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Groundwater Potential Mapping in Semi-Arid Areas Using Integrated Remote Sensing, GIS, and Geostatistics Techniques

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Abstract

Groundwater serves as a vital resource for sustainable water supply, particularly in semi-arid regions where surface water availability is limited. This study explores groundwater potential zones in the East Desert, Qift–Qena, Egypt, using a multidisciplinary approach that integrates remote sensing (RS), geographic information systems (GIS), geostatistics, and field validation with water wells to develop a comprehensive groundwater potential mapping framework. Sentinel-2 imagery, ALOS PALSAR DEM, and SMAP datasets were utilized to derive critical thematic layers, including land use/land cover, vegetation indices, soil moisture, drainage density, slope, and elevation. The results of the groundwater potentiality map of the study area from RS reveal four distinct zones: low, moderate, high, and very high. The analysis indicates a notable spatial variability in groundwater potential, with "high" (34.1%) and "low" (33.8%) potential zones dominating the landscape, while "very high" potential areas (4.8%) are relatively scarce. The limited extent of "very high" potential zones, predominantly concentrated along the Nile River valley, underscores the river's critical role as the primary source of groundwater recharge. Moderate potential zones include places where infiltration is possible but limited, such as gently sloping terrain or regions with slightly broken rock structures, and they account for 27.3%. These layers were combined with geostatistical analysis of data from 310 groundwater wells, which provided information on static water level (SWL) and total dissolved solids (TDS). GIS was employed to assign weights to the thematic layers based on their influence on groundwater recharge and facilitated the spatial integration and visualization of the results. Geostatistical interpolation methods ensured the reliable mapping of subsurface parameters. The assessment utilizing pre-existing well data revealed a significant concordance between the delineated potential zones and the actual availability of groundwater resources. The findings of this study could significantly improve groundwater management in semi-arid/arid zones, offering a strategic response to water scarcity challenges.

Keywords: groundwater; semi-arid regions; remote sensing; GIS; sustainability

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