



Geoinformatics And Swat Model Integration For Groundwater Quality Assessment In Water-Stressed Regions Of Haryana

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ABSTRACT

Groundwater crisis is emerging as a pressing concern in many regions of India, particularly in water-stressed states like Haryana. This study focuses on the integrated application of geoinformatics and the SWAT (Soil and Water Assessment Tool) model to assess groundwater quality and waterlogged areas within Hisar and Bhiwani districts. By leveraging ARC GIS software and remote sensing data, several thematic layers—including base maps, Digital Elevation Models (DEM), NDWI (Normalized Difference Water Index), groundwater depth, and waterlogged regions—were generated. The study demonstrates that remote sensing and GIS provide rapid and accurate methods for groundwater analysis, enabling effective identification of risk zones for policymakers, planners, and administrators.

KEYWORDS: Remote Sensing, Groundwater, GIS, rivers, SWAT Model, Waterlogged Area, Spatial Analysis, Water Resource Management

1. INTRODUCTION

Water resources form the backbone of ecological stability, agricultural productivity, and economic development in any region. In the context of India, where rainfall is seasonal and unevenly distributed, groundwater has become the principal source of irrigation, domestic supply, and industrial use—especially in arid and semi-arid regions such as Haryana. The districts of Hisar and Bhiwani epitomize the growing dependency on groundwater due to limited and erratic surface water availability. As a result, these regions are increasingly vulnerable to aquifer depletion, water quality deterioration, and land degradation, including the emergence of waterlogged zones.

Groundwater, constituting over 21% of the Earth’s freshwater, plays an indispensable role in maintaining the hydrological balance and supporting biodiversity, agriculture, and households. In India, it is particularly crucial given the dominance of hard-rock aquifers in the peninsular region and alluvial aquifers in the Indo-Gangetic plains. Haryana’s groundwater scenario is further



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complicated by overexploitation, seasonal recharge fluctuations, and rising demands driven by urbanization, population growth, and intensive agriculture. The Central Ground Water Board (CGWB) reports a declining trend in water levels and increasing occurrence of deep and very deep observation wells, prompting urgent attention to groundwater management. Surface water bodies such as rivers, lakes, and reservoirs, while significant, are not sufficient to meet the water needs of densely populated or agriculturally intensive areas. The interplay between surface water and groundwater is crucial, as surface water replenishes aquifers and supports the hydrological cycle. However, the spatial and temporal variability of rainfall, coupled with topographical constraints and unsustainable extraction, often leads to situations where groundwater becomes the default lifeline for many communities. This deepening crisis calls for advanced, science-based solutions for monitoring and managing groundwater resources. Traditional methods of groundwater mapping and quality assessment are often labor-intensive, time-consuming, and spatially limited. In contrast, geoinformatics—encompassing remote sensing and GIS—offers novel tools for rapid, accurate, and comprehensive assessment of groundwater dynamics. Through the integration of satellite imagery, spatial analysis, and hydrological modeling (notably the SWAT model), researchers can monitor land use changes, detect waterlogged areas, estimate aquifer recharge and discharge zones, and assess groundwater quality parameters at both local and regional scales.

Remote sensing technology employs both passive and active sensors aboard satellites or aircraft to collect electromagnetic data reflecting surface and subsurface properties. Indices such as NDWI, NDVI (Normalized Difference Vegetation Index), and DEM are invaluable for distinguishing between vegetation, built-up areas, water bodies, and bare land. These indices also support temporal change detection, allowing researchers to analyze the impact of land use practices and climatic variability on water resources over time. Geographical Information Systems (GIS) act as the digital backbone for data integration, management, and spatial analysis. With its ability to store, manipulate, overlay, and visualize both raster and vector data, GIS enables the synthesis of multi-layered thematic maps—critical for groundwater assessment. By combining hydrogeological, topographical, and land use data, GIS facilitates the identification of groundwater potential zones, areas at risk of contamination, and regions susceptible to waterlogging. The SWAT model, when integrated with GIS, further strengthens the analytical framework by simulating the effects of land management practices on water flow, sediment yield, and pollutant transport within the watershed.

The present study is set in Hisar and Bhiwani districts—two regions facing acute water stress, rapid demographic change, and agricultural intensification. Both districts are heavily reliant on groundwater, not only for irrigation but also for domestic and industrial needs. Overexploitation,



insufficient recharge, and unchecked pollution have resulted in declining groundwater tables, deteriorating water quality, and increased prevalence of waterlogging in some areas. These challenges are exacerbated by the expansion of built-up areas and shifting land use patterns. By applying the integrated approach of remote sensing, GIS, and SWAT modeling, this research aims to fill the knowledge gap in spatial and temporal groundwater assessment. It seeks to provide actionable insights for local authorities, urban planners, and water resource managers, empowering them to design targeted interventions for sustainable water use and land management. The findings will also serve as a reference for future research in similar agro-climatic zones, contributing to the broader discourse on water security and environmental sustainability in India.

2. SCOPE OF THE STUDY

The scope of this research extends to the spatial and temporal analysis of groundwater quality and waterlogged areas in Hisar and Bhiwani districts of Haryana. By leveraging advanced geoinformatics tools and the SWAT model, the study encompasses the creation of thematic maps, assessment of land use changes (2005–2015), identification of groundwater risk zones, and evaluation of waterlogged regions. The research addresses the relationship between land use dynamics, groundwater availability, and water quality, with special emphasis on the implications for agricultural sustainability, urban planning, and environmental management. The output is intended for use by policymakers, administrators, and researchers involved in regional water resource management and sustainable development.

3. LITERATURE REVIEW

Gupta and Malik (2020) demonstrated the effectiveness of combining remote sensing and GIS for evaluating groundwater quality in Haryana, highlighting how spatial data can reveal pollution hotspots and support better resource planning. Complementing this, Sharma and Verma (2020) integrated the GIS platform with the SWAT model to map groundwater vulnerability, showing that model-based approaches are crucial for identifying risk-prone zones in semi-arid environments. The role of infrastructure in groundwater sustainability was explored by Mehta and Rani (2021), who found that improved infrastructure supports more sustainable groundwater management in the Hisar region. Singh and Kumar (2021) further applied remote sensing and GIS techniques to assess waterlogged areas, underlining the value of spatial analysis for effective water management and mitigation of land degradation. The National Sample Survey Organisation (2022) provided a comprehensive overview of rural water resource management, emphasizing the growing adoption of GIS applications at the national level for monitoring and planning. Yadav and Chatterjee (2022) focused on the delineation of groundwater recharge zones in arid regions using geoinformatics, demonstrating the precision with which groundwater potential can be mapped for



targeted intervention. Singh and Sharma (2023) advanced the integration of the SWAT model with GIS for holistic groundwater resource evaluation, confirming that such combined approaches yield more robust and actionable insights for policymakers in Haryana. Ahmed and Kaur (2023) examined spatial patterns of groundwater contamination, leveraging remote sensing and GIS to detect and monitor environmental risks associated with groundwater use. Recent authoritative reports, such as the World Bank (2024), have emphasized the critical need for policy innovation and technological adoption in groundwater management for India’s water-stressed regions. Gupta and Singh (2024) highlighted recent advancements in geospatial hydrological modeling, underscoring the role of emerging technologies in achieving sustainable groundwater management and supporting long-term water security.

4. OBJECTIVE

- To assess the spatial and temporal patterns of groundwater quality and waterlogged areas in Hisar and Bhiwani districts using geoinformatics and the SWAT model.
- To generate and analyze thematic layers—such as land use/land cover, groundwater depth, and waterlogged area—using remote sensing and GIS techniques.
- To evaluate the impact of land use changes, urbanization, and agricultural practices on groundwater availability and quality.
- To demonstrate the utility of integrating remote sensing, GIS, and hydrological modeling for rapid, accurate assessment of groundwater issues in semi-arid regions.

5. RESEARCH METHODOLOGY

The study utilized a combination of remote sensing, GIS analysis, and the SWAT model to assess groundwater quality and waterlogged areas in Hisar and Bhiwani districts. Satellite imagery and ARC GIS software were employed to generate thematic layers, including base maps, DEM, NDWI, and groundwater depth. Land use and land cover were analyzed for the years 2005 and 2015, enabling temporal and spatial pattern assessment. Groundwater quality data from laboratory analysis were integrated with geospatial layers. The SWAT model was applied to simulate hydrological processes and evaluate the impact of land use changes on groundwater resources.

6. RESULT AND DISCUSSION

The spatial analysis revealed significant land use dynamics and the extent of waterlogged areas within the study region. The integration of remote sensing indices and GIS mapping enabled a clear distinction between vegetation, built-up zones, and water bodies, providing critical insights into the region’s groundwater status and land use trends.



Table 1: NDWI area analysis

Class	Area in %
Vegetation-Agriculture Land	70
Built-up Area	25
Water content	5

Table 1 presents the NDWI area analysis, showing that 70% of the study area is covered by vegetation and agricultural land, 25% by built-up areas, and 5% comprises surface water. These results indicate a predominance of agricultural activity, with limited water body coverage and increasing built-up space, which may contribute to groundwater stress.

Table 2: Waterlogged area calculation

Class	Area in km ²	Area in %
Waterlogged Area	40.04	1.08

Table 2 details the waterlogged area calculation, indicating that 40.04 km²—equivalent to 1.08% of the total study area—is affected by waterlogging. This highlights the presence of localized water accumulation, which can impact soil health, crop productivity, and groundwater recharge patterns.

7. CONCLUSIONS

The study demonstrates that integrating geoinformatics and the SWAT model provides an effective framework for assessing groundwater quality and mapping waterlogged areas in semi-arid regions. The findings underscore the importance of remote sensing and GIS for rapid, accurate groundwater analysis, supporting sustainable water resource management and informed decision-making in water-stressed areas like Hisar and Bhiwani.

REFERENCES

- Gupta, P. K., & Malik, T. (2020). Assessment of groundwater quality using remote sensing and GIS: A case study of Haryana, India. *Environmental Earth Sciences*, 79(5), 1-14.
- Sharma, R., & Verma, S. (2020). Integrating GIS and SWAT model for groundwater vulnerability mapping in semi-arid regions. *HydroResearch*, 3, 40-52.
- Mehta, R., & Rani, S. (2021). Infrastructure development and groundwater sustainability: Case studies from Hisar. *South Asian Water Studies*, 13(2), 112-127.
- Singh, A., & Kumar, M. (2021). Remote sensing and GIS-based assessment of waterlogged areas in Haryana. *Journal of Geomatics*, 15(1), 23-36.



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- National Sample Survey Organisation. (2022). Rural water resource management and GIS applications in India. Ministry of Statistics and Programme Implementation, 2(2), 50-66.
- Yadav, N., & Chatterjee, R. (2022). Application of geoinformatics for delineating groundwater recharge zones in arid regions. *Groundwater for Sustainable Development*, 18, 100725.
- Singh, P., & Sharma, S. (2023). SWAT model integrated with GIS for groundwater resource evaluation in Haryana. *Geographical Journal of India*, 58(1), 142-160.
- Ahmed, S., & Kaur, G. (2023). Spatial analysis of groundwater contamination using remote sensing and GIS. *Environmental Monitoring and Assessment*, 195(3), 1-15.
- World Bank. (2024). India water resource assessment: Policy, technology, and groundwater management. *World Bank Publications*, 16(1), 101-119.
- Gupta, A., & Singh, R. (2024). Advancements in geospatial hydrological modeling for sustainable groundwater management. *Journal of Hydrology: Regional Studies*, 34, 101235.