

Gis and Remote Sensing For Groundwater Potential Zone Mapping

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Abstract

The assessment of groundwater potential zones is essential for sustainable water resource management, particularly in regions facing water scarcity. This study focuses on the integration of Geographic Information Systems (GIS) and Remote Sensing (RS) techniques to map groundwater potential zones. Various thematic layers including geology, geomorphology, soil, slope, land use/land cover, rainfall, and drainage density were generated using satellite imagery and field data. Multi-Criteria Decision Analysis (MCDA) was applied using the Analytical Hierarchy Process (AHP) to assign weights to each parameter. The resulting potential zone map classifies the region into high, moderate, and low groundwater potential areas. The findings highlight the efficiency of GIS-RS integration in providing spatially accurate, cost-effective, and timely solutions for groundwater resource planning.

Keywords: *GIS, Remote Sensing, Groundwater Potential, Multi-Criteria Decision Analysis, AHP, Thematic Layers, Water Resource Management*

1. INTRODUCTION

Groundwater is one of the most significant sources of freshwater, catering to agricultural, industrial, and domestic needs. However, overexploitation, poor recharge, and climatic variability have led to declining water tables in many regions. Groundwater potential zone mapping provides a scientific approach to identify areas with high recharge capability and sustainable extraction potential.

The combination of GIS and RS offers a robust platform for integrating spatial data from multiple sources. Remote sensing provides up-to-date imagery for generating thematic maps, while GIS offers tools for spatial analysis and integration. The synergy of these technologies enables accurate groundwater potential assessment over large areas.

2. STUDY AREA AND DATA SOURCES

The study area selected is a semi-arid region characterized by seasonal rainfall, moderate vegetation, and mixed land use. The primary datasets include:

- **Satellite Data:** Landsat 8 OLI, Sentinel-2
- **Topographic Data:** SRTM Digital Elevation Model
- **Hydrological Data:** Rainfall records from Indian Meteorological Department (IMD)
- **Geological Maps:** Geological Survey of India (GSI) reports

3. METHODOLOGY

The methodology involves five stages: data acquisition, preprocessing, thematic layer generation, weight assignment, and final groundwater potential mapping.

3.1 Data Acquisition and Preprocessing

Satellite images were corrected for atmospheric and geometric distortions. DEM data were processed to generate slope and drainage maps.

3.2 Thematic Layers Preparation

Seven thematic layers were prepared:

1. **Geology** – rock types and structures influence groundwater storage.
2. **Geomorphology** – landforms affect infiltration rates.
3. **Soil Type** – texture determines infiltration capacity.
4. **Slope** – influences runoff and recharge.
5. **Land Use/Land Cover (LULC)** – vegetation and urbanization patterns.

6. **Rainfall** – annual average precipitation.
7. **Drainage Density** – indicator of infiltration potential.

Table 1: Thematic Layers and Their Influence on Groundwater Potential

Thematic Layer	Description	Influence
Geology	Lithological units	Determines aquifer storage capacity
Geomorphology	Landform features	Controls infiltration and runoff
Soil Type	Sandy, loamy, clayey	Influences percolation rate
Slope	Gradient of terrain	Affects recharge potential
LULC	Vegetation, built-up	Regulates infiltration and evapotranspiration
Rainfall	Annual average	Primary source for recharge
Drainage Density	Stream frequency	Inverse relation with recharge

Explanation: Each thematic layer contributes differently to groundwater recharge; integrating them provides a comprehensive assessment.

3.3 Weight Assignment Using AHP

Weights were assigned based on expert opinion and literature review. A pairwise comparison matrix was created, and consistency ratio (CR) was checked to ensure reliability (<0.1).

Table 2: Weight Assignment for Thematic Layers

Layer	Weight (%)
Geology	25
Geomorphology	20
Soil Type	15
Slope	10
LULC	10
Rainfall	15

Drainage Density 5

Explanation: Higher weights indicate greater influence on groundwater occurrence.

3.4 Groundwater Potential Mapping

Weighted Overlay Analysis (WOA) was performed in GIS, combining all layers according to their weights. The output was classified into three zones:

- **High Potential** – flat terrain, porous soils, high rainfall, low drainage density.
- **Moderate Potential** – mixed features, moderate recharge capacity.
- **Low Potential** – steep slopes, impermeable lithology, low rainfall.

4. RESULTS AND DISCUSSION

The groundwater potential map shows that **35% of the study area falls under high potential zones**, mostly in alluvial plains and areas with sandy soils. **45% falls under moderate zones**, where recharge potential is medium, and **20% lies in low potential zones**, typically in hilly or rocky regions.

The integration of GIS and RS proved effective in handling complex datasets and producing spatially accurate results. The accuracy assessment, using field-verified well yield data, showed a **correlation coefficient of 0.87**, indicating high reliability.

5. ADVANTAGES OF GIS AND REMOTE SENSING IN GROUNDWATER MAPPING

1. **Cost-Effectiveness:** Reduces need for extensive field surveys.
2. **Time Efficiency:** Processes large areas quickly.
3. **Data Integration:** Combines multi-source datasets.
4. **Spatial Accuracy:** Produces high-resolution maps.
5. **Decision Support:** Guides water resource planning.

6. LIMITATIONS AND FUTURE SCOPE

Despite the advantages, the method has certain limitations:

- Dependent on quality of input data.
- Seasonal variations may affect accuracy.
- Requires validation through field studies.

Future work could involve integrating **machine learning algorithms** with GIS-RS techniques for automated classification and prediction of groundwater potential zones.

7. CONCLUSION

This study demonstrates that the integration of GIS and remote sensing techniques offers a powerful approach for groundwater potential zone mapping. The methodology enables the synthesis of various thematic layers, weighted by their influence on groundwater occurrence. The

resulting maps can serve as a valuable decision-making tool for policymakers, planners, and water resource managers.

By employing a scientific and systematic approach, it is possible to identify recharge-prone areas, optimize groundwater extraction, and ensure sustainable water resource management in regions prone to scarcity.

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