



GIS-Based Delineation of Groundwater Potential in a Geologically Heterogeneous Environment, Using Remote Sensing, AHP, and Geophysical Data: Abuja Case Study

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Introduction

Abuja, Nigeria's capital, spans about 8,000 km² with a population exceeding 6.7 million and relies heavily on groundwater for domestic and industrial use. The city's heterogeneous geology, comprising roughly 85% basement complex and 15% sedimentary formations, poses significant challenges to groundwater development.

Previous investigations, mainly based on Vertical Electrical Sounding (VES), provided localized insights but lacked integration of key geological, structural, and climatic factors. To address this gap, this study employs a GIS-based Analytical Hierarchy Process (AHP) integrating remote sensing, geophysical, geological, and climatic datasets to delineate groundwater potential zones and support sustainable water resource planning in Abuja.

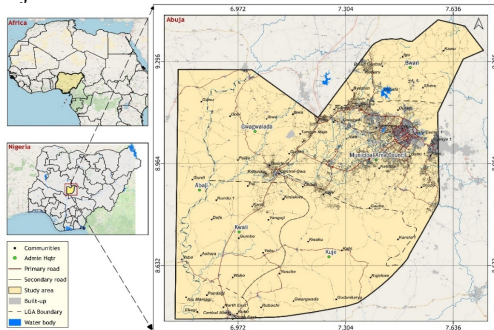


Figure 1: Location Map of Study Area

Aim

This research aims to develop a comprehensive groundwater potential map of Abuja by integrating geophysical, remote sensing, geological, and climatic datasets within a GIS framework using the Analytical Hierarchy Process (AHP) to enhance the accuracy of groundwater assessment and support sustainable water resource management.

Methods

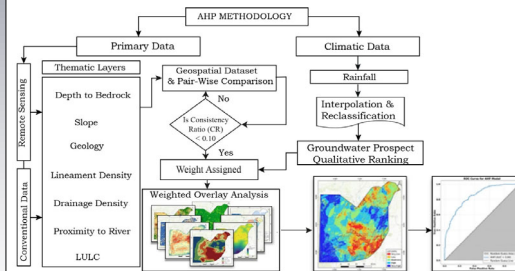


Figure 2: Methodology Flow Chat

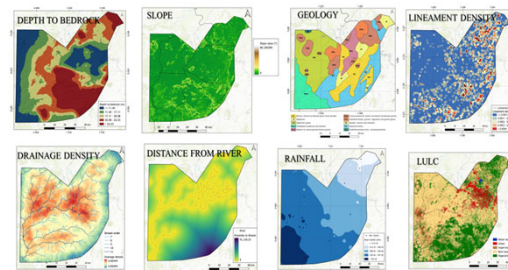


Figure 3: Thematic Layers

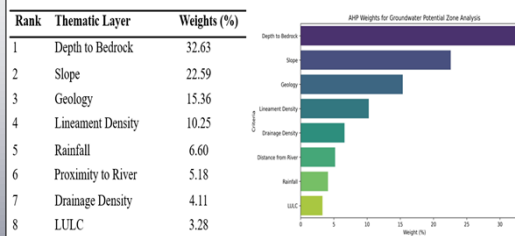


Figure 4: Thematic Layers Calculated Weights

After calculating and validating the weights for each criterion, they were applied to the reclassified raster layers to reflect their relative importance in groundwater potential assessment. Each reclassified layer was then multiplied by its corresponding weight in a weighted overlay analysis to generate the final groundwater potential map.

The groundwater potential zones Map (GPZM) was created in the GRASS GIS environment using the raster calculator by applying the equation below.

$$GPZ = \sum_{i=1}^n (W_i \times X_i)$$

Where:

GPZ = Weighted overlay output (GPZ Map).

W_i = Weight assigned to factor i

X_i = Standardized raster value of factor i

n = Number of layers (criteria).

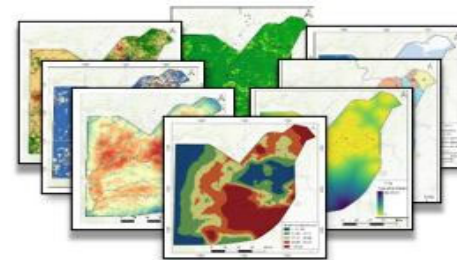


Figure 5: Weighted Overlay Analysis

Results

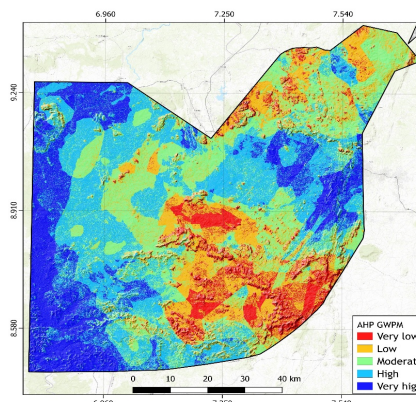


Figure 6: Groundwater Potential Zone Map

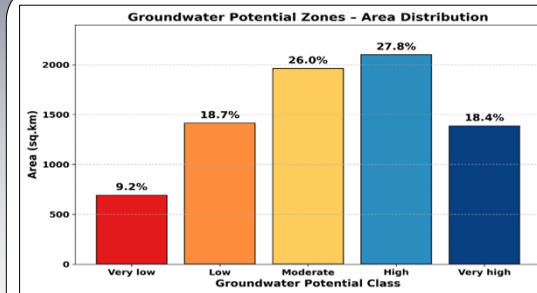


Figure 7: Graphical Distribution of the Zones

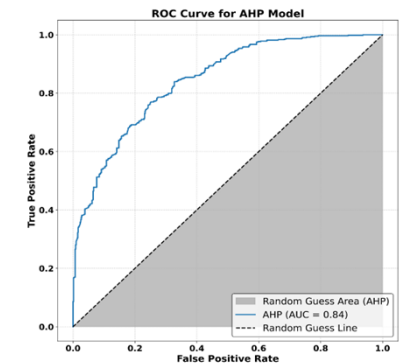


Figure 8: ROC-AUC Curve for AHP

Conclusions

Groundwater potential zones in Abuja were mapped using the above-mentioned method, the final map delineates five classes of groundwater potential, with very high zones concentrated in the south-western and eastern margins, reflecting favourable hydrogeological conditions. Validation analysis using borehole yield data produced an AUC of 0.84, indicating strong predictive performance.

Bibliography

AIIC (2009) Abuja investor guide 2009 – 2010. A publication of the Abuja Infrastructure Investment Centre (AIIC).
Saaty, TL (1980) The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation. Newyork