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RESEARCH ARTICLE OPEN ACCESS

Identification Of Groundwater Potential Zones Of Barpeta District By Using GIS/Remote Sensing Techniques And AHP

Nayan jyoti pegu[1],Dr Pankaj Goswami [2]

1(M.Tech Student, Department of Civil Engineering, Assam Engineering College, Jalukbari, Guwahati
Email: nayanjyotipegu030@gmail.com)

2 (Professor, Department of Civil Engineering, Assam Engineering College, Jalukbari, Guwahati
Email: pgoswami31@rediff.com)

Abstract:

A GIS-based groundwater potential assessment model was developed for Barpeta District using geospatial techniques and the Weighted Overlay Method. The main objective of the study is to identify groundwater potential zones for sustainable water resource planning and management. Multiple thematic layers such as slope, drainage density, soil type, rainfall, geomorphology, land use/land cover, and lineament density were prepared from SRTM DEM and satellite datasets. These layers were processed in ArcGIS by assigning suitable weights and ranks to generate the Groundwater Potential Index (GWPI) and to determine the most suitable groundwater potential zones. For the entire study area, regions having gentle slope, permeable soil, agricultural land cover, and lower drainage density were found to be the most favorable groundwater zones, mainly concentrated in the central and northern parts of the district; in contrast, areas with steep slope and higher drainage density exhibited comparatively lower groundwater potential..

Keywords —District, Groundwater potential assessment, GIS, Weighted Overlay Method, GWPI-Groundwater Potential Index , ArcGIS, SRTM DEM, Remote sensing, Drainage density, Lineament density, Geomorphology, LULC- Land use/Land cover Soil type, Rainfall analysis, Sustainable groundwater management, Groundwater recharge zones.

I. INTRODUCTION

Groundwater potential assessment is a scientific method used to identify suitable zones for groundwater occurrence and sustainable water resource utilization. Geospatial techniques and GIS analysis help improve the accuracy of groundwater evaluation and resource planning. Barpeta District has been selected as the study area for the present investigation. It is situated in the western part of Assam on the northern bank of the Brahmaputra River within Barpeta district. The assessment was carried out using thematic layers prepared from SRTM DEM and satellite datasets for evaluating groundwater potential conditions across the region.

II. STUDY AREA

The Barpeta District is situated in the lower Brahmaputra Valley of Assam and extends approximately between latitude 26°05′ N to 26°49′ N and longitude 90°39′ E to 91°17′ E. The district covers an area of nearly 3,245 km² and has its administrative headquarters at Barpeta town (Fig. 3.1). Geographically, the region is characterized by fertile alluvial plains formed by the Brahmaputra River and its tributaries, resulting in predominantly flat to gently undulating terrain with a few low hillocks in the southwestern part. Administratively, the district comprises several revenue circles and development blocks including Barpeta, Baghbor, Kalgachia, Sarbhog, Chenga, Mandia, and Howly, which support decentralized administration and regional planning. The district experiences a tropical monsoon climate with high annual rainfall, significantly influencing hydrology, flood conditions, agriculture, and groundwater recharge potential across different parts of the region

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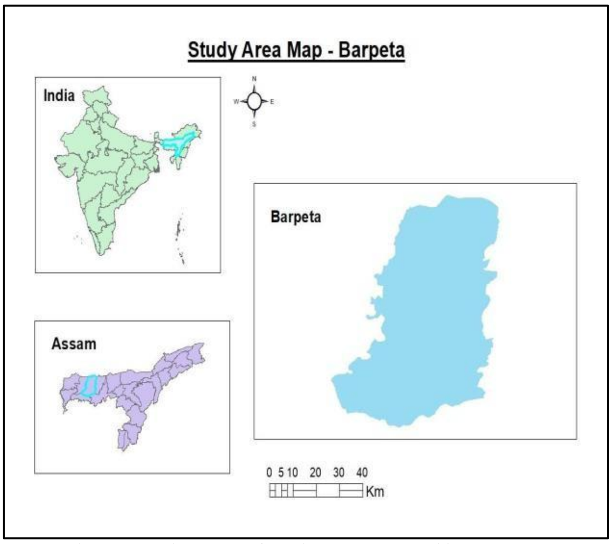

Fig. 1 Location Map of Study Area prepared by Arc-GIS

III. MATERIALS AND METHODOLOGY

Topographical and satellite-based datasets used for the preparation of thematic layers were collected from SRTM DEM, remote sensing imagery, and secondary data sources. Rainfall and soil information were obtained from published reports and government databases. The thematic layers including slope, drainage density, geomorphology, soil type, rainfall, lineament density, and land use/land cover were processed and analysed in ArcGIS environment for groundwater potential assessment.

TABLE 1
THEMATIC LAYERS USED FOR GROUNDWATER POTENTIAL ANALYSIS

Sl. No.	Thematic Layer	Data Source	Purpose
1	Slope	SRTM DEM	Surface runoff analysis
2	Drainage Density	DEM derived	Infiltration assessment
3	Soil Type	Secondary data	Permeability analysis
4	Rainfall	Meteorological data	Recharge assessment
5	Geomorphology	Satellite imagery	Landform characterization
6	LULC	Remote sensing data	Surface condition analysis
7	Lineament Density	Satellite imagery	Groundwater movement analysis

The thematic layers were reclassified according to their influence on groundwater occurrence. Weightages were assigned to each parameter based on their relative contribution toward groundwater recharge and storage conditions.

A. Preparation of Thematic Layers

(i) Slope Map

Slope was derived from SRTM DEM using ArcGIS spatial analysis tools. Lower slope regions were considered favourable for groundwater infiltration, whereas steep slopes were associated with higher runoff and lower recharge potential.

(ii) Drainage Density Map

Drainage density was generated from the drainage network extracted using DEM analysis. Areas with low drainage density were considered suitable for groundwater accumulation due to increased infiltration capacity.

(iii) Soil Map

Soil data were classified according to permeability characteristics. Permeable soils were assigned higher ranks because they facilitate groundwater recharge.

(iv) Land Use/Land Cover Map

LULC classification was prepared from satellite imagery. Agricultural land and vegetation cover were considered favourable for infiltration, while built-up areas showed relatively lower groundwater potential.

(v) Geomorphology Map

Geomorphological features were interpreted from satellite datasets. Flood plains and alluvial formations were identified as highly suitable zones for groundwater occurrence.

(vi) Lineament Density Map

Lineament density was extracted from satellite imagery and geological interpretation. Areas with higher lineament density were considered favourable due to enhanced groundwater movement through fractures and joints.

(vii) Rainfall Map

Rainfall distribution data were incorporated for evaluating recharge conditions. Areas receiving comparatively higher rainfall were assigned greater suitability for groundwater potential.

B. Weighted Overlay Analysis

The groundwater potential assessment was carried out using the Weighted Overlay Method in ArcGIS. Each thematic layer was assigned suitable weights and ranks according to its significance in groundwater occurrence. The weighted thematic layers were integrated to generate the Groundwater Potential Index (GWPI).

The weighted overlay analysis can be expressed as:

$$GWPI = \sum_{i=1}^{n} (W_i \times R_i)$$

Where,
Wi = Weight assigned to each thematic layer
Ri = Rank assigned to individual classes of the thematic layer

C. Classification of Groundwater Potential Zones

The final groundwater potential map was classified into five categories:

1. Very High
2. High
3. Moderate
4. Low
5. Very Low

The classification was carried out based on the Groundwater Potential Index values obtained from weighted overlay analysis.

D. Software Used

The spatial analysis and map preparation were performed using the following software:

(i) ArcGIS
(ii) Google Earth Pro
(iii) Microsoft Excel

E. Output Preparation

The final groundwater potential zonation map was prepared after integrating all thematic layers in GIS environment. The map highlights spatial variation in groundwater availability across the study area and provides useful information for groundwater management, recharge planning, and sustainable utilization of water resources.

IV RESULTS AND DISCUSSIONS

A . Slope Map Result and Interpretation

The slope map of Barpeta District was prepared from SRTM DEM using the Spatial Analyst tool in ArcGIS and subsequently reclassified into different slope categories (Figure 5.1). The slope layer was categorized into five classes representing variations in terrain characteristics across the district.

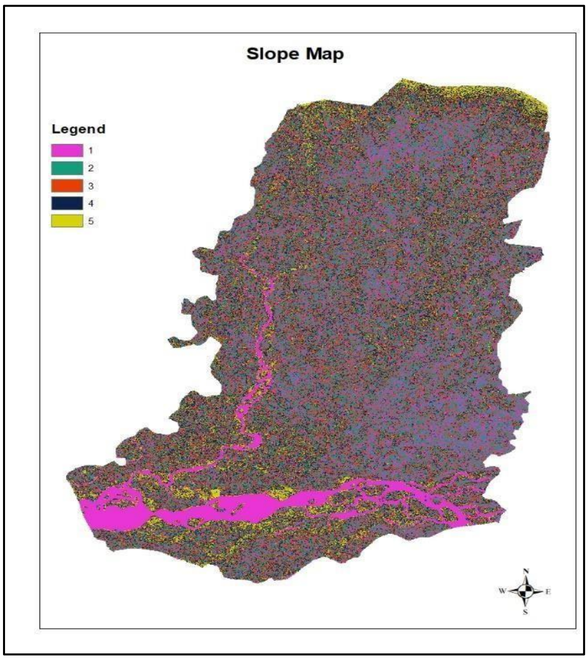

Figure 2 Reclassified Slope Map of Barpeta District

Results

The spatial distribution of slope classes indicates that very gentle slope (0–3°) occupies the major portion of the district, representing the extensive alluvial plains of Barpeta. Gentle slope (3–5°) occurs in limited portions around elevated floodplain surfaces, whereas moderate slope (5–10°) appears only in scattered patches. Steeper slopes (>10°) are restricted mainly to the northern margin near foothill transition zones. Overall, flat terrain dominates most agricultural and floodplain areas of the district.

Interpretation

Slope strongly influences infiltration and runoff processes controlling groundwater recharge. Very gentle slopes promote higher infiltration and lower runoff, resulting in favourable groundwater conditions. Moderate slopes allow moderate recharge conditions, whereas steep slopes generate rapid runoff and comparatively poor groundwater recharge. The dominance of low slope classes across Barpeta district indicates favourable natural conditions for groundwater accumulation and recharge.

B Land Use/Land Cover (LULC) Map Result and Interpretation

The land use/land cover map of Barpeta District was prepared using satellite imagery in ArcGIS for the year 2024 (Figure 5.2). The classified map includes major land cover categories such as water bodies, vegetation, cropland, built-up area, bare land.

Results

The LULC analysis shows that agricultural land occupies the largest portion of the district. Vegetation cover is concentrated mainly in northern and floodplain regions, while built-up areas are distributed around settlement centres and transportation corridors. Water bodies are associated with the Brahmaputra River and seasonal wetlands. Bare land and sandy areas occur near riverine tracts and sandbar regions

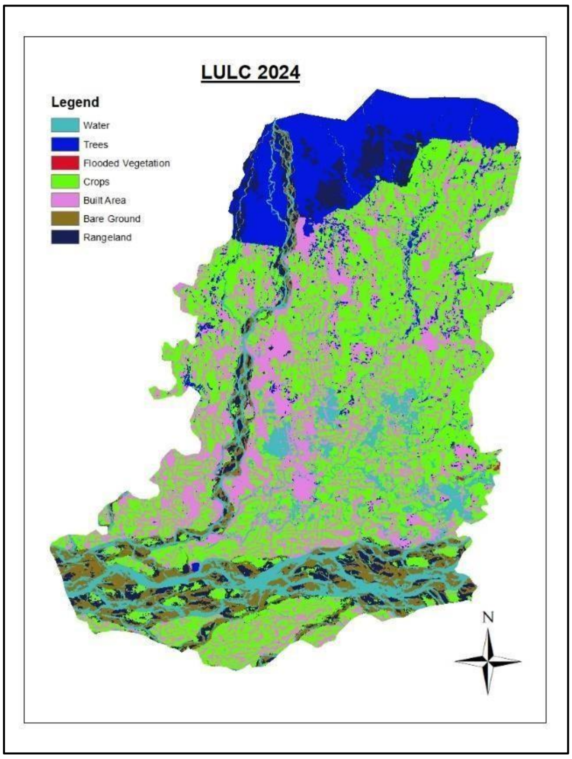

Figure 3 Land Use/Land Cover Map of Barpeta District

Interpretation

Land use pattern significantly affects groundwater recharge capability. Agricultural land and vegetation support better infiltration and groundwater recharge, whereas water bodies and wetlands enhance aquifer recharge conditions. Built-up areas reduce infiltration due to impervious surfaces. Bare surfaces exhibit variable recharge characteristics depending on sediment type. Thus, agricultural plains and vegetated floodplains represent favourable groundwater potential zones in the district.

C Drainage Density Map Result and Interpretation

The drainage density map of Barpeta District was generated from DEM-derived stream networks in ArcGIS (Figure 5.3). The map was classified into five drainage density categories ranging from very low to very high.

Results

The drainage density distribution reveals that low and very low drainage density dominate central and southern parts of the district. Moderate drainage density occurs within transitional floodplain zones, while high drainage density is confined to localized river corridors and northern uplands. Very high drainage density is limited to small dissected terrain patches

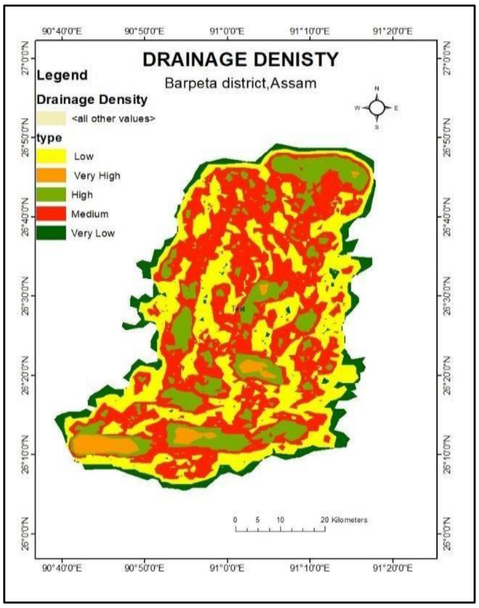

Figure 4 Drainage Density Map of Barpeta District

Interpretation

Drainage density is inversely related to groundwater infiltration. Low drainage density indicates higher infiltration and better groundwater recharge, while moderate drainage density reflects balanced runoff and recharge conditions. High drainage density leads to rapid surface runoff and lower infiltration. The predominance of low drainage density across Barpeta district supports favourable groundwater recharge conditions.

D Soil Map Result and Interpretation

The soil texture map of Barpeta District was prepared using FAO soil datasets and processed in ArcGIS (Figure 5.4). Major soil classes identified include sandy soil, sandy loam, loam, clay loam, and clayey soil.

Results

The soil distribution pattern indicates that sandy loam and loam soils dominate most of the agricultural plains. Clayey soils are concentrated mainly in southern wetland areas, while sandy soils occur near river channels and newly deposited alluvium. Clay-loam soils appear in transitional

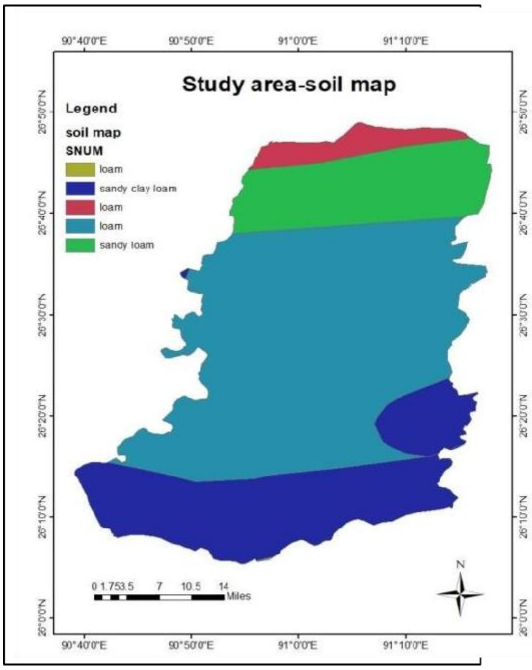

Figure 5. Soil Texture Map of Barpeta District

Interpretation

Soil texture directly controls groundwater recharge capacity. Sandy and sandy-loam soils favour rapid infiltration and high recharge, while loam soils support moderate to good groundwater potential. Clayey soils restrict infiltration and reduce recharge potential. The dominance of alluvial sandy-loam and loam soils enhances groundwater availability in central Barpeta district.

E Rainfall Map Result and Interpretation

The rainfall distribution map of Barpeta District was prepared using long-term rainfall data and spatial interpolation techniques in ArcGIS (Figure 5.5).

Results

The rainfall analysis shows that northern parts of the district receive comparatively higher rainfall. Central regions experience moderate to high rainfall conditions, while southern regions receive relatively moderate rainfall. The district as a whole experiences humid climatic conditions favourable for groundwater recharge

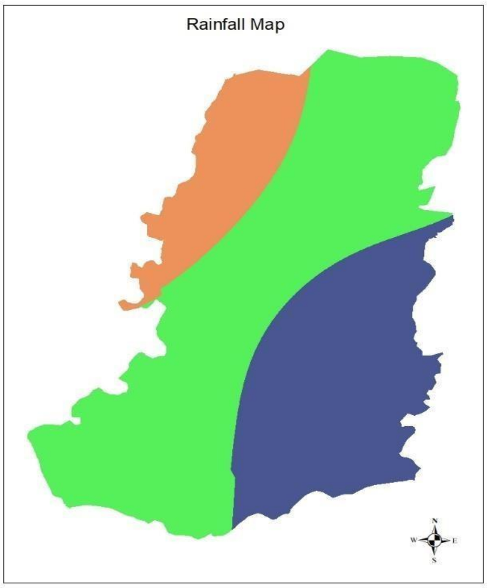

Figure 6 Spatial Distribution of Annual Rainfall in Barpeta District

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Interpretation

Rainfall acts as the principal source of groundwater replenishment. High rainfall zones contribute significantly to recharge, while moderate rainfall areas support seasonal recharge conditions. Uniform rainfall distribution across Barpeta enhances regional groundwater potential and supports natural aquifer recharge throughout the district.

F . Weightage of Thematic Factors

The thematic layers influencing groundwater occurrence were assigned relative weights using the Analytical Hierarchy Process (AHP). The assigned weights reflect the significance of each factor in controlling groundwater recharge and storage conditions.

Factor	**Weight (%)**	**Relative Importance**
Slope	30	Highest
Drainage Density	25	Very High
Soil	20	Moderate
LULC	15	Moderate
Rainfall	10	Lower

The total assigned weight equals 100%.

Interpretation

Slope and drainage density received the highest weights because they strongly control runoff and infiltration. Soil and land use influence percolation and recharge behaviour, whereas rainfall received lower weight due to comparatively uniform rainfall distribution across the district.

G Final Groundwater Potential Zones

The final groundwater potential zonation map of Barpeta District was prepared through weighted overlay analysis in ArcGIS by integrating all thematic layers.

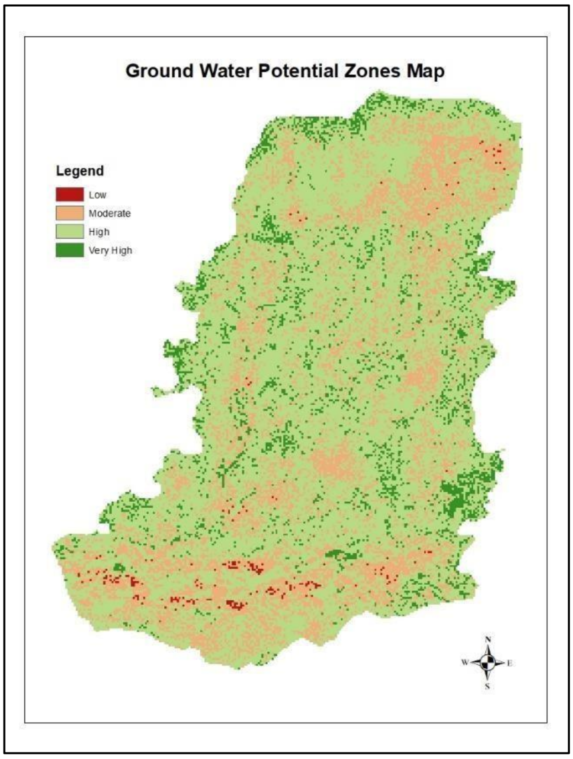

Figure 7 Final Groundwater Potential Zone Map of Barpeta District

The groundwater potential map was classified into four categories: Very High, High, Moderate, and Low.

i) Very High Potential Zone

These zones are concentrated mainly in central alluvial plains characterized by low slope, low drainage density, permeable soil, and agricultural land cover.

ii) High Potential Zone

High potential regions surround the very high zones and exhibit favourable recharge characteristics with moderate infiltration conditions.

iii) Moderate Potential Zone

Moderate zones occur in transitional areas showing mixed topographic and land cover conditions.

iv) Low Potential Zone

Low potential zones are associated with higher runoff, denser drainage networks, and relatively unfavourable recharge conditions.

G Area Statistics of Groundwater Potential Zones

The areal distribution of groundwater potential zones was calculated using zonal statistical analysis in ArcGIS.

Groundwater Potential Zone	Area (sq. km)	Percentage (%)
Low	175.84	0.54
Moderate	751.27	23.49
High	2159.70	67.53
Very High	269.53	8.42

The analysis indicates that a major portion of the district falls under high groundwater potential category.

H Validation of Groundwater Potential Map

The groundwater potential zonation map was

validated using groundwater level observations and secondary hydrogeological information.

Results

High and very high potential zones correspond with shallow groundwater conditions. Moderate zones exhibit seasonal recharge characteristics, whereas low potential zones coincide with comparatively deeper groundwater levels and higher runoff areas.

Interpretation

The validation confirms that the GIS-based weighted overlay method effectively represents groundwater occurrence conditions in Barpeta District and accurately delineates favourable groundwater recharge zones.

I Discussion

The GIS–AHP based groundwater assessment approach successfully delineated groundwater potential zones across Barpeta District. The study highlights the strong influence of alluvial plains, low slope, permeable soil, and agricultural land use on groundwater recharge conditions. Slope and drainage density emerged as the most influential parameters controlling groundwater occurrence.

The generated groundwater potential map provides valuable information for sustainable groundwater management, recharge planning, groundwater exploration, and future water resource development within the district.

V CONCLUSION

For The implementation of the Multi-Criteria Decision-Making (MCDM) approach, particularly the Analytic Hierarchy Process (AHP) integrated with GIS and Remote Sensing techniques, proved effective for delineating Groundwater Potential Zones (GWPZ) across Barpeta District. The final groundwater potential map generated through weighted overlay analysis successfully identified areas having different levels of groundwater favourability within the district. The analysis revealed that High and Very High groundwater potential zones are predominantly concentrated in the southern and central floodplain regions characterized by gentle slopes, permeable alluvial deposits, and favourable land cover conditions. In contrast, Low groundwater potential zones are mainly confined to comparatively elevated and dissected upland areas where runoff is higher and infiltration capacity is lower.

The weighted overlay analysis demonstrated that geomorphology and geology were the most influential thematic parameters controlling groundwater occurrence, contributing significantly to the final groundwater potential output. The study also indicated that areas covered by vegetation, agricultural land, and water bodies exhibited comparatively higher groundwater recharge conditions due to enhanced infiltration and lower surface runoff. Conversely, built-up and settlement areas showed relatively lower groundwater potential because of impervious surfaces restricting natural recharge. The generated groundwater potential zonation map therefore provides valuable information for sustainable groundwater management, artificial recharge planning, groundwater exploration, and future water resource development within the district.

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