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Potential Sites for Aquifer Replenishment using Resistivity and Geospatial Techniques in Kiliyar Sub-Basin, Kanchipuram District, South India

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Abstract

Groundwater depletion in hard rock terrains necessitates scientifically validated approaches for identifying suitable aquifer replenishment sites. This study integrates geophysical resistivity surveys with geospatial multi criteria analysis to delineate recharge potential zones in the Kiliyar Sub-Basin of the Palar River Basin, Tamil Nadu. Seven thematic layers, geomorphology, land use/land cover (LULC), lineament density, drainage density, slope, resistivity layer properties, and depth were generated using Landsat ETM+, SRTM DEM, and 32 Vertical Electrical Sounding (VES) points. These parameters are converted to raster format and assigned rank and weights then computed from the Normalized Weight Method (NWM). All the layers have been integrated to generate final layer to assess the artificial recharge structures in the Kiliyar Sub-Basin. The final output zones are classified into five suitability categories: least suitable (5.66%), poorly suitable (22.91%), moderately suitable (29.25%), highly suitable (30.19%), and very highly suitable (12%), and the resulting recharge zonation map groups the basin into the same five classes from least to very highly suitable. The study area boundaries and drainage framework provide important spatial context for interpreting recharge behavior. This aquifer replenishment zone map will be useful for extraction and management of groundwater in the study area.

Keywords: Aquifer Replenishment, GIS, Resistivity Survey, Multi-criteria Analysis, Kiliyar Sub-Basin, Remote Sensing

Introduction

Groundwater is a vital resource in peninsular India, especially in hard rock terrains where storage and movement are highly heterogeneous, and its demand continues to rise with the growing population. Also, the decreasing rainfall duration, irregular monsoon patterns, intensive agricultural extraction and increasing intensity reduce the groundwater recharge quantity, which leads to groundwater exploitation (Aeschbach-Hertig and Gleeson, 2012, Mondal *et al.*, 2019; Hashemi *et al.*, 2020; Alikhanov *et al.*, 2021; Halder *et al.*, 2021). Studies across the Palar River Basin indicate a persistent imbalance between groundwater recharge and abstraction due to land use change, declining surface water retention, and limited natural infiltration pathways (Jha and Sinha, 2009; MacDonald *et al.*, 2016). A growing body of global research further shows that unsustainable extraction and inadequate management practices have led to rapid groundwater depletion in alluvial aquifers (Aeschbach Hertig and Gleeson, 2012; Bonsor *et al.*, 2017; MacDonald *et al.*, 2015), while natural recharge processes have been significantly disrupted by rapid urbanization, population growth, and other anthropogenic pressures, creating a widening gap between recharge and abstraction rates (Jha and Sinha, 2009).

To contextualize the hydrogeological setting, the study area location and drainage network are shown in the study area map (Fig. 1), which highlights the spatial distribution of tanks, stream courses, and major geomorphic units that influence surface runoff and infiltration dynamics. Groundwater recharge is a key determinant of the hydrological balance and long-term sustainability of subsurface water regimes (Amanambu *et al.*, 2020). Although recharge processes are predominantly governed by atmospheric inputs such as precipitation and evaporation, recent shifts in global climate have markedly affected both the quantity and quality of groundwater replenishment (Cuthbert *et al.,* 2019; Albuquerque *et al.,* 2022). Consequently, effective groundwater management relies heavily on understanding the spatiotemporal dynamics of recharge (Amanambu *et al.,* 2020; Judeh *et al.,* 2021). Direct, in-situ quantification of recharge is often challenging; hence, various indirect approaches including empirical equations, process-based modelling, and geophysical methods such as electrical resistivity and electromagnetic surveys are increasingly employed for recharge estimation (Jourde and Wang, 2023). However, reliance on conventional techniques may introduce additional uncertainties, particularly when evaluating climate-change impacts on recharge processes (Aquilina *et al.*, 2023).

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