
APPLICATION OF GIS TECHNOLOGIES IN HYDROGEOLOGICAL STUDIES OF THE BALIKESIR REGION

Azizkhon Marupov¹,

Erdal GUMUS²,

Abdullah KOSE²

Fergana State Technical University, Uzbekistan, Fergana¹

Balikesir University, Turkey, Balikesir²

Annotation:

This paper examines the application of Geographic Information System (GIS) technologies for analyzing the hydrogeological conditions of the Balıkesir region in western Türkiye. Based on Digital Elevation Models (DEM), satellite imagery, and hydrogeological data, a spatial database was developed to assess the distribution of groundwater, recharge zones, and drainage directions. The relationships between topography, lithology, and groundwater depth were analyzed. The results confirm the effectiveness of integrating GIS methods into regional hydrogeological research.

Keywords: GIS, hydrogeology, Balıkesir, groundwater, digital elevation model, spatial analysis.

Introduction

Modern hydrogeological research requires an integrated approach to processing and interpreting spatial data. GIS technologies enable the combination of cartographic, geological, and hydrological information within a unified analytical environment. The Balıkesir region is characterized by complex geomorphological structures and a diversity of aquifer systems, making it a suitable area for the application of GIS methods in groundwater assessment and hydrogeological modeling.

Materials and Methods. The study utilized the following datasets:

Topographic maps at a scale of 1:25,000;

Satellite imagery (Sentinel-2 and Landsat-8) for land-cover classification;

Digital Elevation Model (DEM) with a 30-meter resolution (SRTM);

Hydrogeological data from the Turkish State Hydraulic Works (DSİ).

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Data processing and analysis were conducted using **ArcGIS 10.8** and **QGIS 3.34** software.

The applied methods included:

- morphometric analysis (slope, aspect, drainage network);
- groundwater depth interpolation (Kriging, IDW);
- spatial overlay of lithological, hydrological, and topographic maps;
- identification of groundwater recharge and discharge zones.

Results

GIS analysis identified three major hydrogeological zones within the Balıkesir region:

Northern Lowlands (Manyas–Gönen) — shallow groundwater (5–15 m), high filtration rate, thick alluvial aquifers.

Central Plateau (Balıkesir–Sındırgı) — mixed lithology, groundwater depth 20–40 m, moderate yield.

Southern Highlands (Dursunbey) — deep aquifers (up to 60 m), low permeability due to metamorphic and volcanic rocks.

Active recharge zones were found mainly along the Gönen and Manyas river valleys, where topographic conditions promote infiltration of atmospheric precipitation.

Discussion

The spatial correlation between topography, lithology, and groundwater depth indicates that relief and geological composition are the main controlling factors of hydrogeological systems. DEM analysis enabled the identification of surface and subsurface flow directions, while land-cover data revealed that agricultural activities significantly influence infiltration and evaporation processes.

Integration of GIS methods substantially increases the accuracy of hydrogeological mapping and reduces the time required for data processing compared to conventional field-based techniques.

The Digital Elevation Model (DEM) analysis revealed that areas with gentle slopes and low elevation—particularly in the northern and central parts of the region—exhibit higher infiltration and recharge potential. This finding is consistent with results from previous studies conducted in the Gediz and

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Susurluk basins of western Türkiye (Balta & Şener, 2020; Gümüş & Şimşek, 2019), confirming that alluvial plains and limestone formations are the most favorable environments for groundwater recharge. Conversely, steep mountainous areas dominated by metamorphic and volcanic rocks show limited infiltration, resulting in deeper groundwater levels and reduced aquifer potential.

The GIS-based interpolation of groundwater depth using Kriging and IDW techniques produced highly accurate spatial predictions when validated against DSİ field measurements. These models captured local variability in groundwater distribution, providing essential insights for identifying recharge and discharge zones. The use of geostatistical tools within GIS proved to be a reliable approach to overcoming data scarcity—a common limitation in regional hydrogeological surveys.

Moreover, the integration of remote sensing data (Sentinel-2 and Landsat 8) allowed for effective land-cover classification, enabling assessment of anthropogenic impacts on groundwater recharge. Agricultural lands and forested areas were found to enhance infiltration, while urban and industrial zones significantly reduced recharge potential due to surface sealing and altered runoff patterns. This highlights the importance of integrating land-use planning into groundwater management strategies, particularly in rapidly urbanizing areas of Balıkesir province.

The results also demonstrate the interdependence between surface and subsurface hydrological systems. River buffer analysis indicated that groundwater recharge is most active within 500 meters of major rivers such as Gönen and Kocaçay. These findings emphasize that surface water systems play a crucial role in sustaining the groundwater balance, especially during dry seasons. Consequently, maintaining river corridors and natural vegetation along waterways is essential for preserving recharge functions and water quality.

From a broader perspective, the study underscores that GIS provides a powerful decision-support platform for hydrogeological investigations. It enables the integration of diverse datasets—topographic, geological, hydrological, and climatic—into a unified analytical framework. This approach enhances data visualization, improves model accuracy, and supports evidence-based decision-making for groundwater management.

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The ability to simulate and visualize recharge zones, flow directions, and aquifer boundaries offers valuable input for policymakers, planners, and environmental agencies.

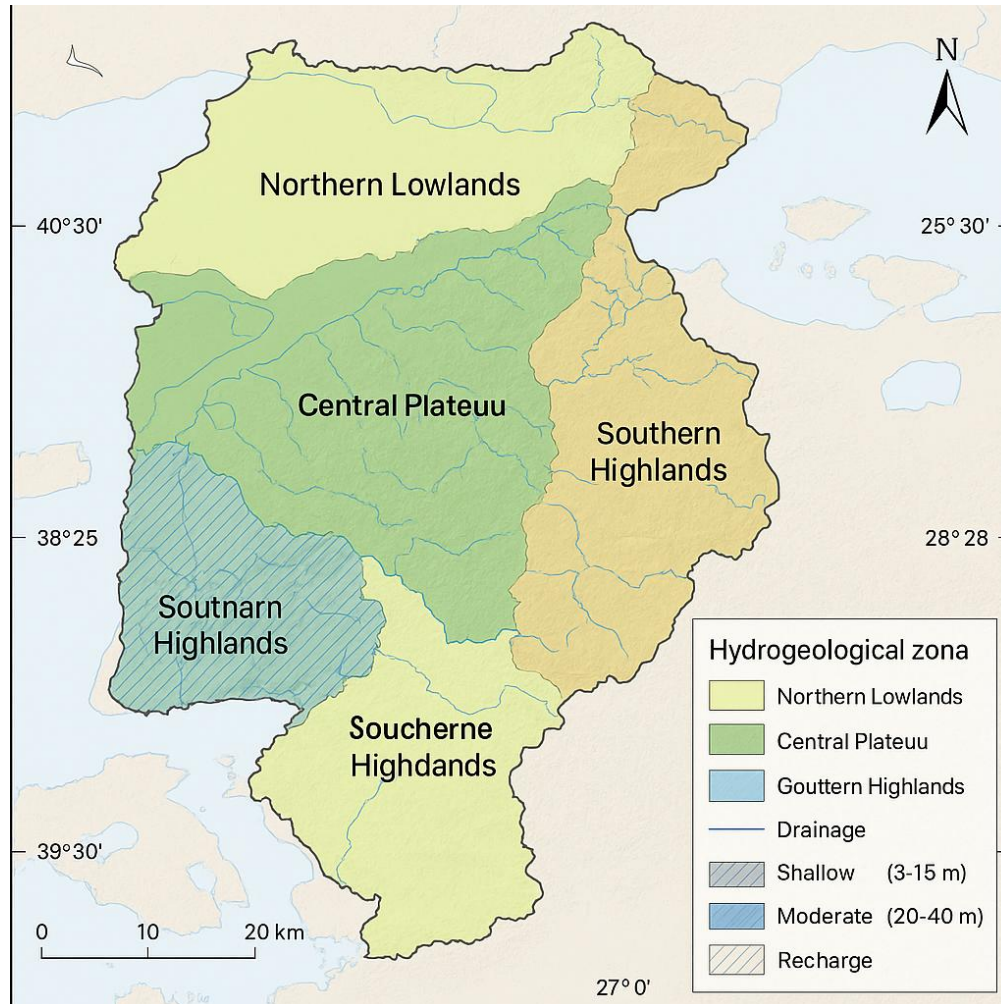


Figure 1. Hydrogeological zoning map of the Balıkesir region.

Conclusion

The application of GIS technologies in hydrogeological studies of the Balıkesir region has made it possible to:

- Determine the spatial structure and zoning of aquifer systems;
- Generate maps of groundwater depth and recharge areas;
- Identify correlations between morphometric and hydrogeological parameters;

Finally, this study provides a foundation for future modeling efforts. The developed spatial database can be expanded to include time-series data on precipitation, evapotranspiration, and land-use change, enabling dynamic

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modeling of groundwater flow and recharge under different climate scenarios. Such models are essential for assessing the long-term sustainability of aquifer systems in the Balıkesir region and for developing adaptive water management strategies in response to ongoing environmental change.

Create a foundation for further modeling and monitoring of groundwater resources. The GIS-based approach has proven effective as a tool for sustainable groundwater management and land-use planning under changing climatic conditions.

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