International Journal of Advanced Research in Science, Engineering and Technology

ISSN: 2350-0328

Vol. 12, Special Issue, December 2025

National Conference on Earth, Elements and Energy: Interdisciplinary Perspectives (NC3EIP–2025)

IJARSET IMPACT FACTOR 7.150

Selection of Water Conservation Sites for Sustainable Groundwater Management in Korhardhari Watershed, Part of Central India: RS and GIS Approach

Shrideep A. Chavan, M. S. Deshmukh*, H. W. Khandare

P.G. Department of Geology, Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur-440001(MS), India

ABSTRACT: The study was carried out in Korhardhari watershed of Saoner tahsil, Nagpur District, Maharashtra State, India for identification of artificial recharge sites. Korhardhari area is a part of WGK-5 watershed of Kanhan river which ultimately merges into Wainganga River basin of Central India. The elevation measured on the basis of SRTM-DEM data, which varies from approximately 275 metres to 443 metres above mean sea level. The difference in elevation is 168 meter which is crucial for selecting suitable sites for artificial recharge structures, along with the geological setup. The area faces acute hydrological stress due to erratic rainfall, declining groundwater levels, and rising temperatures. This paper presents a comprehensive analysis of the hydrological profile of the area suitable for site selection of the artificial recharge structures. On the basis of DEM, slope and geological setup, suitable sites for 12 check dams, 5 gabion structures and 3 cement nalah bunds are selected which will be useful to recover groundwater levels and water scarcity issue during pre- monsoon season.

KEYWORDS: Groundwater, Watershed Management, Artificial Recharge, Gabion structures, DEM

I.INTRODUCTION

Water is the foundation of life, indispensable for economic development, and environmental stability. Despite covering over 70% of the Earth's surface, only about 2.5% of the water is freshwater, and less than 1% is accessible for human use (UNESCO, 2021). Global freshwater withdrawals amount to several trillion cubic metres annually, with approximately 72% allocated to agriculture, 15% to industrial activities, and 13% to municipal use, reflecting the dominant role of irrigation in global water consumption (FAO, 2023a). This finite resource is under increasing pressure due to population growth, industrial expansion, agricultural intensification, and climate change. Globally, over 2 billion people lack access to safely managed drinking water, and nearly 4 billion experience water scarcity at least one month per year (UNICEF: WHO, 2023). Water scarcity manifests in two forms: physical scarcity, where natural water availability is insufficient, and economic scarcity, where infrastructure or governance limits access despite adequate resources (Biswas et al., 2025). Urban centres, especially in developing nations, face dual risks of quantity and quality degradation due to pollution, overextraction, and poor watershed management (Liuet al., 2024).

India, home 18% of the world's population, but only 4% of its freshwater resources, is particularly vulnerable. The country's water demand is expected to exceed supply by 2030, driven by agriculture (which consumes ~80% of freshwater), urbanization, and erratic monsoons (NITI Aayog, 2019). The Maharashtra State including regions like Savner tahsil of Nagpur district, exemplifies this crisis, where declining groundwater levels, and rising temperatures threaten both livelihoods and ecosystems (WRD, 2023 & CGWB, 2024).

In this context, water conservation is not merely a technical challenge but a strategic imperative. It involves reducing wastage, enhancing efficiency, and protecting natural water systems through integrated hydrological planning. Sustainable hydrology, which emphasizes the balance between human needs and ecological integrity, offers a pathway to resilience. The GIS-based mapping of watershed assets to identify recharge hotspots and optimize land use (SWCD, 2024 & IWMP, 2020). This paper explores the hydrological profile of Savner tahsil to identify suitable sites for water conservation and propose strategies for sustainable development.

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II.STUDY AREA

The study area (Korhardhari watershed) is a part of Saoner tahsil, Nagpur District, Maharashtra, India and included in WGK-5 watershed. The watershed is a part of Kanhan river catchment which ultimately merges into Wainganga River basin (Figure 1). The study area falls under toposheets 55 K/15 and 55 O/3 which covers an area of about 83.7 km^2 and the area is bounded by 21° 10' to 21° 30' Latitude and 78° 48' to 79° 00' Longitude. The geospatial data shown in **Figure 2** was sourced from Google Earth using publicly available search tools. Based on SRTM-DEM data, the elevation within the watershed varies from approximately 275 metres to 443 metres above mean sea level. The DEM map is prepared using Arc Map-10.1 GIS software and DEM data is downloaded from Bhuvan, ISRO website (**Figure 3**).

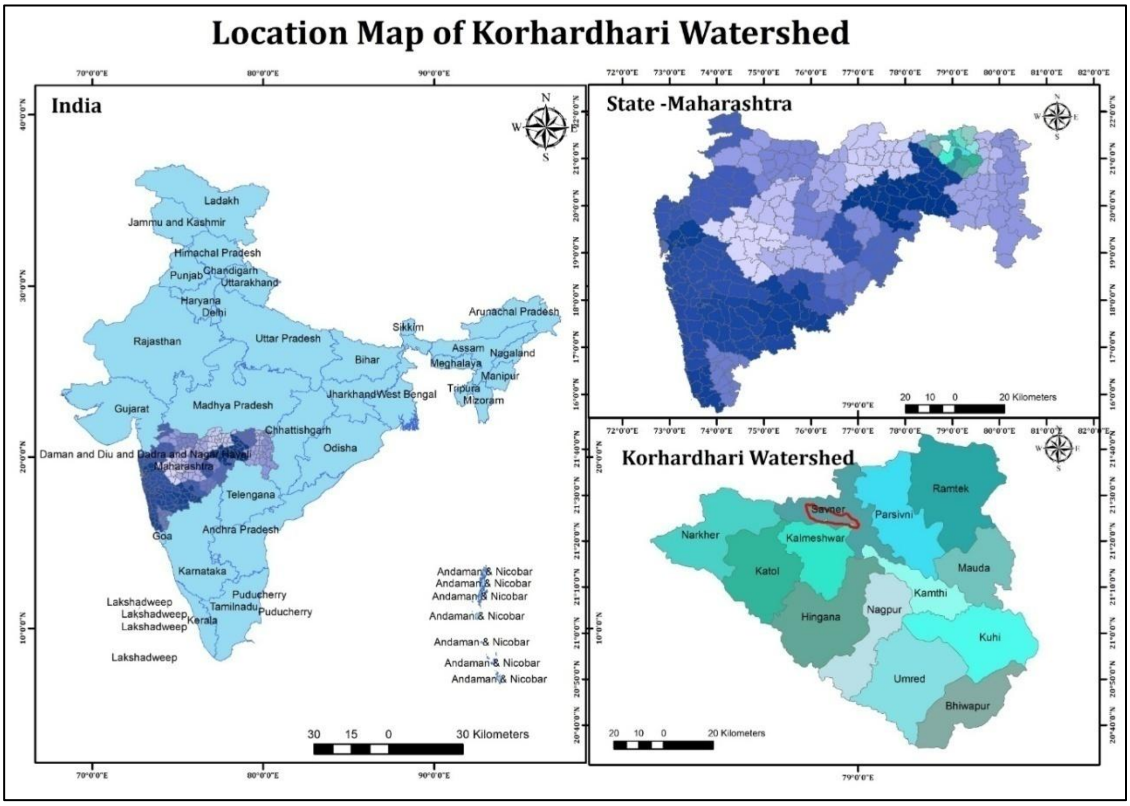

Figure 1: Location map of Korhardhari watershed, Saoner tahsil, Nagpur district (M.S.).

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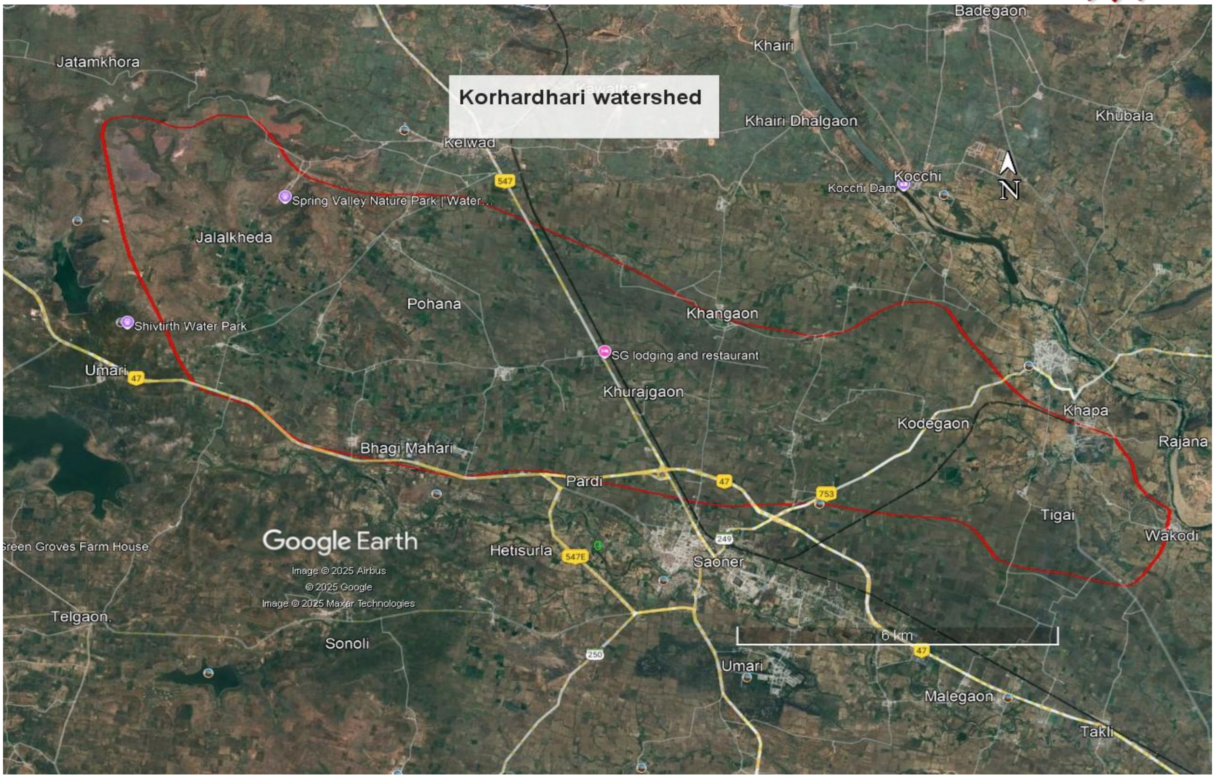

Figure 2: Google image of Korhardhari watershed, Saoner tahsil, Nagpur district (M.S.)

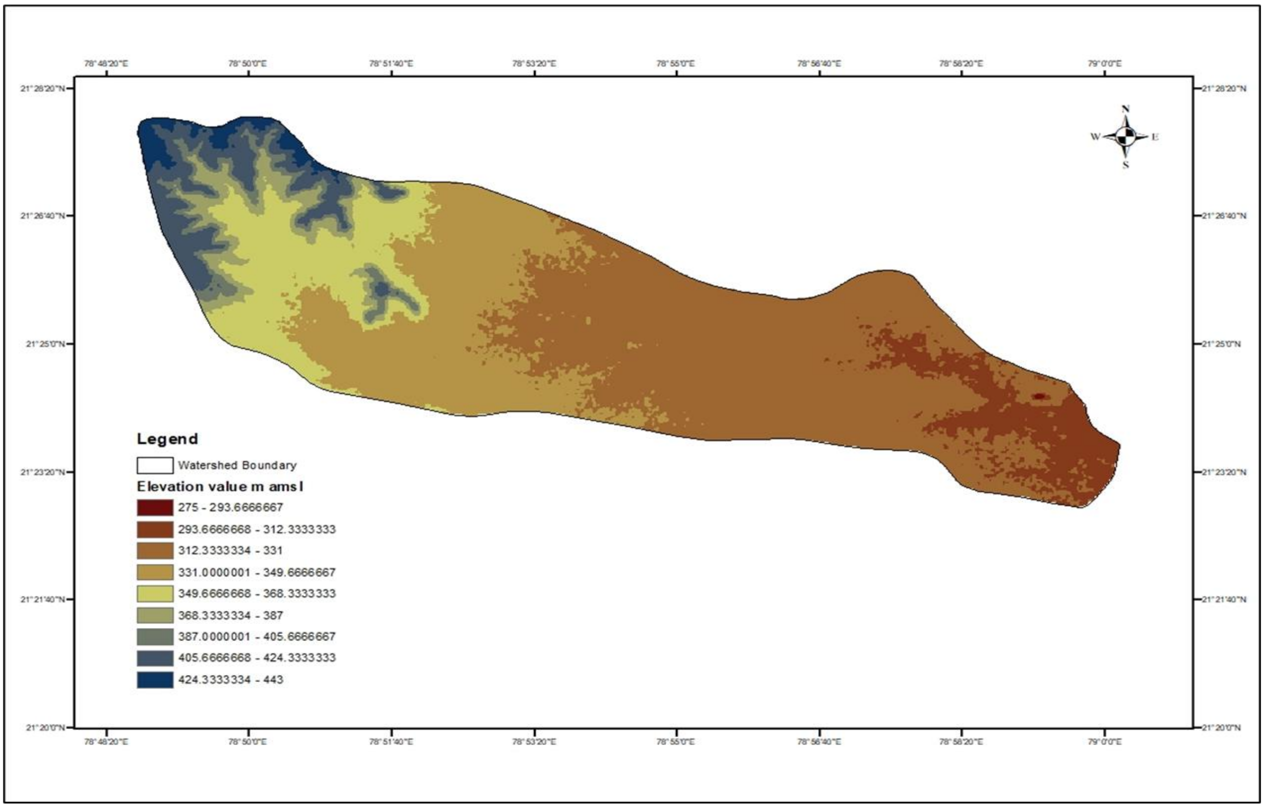

Figure 3: Digital elevation model of the Korhardhari Watershed.

III.RAINFALL AND CLIMATE

The climate of Savner area is hot during summer, well-distributed rainfall, and prevailing dryness throughout the year (IMD, 2020). The cold season spans from December to February, followed by the hot season from March to May. The south-west monsoon dominates from June to September, while October and November mark the post-monsoon transition (IMD, 2020). Rainfall is mostly concentrated during the monsoon months, with peak precipitation occurring between July, August and September. Summer temperatures often rise to 40°C or even more which intensify evaporation and diminishes effective water availability (IMD, 2023).

IV.METHODOLOGY

Methodology adopted for the present study involves combination of primary data collection, secondary data analysis, and field-based observations along with the remote sensing imageries, processed in GIS platform. The data include academic journals, government reports, and policy documents related to water conservation structures, hydrological assessments, and sustainable management strategies. The sites for artificial recharge structures were selected based on the geological setup, depth of weathering, existing water levels, and existing water conservation initiatives. Primary data is collected from the field survey and secondary data from GSDA, CGWB, meteorological records, and previous hydrological studies. The Survey of India toposheets 55 K/15 and 55 O/3 of 1: 50,000 scale are utilized as base maps. Arc Map-10.1 GIS software has been utilized to prepare the digital elevation model (DEM) and the drainage map.

A.Geology

The Korardhari watershed encompasses three distinct stratigraphic units. In the central and eastern part, the Mansar Formation is overlain by the Chorbaoli Formation, both belongs to the Sausar Group of Paleoproterozoic age. These are further overlain in the western part of the watershed by the Satpuda Formation of the Deccan Traps, characterized by two separate basaltic flow units of Upper Cretaceous to Lower Eocene period (DRM, 2021).

B.Hydrogeology

The region is underlain by the Deccan Traps and Metamorphic formations, with limited porosity and recharge capacity. The Central Ground Water Board (CGWB) has classified Savner tahsil as a water-stressed block and conducted aquifer mapping under NAQUIM project (CGWB, 2024). There are conservation challenges in the watershed due to varying lithological setup, declining groundwater levels and fragmented infrastructure. The groundwater depletion in the watershed has become a critical concern due to excessive extraction of groundwater for irrigation, especially in areas cultivating water-intensive crops. The Central Ground Water Board (CGWB) classified Savner tahsil as a water-stressed block, with aquifer mapping revealing declining water tables and poor recharge rates (CGWB, 2024). The imbalance between withdrawal and natural replenishment threatens long-term water security and agricultural sustainability within the watershed. The canals are operated without integrated watershed planning, leading to inefficient water distribution and poor recharge outcomes. The Soil and Water Conservation Departments of Government of Maharashtra highlights the need for convergence between irrigation, forestry, and rural development schemes to optimize watershed performance (SWCD, 2024).

Also, the climate variability, including erratic monsoon and rising temperature have disrupted traditional recharge cycles. Increased evapotranspiration and shorter rainfall windows reduce infiltration, especially in basaltic terrains with low permeability. TERI (2022) notes that semi-arid regions like Vidarbha are particularly vulnerable to climate-induced hydrological stress, necessitating adaptive planning and resilient infrastructure.

The strategic interventions include delineation of recharge zones using hydrogeological surveys and GIS tools, construction of percolation tanks and check dams to enhance infiltration in basaltic and metamorphic formations and regulation of groundwater extraction through community monitoring and water budgeting.

V.WATERSHED MANAGEMENT

Watershed management refers to the integrated approach of conserving, restoring, and sustainably utilizing natural resources: primarily water, soil, and vegetation within a defined hydrological boundary (Kumar R et al., 2025). It aims to enhance water availability, reduce soil erosion, and improve livelihoods, through participatory and science-based interventions. Key strategies for watershed management includes de-silting of reservoirs to restore storage capacity and improve runoff capture. Construction of farm ponds and Cement Nala Bunds (CNBs) for decentralized water retention. GIS-based mapping of watershed assets to identify recharge hotspots and optimize land use (SWCD, 2024 & IWMP, 2020).

Community engagement empowering local communities is vital for sustainable watershed management. The actions recommended are Farmer-led water budgeting to align crop choices with water availability. Reviving traditional water structures such as contour bunds and earthen tanks. Trainings on micro-irrigation and soil moisture conservation, facilitated by NGOs like WOTR (2021), enhances efficiency and resilience. The climate resilience to mitigate climate impacts, essentially promotion of drought-resistant crops and crop diversification to reduce water demand. Solar-powered irrigation systems to reduce energy costs and improve access and hydrological forecasting tools to guide planting schedules and irrigation planning (ICAR, 2022).

A.Priority Zones for Watershed Interventions

On the basis of remote sensing and GIS technique, various priority zones are classified which are as follows:
High Priority Zones: Upper catchment areas with steep slopes and first-order streams should be targeted for check due to their high erosion potential and recharge capacity [Pan et al, 2025 & Murthy, 1994).
Moderate Priority Zones: Mid-catchment zones with moderate slopes and third-order streams are suitable for gabion structures which help in runoff moderation and seasonal water storage (Rajora, 2002 & NITI Aayog, 2023].
Low Priority Zones: Lower catchment areas near stream confluences are ideal for nalah bunds, enhancing aquifer recharge and mitigating downstream flooding (Pani et al., 2021).

On the basis of all above classification and approximation, various tentative structures are suggested which will be finalized after detailed geological field study. The structure suggested include check dams (12), Gabion structures (05) and cement nalah bunds (03) (**Figure 4**).

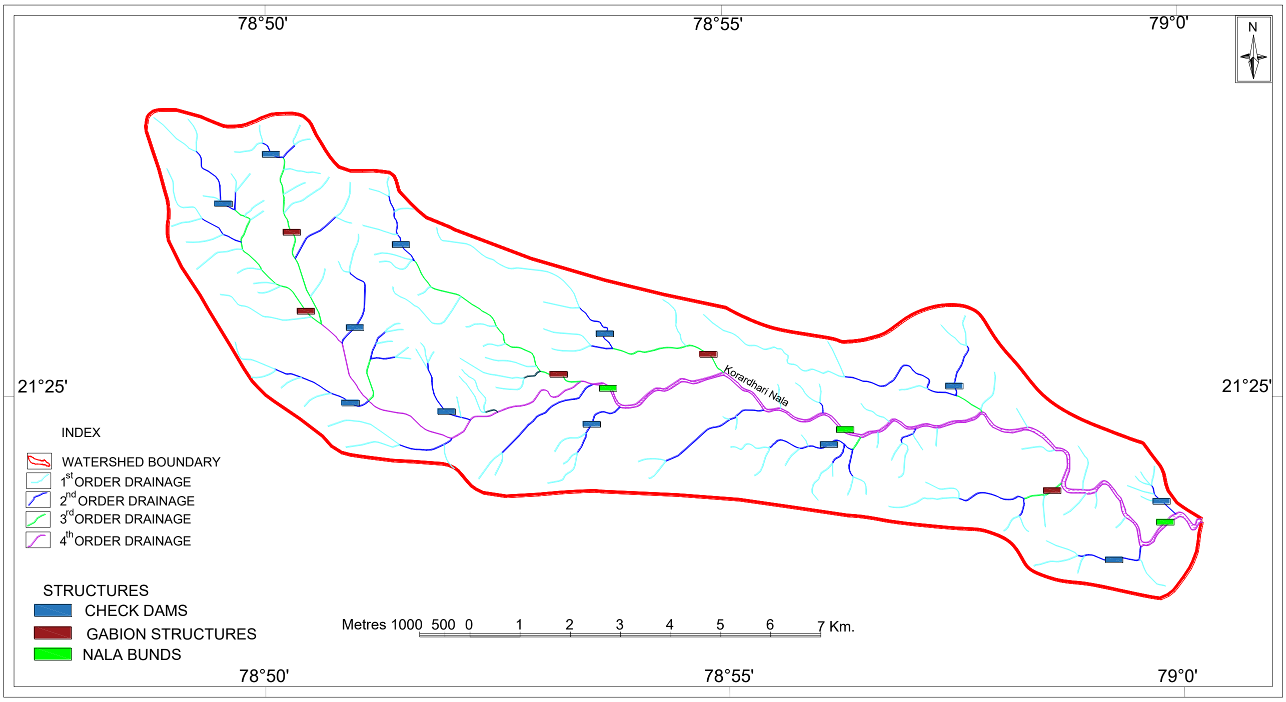

Figure 4: Artificial recharge structures proposed for the study area.

VI.CONCLUSION

Present study of Korardhari watershed represents a comprehensive evaluation of water conservation needs and strategic interventions in a semi-arid region of Saoner Tahsil, Nagpur District, Maharashtra, India. Through integrated analysis of topography, geology, climate, and hydrogeology, the research identifies critical zones of groundwater stress. The geological setup of the watershed comprises Paleoproterozoic metamorphic formations, overlain by the Deccan Trap basalts which directly influences recharge dynamics and surface runoff. Using GIS-based morphometric prioritization and field validation, present study suggests 20 water conservation structures, including 12 check dams, 5 gabion structures, and 3 nalah bunds. These are strategically distributed across high, moderate, and low-priority zones to optimize infiltration, reduce erosion, and support aquifer recharge. The interventions align with national frameworks such as CGWB's Aquifer Management Plan, Jal Shakti Abhiyan, and ISO 14001 Environmental Standards. Community engagement, climate-resilient agriculture, and decentralized water budgeting are the essential pillars for sustainable watershed management. The study advocates convergence across departments like irrigation, forestry, rural development and recommends long-term monitoring, hydrological forecasting, and participatory planning to face water scarcity. In conclusion, the Korardhari watershed model offers a replicable blueprint for integrated water resource management in similar agro-climatic zones.

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AUTHOR'S BIOGRAPHY

Full name	**Shrideep Avinash Chavan**
Science degree	-
Academic rank	Research Scholar
Institution	Post Graduate Department of Geology, Rashtrasant Tukadoji Maharaj Nagpur University

ISSN: 2350-0328

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Vol. 12, Special Issue, December 2025

National Conference on Earth, Elements and Energy: Interdisciplinary Perspectives (NC3EIP–2025)

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Full name	**Manish S Deshmukh**
Science degree	PhD
Academic rank	Assistant Professor
Institution	Post Graduate Department of Geology, Rashtrasant Tukadoji Maharaj Nagpur University

Full name	**Hemant W Khandare**
Science degree	PhD
Academic rank	Assistant Professor
Institution	Post Graduate Department of Geology, Rashtrasant Tukadoji Maharaj Nagpur University