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Water Resource Management and Challenges in Rajgarh Tehsil, Alwar District: A Geographical Study

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Abstract
Water scarcity is one of the most pressing environmental and socio-economic challenges confronting arid and semi-arid regions of northwestern India, particularly in the state of Rajasthan. This research paper presents a comprehensive geographical study of water resource management, groundwater depletion, and hydro-climatic challenges specific to Rajgarh Tehsil within the Alwar district. Situated in the transition zone between the Aravalli hill ranges and the eastern plains, Rajgarh experiences erratic semi-arid rainfall patterns, rapid urbanization, and heavy agricultural reliance on subterranean aquifers.
Utilizing secondary data from the Central Ground Water Board (CGWB), Indian Meteorological Department (IMD), and primary socio-economic surveys across selected villages of Rajgarh tehsil, this study evaluates the spatial-temporal variations in rainfall, temperature extremes, and groundwater table fluctuations. Statistical analyses—including coefficient of variation, groundwater exploitation indices, and decadal trend evaluations—reveal that over 75% of observation wells in the tehsil fall under 'Critical' to 'Over-exploited' categories, with groundwater tables plunging beyond 50 to 80 meters in several blocks.
The paper further explores micro-level case studies from rural settlements, evaluates traditional water harvesting structures (such as johads, bawries, and earthen check dams), and investigates the impacts of shifting cropping patterns on hydrological stress. Finally, the study outlines a scientific, community-driven framework for sustainable watershed management, artificial groundwater recharge, micro-irrigation adoption, and policy interventions to mitigate the escalating water crisis in the region.
Keywords: Hydro-geography, Groundwater Depletion, Rajgarh Tehsil, Watershed Management, Semi-Arid Climate, Rainwater Harvesting, Aravalli Ecosystem.

I. Introduction

Water is the fundamental prerequisite for ecological stability, human sustenance, and socio-economic development. In dryland and semi-arid geographies, the spatial and temporal distribution of water resources dictates the carrying capacity of the landscape. Rajasthan, being India's largest state by area, suffers from extreme hydro-climatic vulnerability due to high potential evapotranspiration, sparse precipitation, and the absence of perennial river systems. Within Rajasthan, the Alwar district occupies a critical strategic and transitional position, bounded by the Mewat hills and transitional alluvial plains.

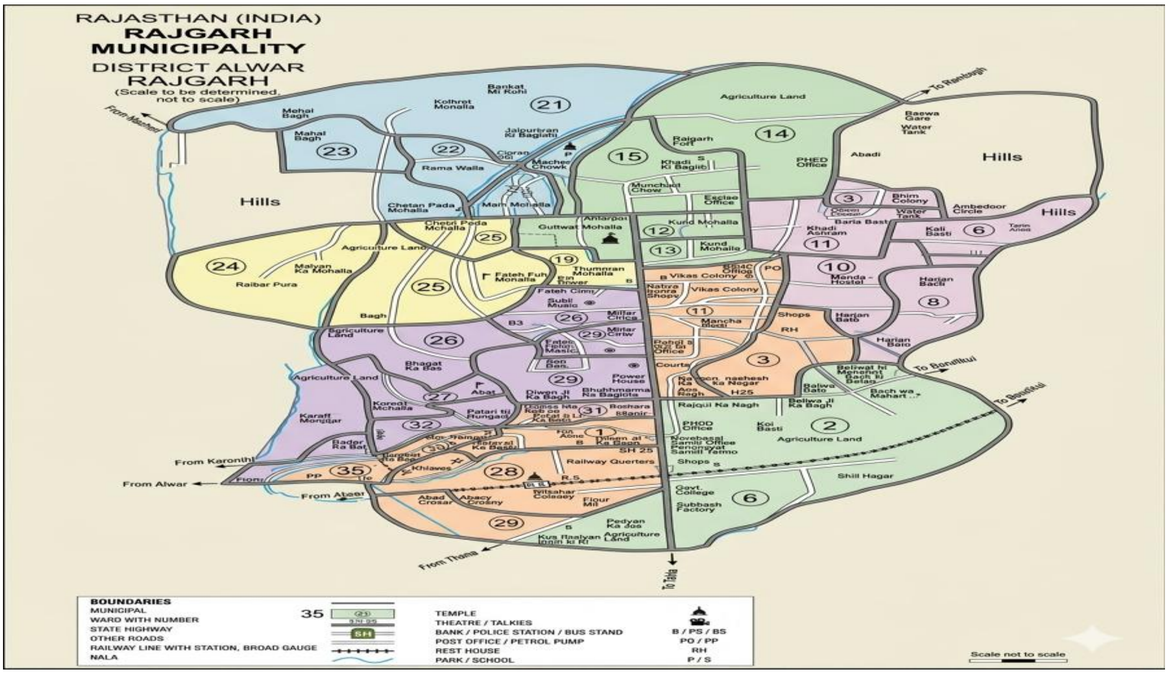
While the district as a whole has faced severe hydro-geological stress due to unchecked industrialization and intensive agriculture, Rajgarh Tehsil presents a distinct micro-geographical setting. Characterized by rugged Aravalli topography, undulating terrain, rocky outcrops, and seasonal river channels like the Sanwan and local tributaries, Rajgarh's hydrological regime is highly sensitive to climatic aberrations.

Historically, Rajgarh maintained a resilient socio-ecological balance through indigenous water harvesting structures. However, over the past three decades, demographic pressures, conversion of traditional commons, widespread adoption of energy-intensive tube wells, and shifts toward water-demanding crops have severely destabilized the hydrological equilibrium. This research investigates the multi-dimensional facets of water resource depletion in Rajgarh Tehsil, combining rigorous geographical methodology with actionable mitigation strategies.

II. Geographical Introduction of the Study Area

2.1 Location and Extent

Rajgarh Tehsil is an administrative and geographical subdivision located in the southern part of the Alwar district of Rajasthan. It is situated roughly between latitudes 27.22°N to 27.45°N and longitudes 76.22°E to 76.65°E. It is flanked by the Sariska Tiger Reserve to its west and north, Dausa district to its south and southwest, and Laxmangarh/Alwar tehsils to its north and east.



2.2 Physiography and Relief

The physiography of Rajgarh is heavily influenced by the North-Aravalli mountain chain. The terrain can be broadly divided into three distinct geomorphological units:

1. Hilly and Undulating Tracts: Dominated by quartzites, schists, and phyllites of the Delhi Supergroup, forming steep ridges and narrow structural valleys (ghatis).
2. Piedmont Zones and Bajada Slopes: Gentle sloping debris zones flanking the hills, historically utilized for localized agriculture and subsurface moisture retention.
3. Alluvial Plains: Low-lying flat tracts formed by ephemeral streams and seasonal rivulets, constituting the primary agricultural zone.

III. Hypotheses and Research Objectives

3.1 Hypotheses

H1: The rapid decline of groundwater tables in Rajgarh Tehsil is directly correlated with the unscientific expansion of deep borewell irrigation and changing cropping geometry rather than mere meteorological drought.
H2: Revitalization of traditional water-harvesting structures combined with decentralized watershed management significantly enhances regional groundwater recharge and stabilizes agricultural productivity.

3.2 Research Objectives

1. To analyze the physiographic, climatic, and hydrological characteristics of Rajgarh Tehsil.

2. To assess the spatial distribution of groundwater levels, extraction rates, and water quality parameters across selected rural and semi-urban clusters.

IV. Sources of Data and Methodology

This study adopts an empirical, analytical, and cartographic approach, integrating primary field observations with secondary official datasets.

• Secondary Data Sources: Central Ground Water Board (CGWB) groundwater assessment reports for Alwar district, Indian Meteorological Department (IMD) gridded rainfall and temperature datasets, and Directorate of Economics and Statistics, Government of Rajasthan.

• Primary Data Sources: Structured questionnaire surveys administered across 10 representative villages in Rajgarh Tehsil, and well-inventory logging (measuring depth to water table in unconfined aquifers).

• Statistical and Cartographic Techniques: Descriptive statistics (Mean, Standard Deviation, Coefficient of Variation), graphical modeling, and thematic mapping using Geographic Information Systems (GIS).

V. Climatic Profile of Rajgarh Tehsil

Rajgarh experiences a typical semi-arid climate (Köppen: BSh), characterized by extreme thermal variations and erratic monsoonal precipitation.

5.1 Temperature Regimes

Summer Season (March to June): Temperatures soar rapidly, with mean maximum temperatures ranging between 40°C and 45°C (peak values occasionally touching 47°C in May/June). High thermal radiation accelerates surface evaporation.

Winter Season (November to February): Crisp and cold winters with mean minimum temperatures dropping to 3°C to 8°C, occasionally experiencing frost spells in low-lying valley pockets.

Annual Mean Temperature: Approximately 26.5°C.

5.2 Rainfall Characteristics

Rainfall is heavily concentrated during the southwest monsoon months (July to September), accounting for nearly 90% of the annual precipitation. Mean annual rainfall ranges approximately between 620 mm to 680 mm.

Spatial Variance: The western and north-western hilly tracts (bordering Sariska) receive slightly higher precipitation (700 mm) due to orographic uplift, whereas the eastern and southern plains receive lower amounts (550 mm to 600 mm).

Temporal Instability: The Coefficient of Variation (CV) for annual rainfall exceeds 28%, indicating high inter-annual volatility and frequent agricultural droughts.

VI. Hydro-Geological Status and Water Level Analysis

6.1 Groundwater Scenario (Post-Monsoon Assessment)

Groundwater forms the lifeblood of Rajgarh's domestic, agricultural, and industrial sectors. Due to lack of perennial surface water bodies, borewells and tube wells tap the underlying weathered and fractured quartzitic aquifers.

Depth Category (mbgl)	Percentage of Monitored Wells (%)	Aquifer Status / Category
5 – 10 m	4.2%	Safe / Shallow Water Table (Piedmont fringes)
10 – 20 m	18.5%	Moderate Depth (Transition zones)
20 – 40 m	37.1%	Deep Water Table (Stressed zone)
≥ 40 m	40.2%	Critical / Over-Exploited Zone

Note: In localized urban pockets and intensive farming tracts, water tables have receded beyond 70 to 90 mbgl.

VII. Micro-Level Case Studies: Villages of Rajgarh Tehsil

To ground the macro-level statistics, detailed reconnaissance surveys were conducted across four diverse village clusters in Rajgarh Tehsil:

1. Village A (Tehsil Fringe - Hilly Foothill): Benefiting from proximity to Aravalli ridges, traditional anicut structures built under watershed programs have maintained water tables around 22 mbgl. Rainfed bajra and mustard dominate.

2. Village B (Central Alluvial Plain): Heavily dependent on intensive tube-well irrigation for wheat and mustard. Water tables have plummeted from 15 mbgl (in 2000) to over 65 mbgl (in 2025). Drinking water is heavily reliant on piped supply schemes fed by distant sources.
3. Village C (Southern Transitional Tract): Characterized by high Total Dissolved Solids (TDS) and fluoride concentration in groundwater, posing severe public health challenges.
4. Village D (Drainage Basin of Seasonal Stream): Exhibits moderate recovery during high monsoon years (such as the positive anomalies recorded in 2024–2025), but rapid summer pumping neutralizes monsoon gains within four months.

VIII. Sectoral Water Use Dynamics

Water allocation across Rajgarh reflects a typical agrarian-semi-arid economy:
• Agricultural Sector (~84%): Consumes the vast majority of extracted groundwater. Flood irrigation remains prevalent, leading to massive conveyance and application losses.
• Domestic & Livestock Sector (~13%): Drinking, sanitation, and cattle rearing. Rapid cattle population concentration near foothill grazing lands increases local daily draft.
• Industrial & Commercial Sector (~3%): Small-scale agro-processing units, stone-cutting mills, and local commercial establishments.

IX. Major Challenges and Problem Identification

1. Unregulated Groundwater Extraction: Proliferation of submersible pumps without legal pricing or volumetric rationing.
2. Degradation of Traditional Water Bodies (Johads, Baories, Talabs): Siltation, encroachment, and breaking of community upkeep mechanisms.
3. Climatic Shocks & Erratic Monsoons: Extended dry spells interspersed with high-intensity short-duration cloudburst events that cause surface runoff rather than effective infiltration.
4. Hydro-Chemical Deterioration: Deep aquifer mining has released geo-genic contaminants, elevating fluoride, nitrate, and TDS levels beyond permissible WHO drinking water limits.
5. Shifting Agronomic Practices: Increased cultivation of water-guzzling Rabi crops (wheat, summer vegetables) outside traditional agro-climatic wisdom.

X. Scientific and Geographical Solutions

Mitigating the water crisis in Rajgarh Tehsil requires an integrated hydrologic paradigm:
A. Decentralized Rainwater Harvesting & Watershed Treatment: Construction of contour trenches, staggered trenches, and gabion structures along Aravalli slopes. Desiltation and restoration of historical village ponds (johads) and stepwells (bawries).
B. Agricultural Demand Management: Mandatory transition from flood irrigation to micro-irrigation technologies (drip and sprinkler systems). Crop diversification away from high-duty Rabi crops toward drought-hardy millets (bajra, jowar) and pulses.
C. Artificial Aquifer Recharge Structures: Utilizing abandoned open wells and dry borewells as direct recharge shafts for rooftop and surface runoff.
D. Participatory Groundwater Governance: Empowering Village Water and Sanitation Committees (VWSCs) to monitor local extraction quotas and enforce community-based aquifer management rules.

XI. Conclusion

The geographical analysis of Rajgarh Tehsil establishes that the prevailing water crisis is not merely a manifestation of natural aridity, but a complex socio-ecological imbalance driven by unbridled anthropogenic pressures on subterranean reserves. While the hydro-geological setting—defined by Aravalli topography and semi-arid monsoons—imposes inherent limits on natural recharge, traditional wisdom and modern scientific interventions offer a viable pathway toward sustainability.
By aggressively scaling up watershed restoration, enforcing strict regulatory frameworks on deep-well drilling, promoting micro-irrigation, and reviving community-managed water bodies, Rajgarh Tehsil can transition from an over-exploited hydrological vulnerability zone to a resilient, water-secure rural economy.

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