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GIS-Based Groundwater Recharge and Urbanization Analysis

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Abstract: ***Groundwater is a vital source of water for domestic, agricultural and industrial use, but rapid urbanization, population growth and over-extraction are placing it under increasing stress. The expansion of built-up areas replaces permeable ground with impervious surfaces, which reduces infiltration and natural recharge while the demand for water continues to rise. This paper presents the framework and preliminary study for a GIS-based assessment of groundwater recharge and the influence of urbanization in selected areas of Manjeri Municipality, Malappuram district, Kerala. Recent studies on GIS–AHP groundwater potential zonation, the effects of urbanization and climate variability on groundwater, the validation of groundwater potential maps and site selection for managed aquifer recharge are reviewed, and an integrated methodology is proposed that combines approximately twenty years of groundwater-level and rainfall data, Google Earth and satellite-based urbanization analysis, GIS thematic layers and statistical modelling in SPSS. The literature review and methodology are complete. Data collection, spatial analysis, modelling and field verification are planned for the next phase, so no conclusions on groundwater conditions are drawn in this paper.***

Keywords: Groundwater recharge; urbanization; GIS; remote sensing; Google Earth; SPSS; artificial recharge; groundwater potential zones.

I. INTRODUCTION

Groundwater is one of the most important natural resources and a major source of water for domestic, agricultural and industrial purposes. It is stored beneath the Earth's surface in aquifers and is replenished mainly through the infiltration of rainfall. Its availability depends on rainfall, soil permeability, geological formations, topography, land use and the rate of extraction. Excessive extraction combined with reduced natural recharge leads to declining groundwater levels and water shortages, affecting the long-term sustainability of water resources [1].

Rapid urbanization is one of the major factors affecting groundwater recharge. The expansion of urban areas converts agricultural land, vegetation and open spaces into buildings, roads and other impervious surfaces, which reduce rainwater infiltration and increase surface runoff. At the same time, population growth and infrastructure development increase water demand, placing greater pressure on groundwater resources [2]. Understanding the relationship between urbanization and groundwater recharge is therefore essential for effective water-resource planning.

Geographic Information Systems (GIS) and remote sensing provide useful techniques for analysing groundwater conditions and urban expansion. GIS enables the integration of thematic parameters such as slope, soil, geology, lineaments, drainage, rainfall and land use/land cover (LULC) to identify potential recharge zones [1], [3], while satellite imagery and Google Earth can be used to examine changes in built-up area over different periods. Historical groundwater-level and rainfall records can also be analysed with statistical tools such as SPSS to identify trends and relationships and, where sufficient reliable data are available, to forecast future groundwater conditions.

The aim of this work is to assess the applicability of GIS and remote-sensing techniques for analysing groundwater recharge potential and urbanization patterns in selected areas of Manjeri Municipality, Malappuram district, Kerala, through the integration of historical groundwater-level and rainfall data, LULC change and relevant spatial parameters, and to identify suitable recharge zones and sustainable artificial recharge measures. The specific objectives are to (i) delineate the study area and examine its groundwater and environmental characteristics; (ii) analyse approximately twenty years of groundwater-level and rainfall data, subject to availability; (iii) process satellite imagery and spatial datasets to assess LULC change associated with urbanization; (iv) conduct field surveys at representative locations; (v) prepare thematic maps of slope, soil, geology, drainage density, rainfall, lineaments and LULC; (vi) assess the influence of impervious surfaces on infiltration and recharge potential; (vii) delineate potential recharge zones using GIS-based methods; (viii) analyse the relationship between rainfall and groundwater levels in SPSS; and (ix) recommend suitable artificial recharge methods such as recharge pits, trenches, percolation structures and rainwater harvesting.

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II. LITERATURE REVIEW

A. GIS–AHP Groundwater Potential Zonation in Kerala

Raicy et al. [1] evaluated the groundwater potential of the Kadalundi River Basin, which covers 1257.37 km² across the Palakkad and Malappuram districts, using the Analytic Hierarchy Process (AHP) and GIS. Although the basin receives more than 2800 mm of annual rainfall, most open wells become dry during summer. Eleven geo-environmental variables, including lithology, geomorphology, groundwater-level fluctuation, lineament density, LULC, slope, soil texture, rainfall, drainage density, topographic wetness index, curvature and topographic position index, were weighted using Saaty's 1–9 scale, and matrices with a consistency ratio above 0.1 were excluded. Lithology (0.246) and geomorphology (0.180) were the most influential factors. The basin was divided into five classes of roughly equal extent, and the zonation was validated using vertical electrical sounding (VES) surveys and the yield of 28 wells, giving a strong correlation (R^2 = 0.877). The authors recommended rainfall harvesting and artificial recharge in low-potential zones. Vidya et al. [3] combined remote sensing, GIS, AHP and geophysical data in the Shiriya River Basin, Kerala. Seven thematic layers were integrated through weighted overlay and classified into poor, moderate and good zones; fifty Schlumberger VES surveys characterised the subsurface, and the map was validated with 40 observation wells. Together, these studies demonstrate the thematic layers, weighting procedures and validation methods suitable for the lateritic and hard-rock terrain of the region.

B. Urbanization, Climate Variability and Groundwater

Abidakun et al. [2] investigated the combined effects of urbanization and climate variability on groundwater in the Nara Basin, western Japan, comparing a pre-urbanization period (1980–1988) with a post-urbanization period (2000–2008). A three-dimensional groundwater flow model was developed using MODFLOW 6 and the ModelMuse interface and calibrated with groundwater-level data from 13 observation sites (R^2 = 0.95, RMSE ≈ 3.97 m). Hydraulic heads declined by about 5 m in the unconfined aquifer and about 4 m in the deeper confined aquifers. The expansion of impervious surfaces restricted infiltration, while reduced precipitation and increased temperature also lowered recharge. The spatial distribution of recharge had a greater influence on simulated heads than its temporal variation, and groundwater discharge to the river decreased by 27% while river seepage into the aquifer increased by 16%. The study directly supports the central concern of the present work: that the growth of built-up and impervious surfaces reduces recharge and contributes to declining groundwater levels.

C. Validation of Groundwater Potential Maps

Bennett [4] reviewed 125 articles published between 2002 and 2023 to examine how remote-sensing and GIS-based groundwater potential maps are validated. About 85% of the studies validated their maps, while 15% did not. Ten validation methods were identified, based on parameters such as well yield, groundwater level, well and spring discharge, aquifer transmissivity, specific capacity and the presence of wells or springs. The review emphasised that validation with suitable field data is essential, and that the choice of validation parameter should reflect local hydrogeological conditions. GIS-based assessment should therefore not rely solely on thematic maps.

D. Site Selection for Managed Aquifer Recharge

Hussaini et al. [5] integrated GIS with multi-criteria decision analysis to select sites for managed aquifer recharge (MAR) in Kabul, Afghanistan, a rapidly growing city of about 4.5 million people where water levels declined in all but two of 23 monitoring wells between 2004 and 2013. Six criteria—slope, drainage density, surface infiltration rate, unsaturated-zone thickness, soil type and groundwater electrical conductivity—were evaluated using Boolean logic, fuzzy logic, AHP and the Analytic Network Process (ANP). Because several criteria influence one another, ANP produced more reliable weights, with soil type (28.24%) and infiltration rate (25.39%) ranked highest. Seven sites were prioritised after considering land use, three of which matched an ongoing pilot MAR project. The study shows how GIS-based analysis can progress from recharge-suitability mapping to practical recharge locations within an urbanising city.

E. Summary of the Literature

The reviewed studies, summarised in Table I, show that integrating remote sensing, GIS and multi-criteria or statistical techniques is effective for groundwater potential assessment, urbanization analysis and recharge planning. They also emphasise the need to consider land-use change, rainfall variation and geological characteristics, and to validate GIS results with field observations. However, most Kerala studies have been carried out at the river-basin scale and have not specifically examined the effect of urban growth on recharge within developing towns. This gap motivates the integrated design proposed for Manjeri.

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TABLE I
SUMMARY OF REVIEWED STUDIES

Study	Area	Approach	Key finding
Raicy et al. [1]	Kadalundi River Basin, Kerala	GIS–AHP; 11 layers; VES and well-yield validation	Lithology and geomorphology dominant; R^2 = 0.877 with well yield
Abidakun et al. [2]	Nara Basin, Japan	MODFLOW 6 model; pre- and post-urbanization periods	Heads declined by about 5 m (unconfined) and 4 m (confined)
Vidya et al. [3]	Shiriya River Basin, Kerala	RS–GIS–AHP; 7 layers; 50 VES surveys	Validated with 40 observation wells
Bennett [4]	Review (125 articles)	Analysis of validation methods, 2002–2023	85% of studies validated; ten validation methods identified
Hussaini et al. [5]	Kabul, Afghanistan	Boolean, fuzzy, AHP and ANP with GIS	ANP more reliable; seven MAR sites prioritised

Source: compiled from [1]–[5].

III. METHODOLOGY

A. Sequence of Work

The methodology integrates GIS and remote-sensing techniques with historical hydrological data and field observations. The study begins with a literature review and the collection of groundwater-depth and rainfall data, followed by a survey of the selected urban areas, urbanization analysis, GIS-based spatial analysis and statistical modelling. Suitable artificial recharge methods are then identified, and the results are presented as maps, charts and tables, as summarised in Fig. 1.

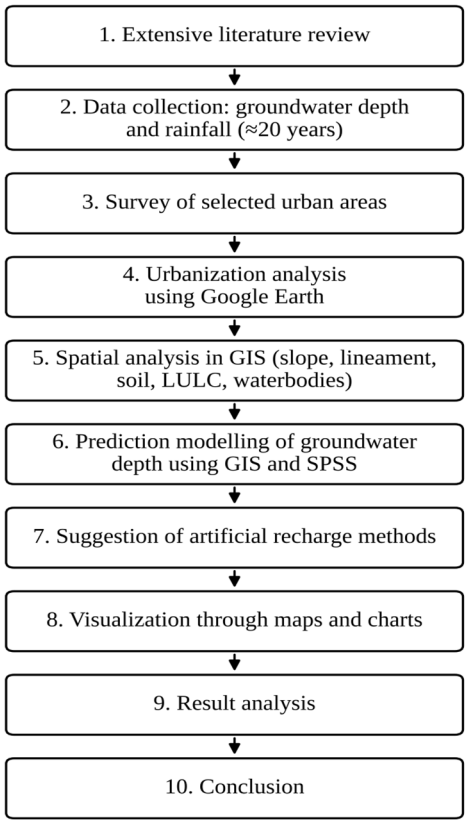


Fig. 1. Methodological sequence adopted for the study, from literature review to result analysis and conclusion.

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B. Data Collection

Groundwater-depth and rainfall data for approximately the past twenty years are collected from available and reliable sources. Groundwater-depth data are used to understand variations in groundwater levels over time, while rainfall data help assess the relationship between precipitation and recharge. The availability, reliability and consistency of the records are checked before analysis. Sentinel-2 and Landsat imagery, digital elevation models (DEM), soil, geology and drainage information are also collected from suitable sources.

C. Survey of Selected Urban Areas

A survey of the selected urban areas is conducted to understand the existing geographical and environmental conditions. Information on land use, buildings, roads, drainage systems, waterbodies and available wells is collected wherever possible. Field observations help verify the available information and provide a better understanding of the urban characteristics that may influence recharge.

D. Urbanization Analysis

Google Earth and satellite imagery from different years are used to analyse changes in urban development. LULC maps are prepared using GIS-based classification, with categories such as built-up area, vegetation, agricultural land, barren land and waterbodies, and maps from different years are compared to quantify the expansion of built-up area and the reduction of permeable surfaces. The observed changes are assessed in relation to their potential effects on surface runoff, soil infiltration and groundwater recharge.

E. Spatial Analysis and Recharge Potential Zones

GIS software is used to prepare, process and analyse the spatial layers that govern recharge, summarised in Table II. The layers are integrated in a GIS environment, and a multi-criteria decision analysis approach such as AHP [1], [3] may be used to assign weights to the selected factors. A weighted overlay then produces the recharge potential index (RPI):

$$\mathrm{RPI} = \Sigma_i \, (W_i \times R_i) \tag{1}$$

where W_i is the weight of thematic layer i and R_i is the rating of its sub-class. The resulting zones may be classified as very high, high, moderate, low and very low recharge potential, depending on the adopted method and results.

TABLE II
THEMATIC PARAMETERS INFLUENCING GROUNDWATER RECHARGE

Parameter	**Influence on recharge**
Slope	Controls surface runoff and the time available for infiltration
Soil	Soil characteristics govern the movement of water into the ground
Lineaments	Indicate geological features that may guide groundwater movement
Land use/land cover	Identifies built-up areas, vegetation and open land; impervious cover reduces infiltration
Waterbodies	Provide information on the local hydrological environment
Geology, drainage density and rainfall	Considered according to data availability and suitability of the study area

Source: adapted from the Phase 1 project report.

F. Prediction Modelling Using SPSS

Groundwater-depth data are analysed using statistical techniques in SPSS to identify patterns and relationships with rainfall and other available variables, while GIS is used to represent their spatial distribution. Where sufficient and suitable data are available, a prediction model can be developed to estimate groundwater depth, and its performance is evaluated using appropriate validation methods.

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G. Artificial Recharge, Visualization and Validation

Based on the spatial and statistical analyses, suitable artificial recharge methods such as recharge pits, recharge trenches, recharge wells and percolation ponds are considered. Their selection depends on site conditions, soil permeability, geology, groundwater conditions, water quality and the availability of runoff. The results are presented as GIS maps of groundwater depth, land-use patterns and recharge potential, and as charts of rainfall and groundwater-level variation. Where reliable groundwater-level records, well information or field observations are available, they are used to validate the recharge potential map [4], and the LULC classification is evaluated using suitable accuracy-assessment techniques.

IV. PLANNED ANALYSIS AND EXPECTED OUTCOMES

At the completion of Phase 1, the literature review and methodology development have been carried out; data collection, spatial analysis, statistical modelling and field verification are planned for Phase 2. Phase 2 will consist of study-area mapping and delineation, satellite and spatial data collection, LULC mapping, urbanization analysis, identification of recharge potential zones, GIS integration and spatial analysis, result validation and discussion, and preparation of the final report.

Satellite imagery from different years is expected to reveal changes in LULC, particularly the expansion of built-up areas and the loss of vegetation and open space. Analysis of the groundwater-level and rainfall records is expected to identify seasonal variations, long-term trends and possible relationships between rainfall and groundwater levels. Integrating the thematic layers is expected to delineate areas of differing recharge potential, and combining the urbanization analysis with the recharge potential map is expected to identify locations where urban development may limit recharge and where measures such as rooftop rainwater harvesting, recharge pits and trenches could be recommended. Any conclusions will be based only on processed data and verified field observations.

V. CONCLUSION

This paper has presented the background, literature review and methodological framework for a GIS-based study of groundwater recharge and urbanization in selected areas of Manjeri Municipality, Malappuram district, Kerala. The reviewed literature shows that GIS–AHP methods, supported by field validation, can reliably delineate groundwater potential zones in Kerala's hard-rock and lateritic terrain, that the growth of impervious surfaces reduces recharge and lowers groundwater levels, and that GIS-based multi-criteria analysis can identify practical locations for artificial recharge. The next phase will collect groundwater-level, rainfall and satellite data, prepare thematic maps, delineate recharge potential zones and recommend suitable artificial recharge methods, thereby contributing to sustainable groundwater management in the study area.

VI. ACKNOWLEDGMENT

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REFERENCES

[1] M. C. Raicy, C. D. Aju, A. L. Achu, P. Mohammed Maharoof and A. Ashwin, “Groundwater potential zonation in a tropical hard-rock basin, South India: An evidence-based approach,” Evolving Earth, vol. 4, 100121, 2026.

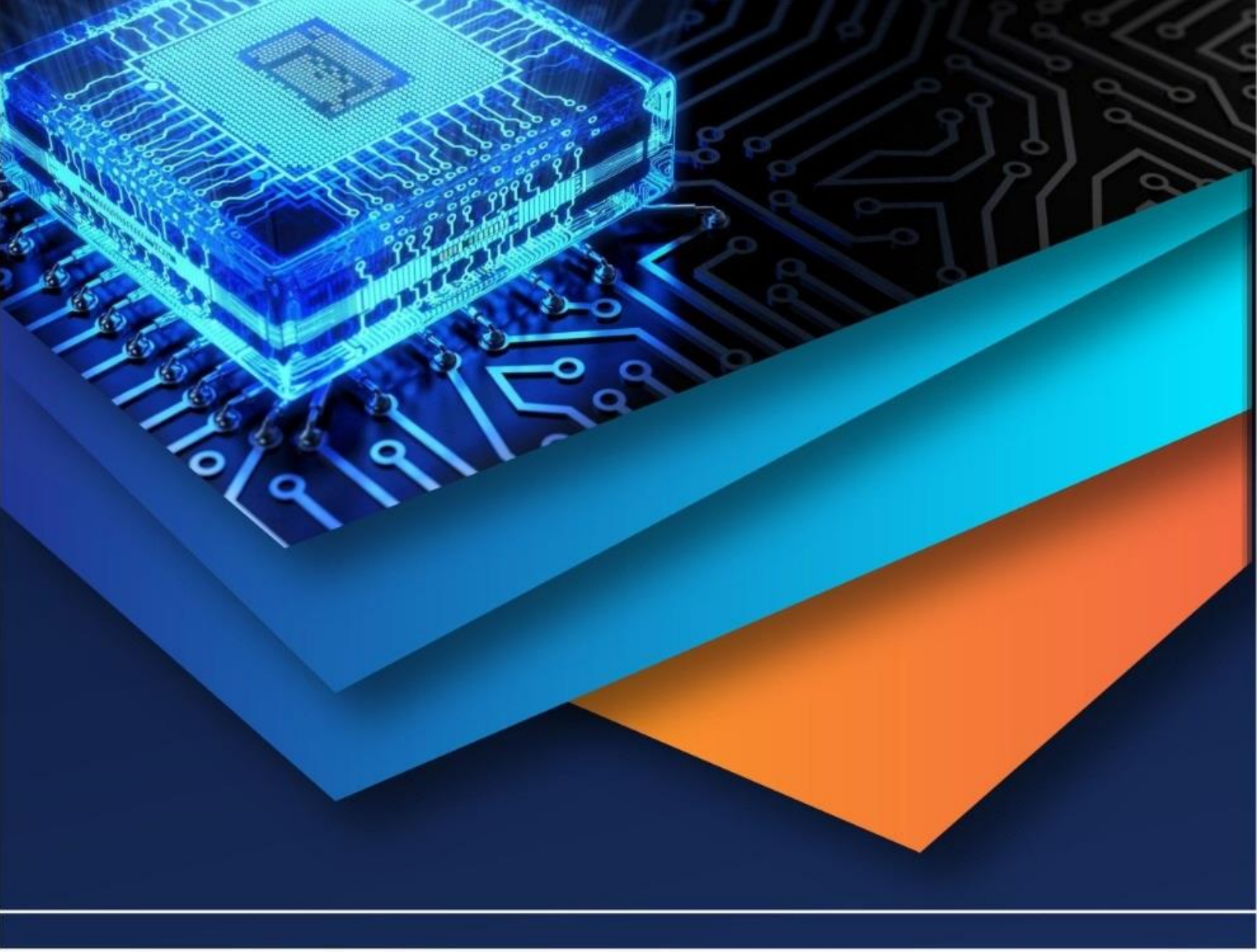
[2] O. J. Abidakun, M. Saito, S. Onodera and K. Wang, “Impacts of urbanization and climate variability on groundwater environment in a basin scale,” Hydrology, vol. 12, 173, 2025.

[3] K. M. Vidya, A. N. Manoharan, B. Suchitra and M. Shyni, “Combination of remote sensing, GIS, AHP techniques and geophysical data to delineate groundwater potential zones in the Shiriya River Basin, South India,” Geosystems and Geoenvironment, vol. 3, 100294, 2024.

[4] G. Bennett, “Analysis of methods used to validate remote sensing and GIS-based groundwater potential maps in the last two decades: A review,” Geosystems and Geoenvironment, 2024.

[5] M. S. Hussaini, A. Farahmand, S. Shrestha, S. Neupane and M. Abrunhosa, “Site selection for managed aquifer recharge in the city of Kabul, Afghanistan, using a multi-criteria decision analysis and geographic information system,” Hydrogeology Journal, vol. 30, pp. 59–78, 2022.

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