires the combination of geophysical and aeromagnetic surveys in addition to RS & GIS. [5], [6] It has been discovered that RS and GIS techniques are useful in identifying the GWPZ, and they have gained favour as a result. [7], [8] Researchers have utilized a variety of RS and GIS-based approaches, including fuzzy sets, in order to outline the GWPZ. Morphometric analysis is another essential consideration in groundwater exploration[9].

My research area (Bellampalli) is located in the north part of the mancherial district and centred in the Godavari and Pranahita river basins. One of the Godavari River's major tributaries is Rallavagu. The region is in with the Survey of India toposheet nos E44B8, E44B12, E44H05 and E44H09. The study area runs northwest to southeast and is roughly 18km from the Mancherial Centre (Fig. 1). The research study area is between 19^o 00' to 19^o10' North latitudes and between 79^o 25' to 79^o 35' East longitudes. The overall geographical area encompassed is 425 km².

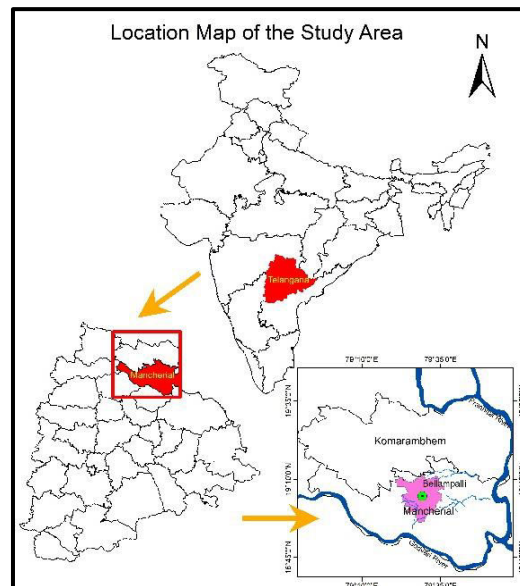


Fig. 1. Geographical representation of the study area.

The hydrological conditions of the Bellampalli area are favourable for the part of this area, most of the area is composed of hard rock sandstone of Gondwana Super Group [10]. The litho-logs [11] also conclude the study area contains sandstone, shale, interbedded with clay and coal.

This study aimed to identify the zones with high GWP in Bellampalli using geospatial techniques. The specific objectives were: (1) to prepare thematic maps of land use, geology, slope, geomorphology, lineament density and drainage density; (2) to assign weightages to each theme based on their importance for groundwater occurrence; and (3) to use GIS to incorporate thematic maps and analyze groundwater potential zones (GWPZ).

II. DATA AND METHODS

The results of the current research were obtained by employing satellite images obtained from Landsat-8 TM and SRTM. These images were taken from the USGS website and gathered. The geology map of the research region was derived from a resource map that was published in GSI, Kolkata (2005). This map was referred to compile the geology map of the study area. The ERDAS 9.2 programme was used to perform image-to-image registration, which enabled the GSI resource map to become registered. Following the completion of the registration, the registered resource map was imported into ArcGIS 10.5 software, where the geological features were further digitized.

The Pranhita Godavari subbasin's northernmost region is the area bounded by Bellampalli. Talchir, Barakar, Barren Measure, Raniganj, Maleri, and Bheemaram formations are all examples of Gondwana rocks in this region. Most of the study area is composed of sandstone, shale, little amount of limestone and basalts in the western part of the area. Fig. 2 illustrates the lithology of the research region.

The basement in this region is made up of Proterozoic rocks, which make up the Pakhal and Sulluvai groups. Along the western edge, these sediments are mostly exposed. The south-central region also exposes an outlier of Proterozoic rocks. The quartzites, phyllites, grey shales, coarse-grained sandstone, and mottled shales make up the Proterozoic rocks.

The data from Landsat-8 TM were used to compile the geomorphology map. There is a reference to the geomorphology of the study region in the Indian geomorphological thematic map that was created at the National Remote Sensing Centre in Hyderabad. This reference states that the geomorphologies of the research region were categorized by utilizing the supervised classification technique in the ERDAS 9.2 programme. In particular, the maximum likelihood classification was used, which is a classification approach that is highly useful in determining landforms.

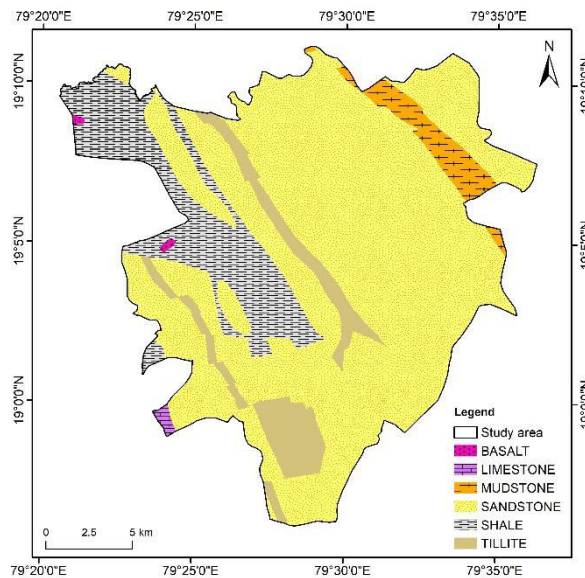


Fig. 2. illustrates the geology of the study area.

Numerous geomorphic features were mapped (Fig. 3) for this analysis based on the interpretation of satellite images and the SOI toposheet. Denudation Hills, which comprise 1.90 km² in the research area, are the geomorphic features in the study area. A total of 27.20 km² is covered by structural hills, 2.83 km² by plateaus, 377.52 km² by the Pediment Pediplain Complex, and 15.50 km² by rivers and other bodies of water.

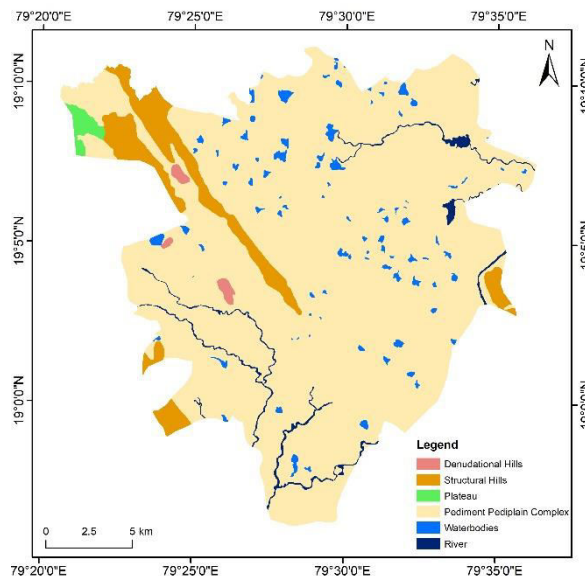


Fig. 3. illustrates the Geomorphology of the study area.

LULC are important factors that affect the environmental and socio-economic conditions of a region. LU refers to the human activities that take place on a specific area of land, such as agriculture, forestry, urbanization, etc. LC refers to the earth's surface's physical characteristics, such as vegetation, water, soil, etc. The LULC of the research area were categorized by utilizing the supervised classification technique approach that is highly useful in defining the classification.

The categorized LULC classes in the study area (Fig. 4) are agricultural land comprise of 244.15 km², barren land covering 15.76km², buildup area covering 25.74 km², forest land by 82.55 km², forest plantation by 35.78 km² and river and water bodies are covered by 130 km².

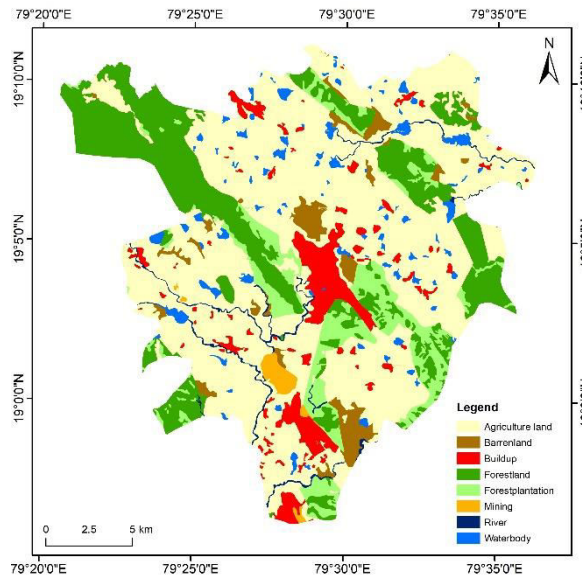


Fig. 4. Land use Land Cover map of the study area.

The slope map is a useful tool for analyzing the terrain and its suitability for various purposes. To create the slope map, we used data from the SRTM-DEM, which provides high-resolution elevation information for most of the world. The slope map shows the angle of the terrain surface in degrees, with higher values indicating steeper slopes.

The slope is an important factor that affects the groundwater prospects in a region. Slope determines the direction and rate of surface runoff, infiltration, and recharge of groundwater. Generally, areas with gentle slopes have better groundwater prospects than areas with steep slopes, as they allow more time for water to percolate into the soil and aquifers. The slope map of the research region is shown Fig. 5.

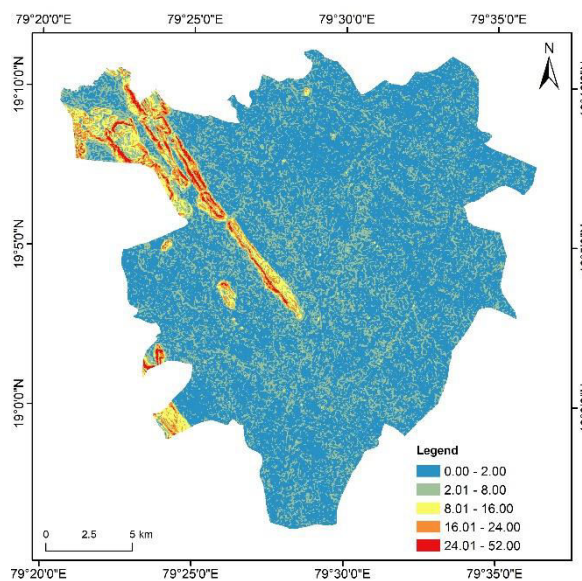


Fig. 5. illustrates the slope of the study area.

Using many different automated lineament extraction techniques, the lineament of the research region was extracted from the satellite image. The satellite data was worked on using certain preprocessing techniques, and then they were turned into a PCA using the ERDAS 9.2 programme. This was done before the lineament was extracted. After that, the PCA image was imported into ArcGIS 10.5 programme, and the lineament was investigated with the help of a tool that extracts lineaments. After that, the extracted lineament was imported into the ArcGIS 10.5 programme so that the lineament density map could be created. To calculate the lineament density, the line density tool must first be used.

After conducting an in-depth analysis of the values that were acquired, the collected information was separated into the following five categories: Very low (lineament density of less than 0.27 km/km²), Low (0.28 km/km² to 0.77 km/km²), Moderate (0.78 km/km²-1.37 km/km²), High (1.38 km/km²-2.10 km/km²), and very high (above 2.11 km/km²). Fig. 6 shows the lineament density map that was calculated.

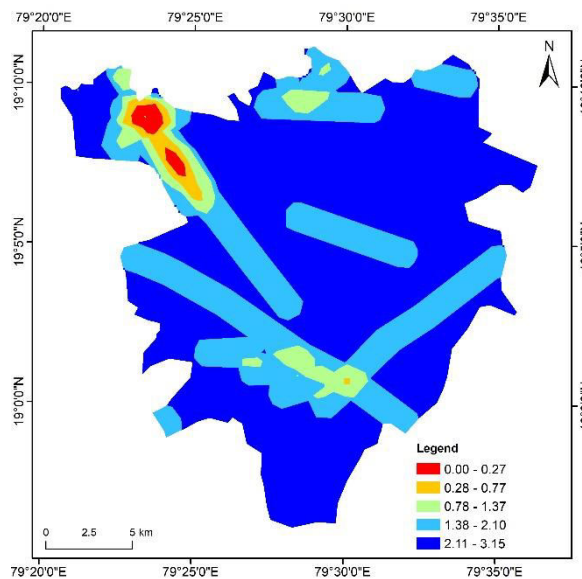


Fig. 6. Illustrates the drainage density map of the study area.

From the SRTM data, with the assistance of automated drainage extraction techniques, in particular, those found in the hydrology tools of ArcGIS 10.5, the drainage of the study region was investigated. The drainage density is then derived with the use of a tool called the line density tool.

Drainage density can be used to identify potential areas of groundwater production and recharge or to assess the hydrologic response of a watershed. High effluent density indicates low infiltration capacity, high runoff and low groundwater potential. Low effluent density means high infiltration, low runoff and high groundwater potential. Drainage density can be influenced by various factors such as climate, geology, topography, soil, vegetation and human activities. The distribution of different classes of drainage density in the study area is shown in Fig. 7.

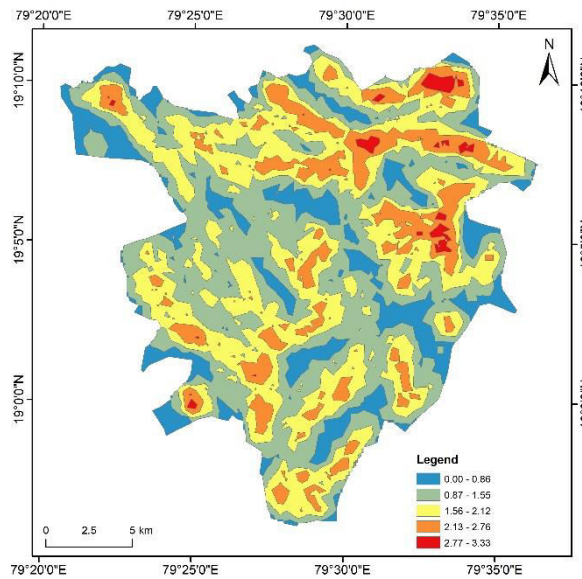


Fig. 7. shows the drainage density of the study area.

III. RESULTS AND DISCUSSION

ArcGIS 10.5 was used to assist in the delineation of the groundwater potential zones. Geomorphology, Geology, LULC, Slope, drainage density and lineament density are the types of criteria that are taken into consideration while attempting to determine groundwater potential zones. Appropriate weightage factors were awarded for each category of the criteria that were taken into consideration (Table 1). The sandstone rocks were given the greatest weightage among the major geological units. In geomorphic landforms, weightage factors were allocated based on their capacity to store water. Landforms such as pediments and pediplain, water bodies and rivers were given the greatest weightage factors, while lesser weightage values were provided in the dissected hills and valleys. In the slope classification highest value is given lower degree values and the lowest value is allotted to the highest degree value. Based on water-bearing capacity, assigned the highest weightage value in the Land use land cover classification. i.e., rivers/water bodies, forest land and forest plantation. The lowest weightage values are assigned to buildup areas and mining areas. Within the drainage density classifications, the extremely low drainage density group was given a greater weightage factor than the other categories. Because these extremely low drainage density class variables have more infiltration than surface runoff, greater values have been assigned to this group. Lower values were awarded to drainage density classes with lower drainage volumes, followed by density classes with intermediate drainage volumes, and the lowest values were given to drainage density classes with larger drainage volumes. The extremely high lineament density category was given higher values than the other lineament density classes since this category has a better probability of groundwater penetration.

Table 1 Assigned weights of thematic layer classes for groundwater potential zones

Parameters	Classes	Groundwater Prospects	Rank
Geomorphology	River & Active floodplain	Very Good	1
	Waterbodies & Dam and Reservoir	Good	2
	Pediment Pedi plan Complex	Moderate	3
	Active Quarry & Denudational Hills	Poor	4
	Structural Hills	Very Poor	5
Geology	Sandstone	Very Good	1
	Limestone	Good	2
	Mudstone	Moderate	3
	Tillite	Poor	4
	shale/Granite	Very Poor	5
	0.00 - 0.27	Very Poor	5

Lineament Density	0.28 - 0.77	Poor	4
	0.78 - 1.37	Moderate	3
	1.38 - 2.10	Good	2
	2.11 - 3.15	Very Good	1
LULC	River /Water bodies	Very Good	1
	Forest land / Forest Plantation	Good	2
	Agriculture land	Moderate	3
	Barren land	Poor	4
	Buildup / Mining	Very Poor	5
Slope	0.00 – 2.00	Very Good	1
	2.01 – 8.00	Good	2
	8.01 – 16.00	Moderate	3
	16.01 – 24.00	Poor	4
	24.01 – 52.00	Very Poor	5
Drainage Density	0.00 - 0.86	Very Good	1
	0.87 - 1.55	Good	2
	1.56 - 2.12	Moderate	3
	2.13 - 2.76	Poor	4
	2.77 - 3.33	Very Poor	5

The weighted overlay technique in ArcGIS software was used to integrate the layers of different parameters with their assigned weightage values and delineate the GWPZs. Fig. 8 shows the model builder for the GWPZ analysis.

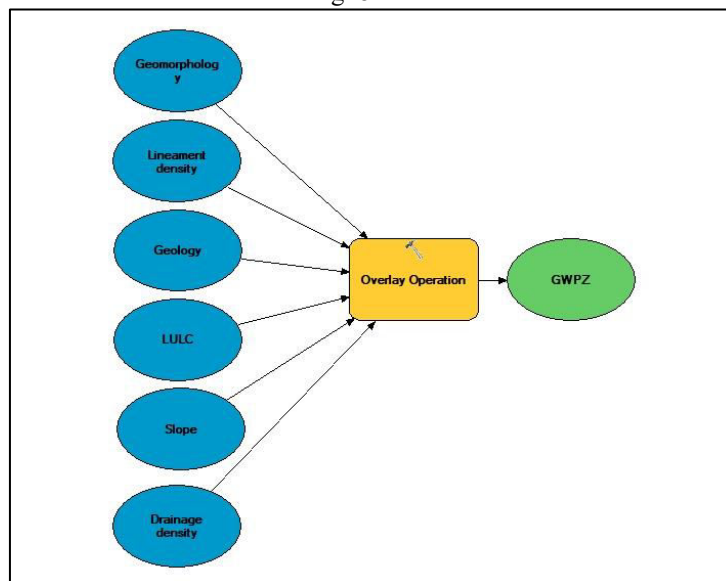


Fig. 8. illustrates the Integrated overlay analysis.

The GWPZ of the study area was derived by integrating the reclassified layers of various thematic maps. The reclassified layers were assigned different weights and ratings based on their influence on groundwater occurrence and movement. The weighted overlay analysis was performed to combine the reclassified layers and produce a groundwater potential map. The map was divided into five categories: very good, good, moderate, poor and very poor, indicating the relative suitability of the area for groundwater exploration. The spatial distribution of these zones is shown in Fig. 9.

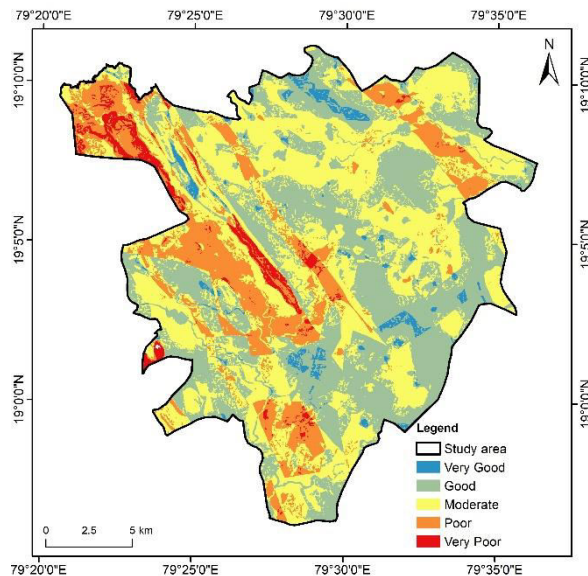


Fig. 9. Groundwater Prospects map of the study area.

IV. CONCLUSION

The final output came from the integrated analysis, very good potential zones are found in the north and some parts of SE which are covered with sandstone origin, covered an area of 9.50% i.e., 40.38km² of the study area. The study area has good GWPZs in the highest part, which covers an area of 47.82% i.e., 203.23 Km². These zones are distributed throughout the study area in sandstone and pediment PEDI plan complex origin. A moderate GWPZ that covers an area of 31.46% (133.71 Km²). This zone is distributed throughout the study area and indicates a moderate possibility of groundwater availability. The study area exhibits poor groundwater potential in the NE and SW to NW regions, which comprise 10.26 % (43.60 Km²) of the total area. These regions have unfavorable hydrogeological conditions that limit the availability and recharge of groundwater resources. The Very poor groundwater potential of the study area is in the northwest region, where it covers only 0.96% (4.08 km²) of the total area. This is due to the geological and hydrological characteristics of the region.

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