Groundwater Depletion in Jind District, Haryana: Spatiotemporal Pattern and Driving Factors

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Abstract: ***Groundwater depletion has emerged as a critical environmental and socio-economic concern in India, particularly in the northwestern regions of the Indo-Gangetic plains. Haryana, being an intensively cultivated state, is experiencing rapid groundwater decline due to increasing dependence on tube well irrigation, population growth, and climate variability. In this context, the present study investigates the spatiotemporal patterns and driving factors of groundwater depletion in Jind district, a predominantly agrarian region of Haryana. This analysis shows that there is a significant decline in groundwater levels (2000–2024), with depth increasing from 6.84 m to 15.92 m, at an average rate of approximately 0.37 m per year ($R^2 \approx 0.96$), highlighting a strong and consistent downward trend. The study concludes that Jind district is facing a critical groundwater situation, requiring immediate and integrated management interventions. It emphasizes the need for sustainable practices such as regulated groundwater extraction, adoption of water-efficient irrigation techniques, rainwater harvesting, and community-based resource management. Coordinated efforts among policymakers, local authorities, and farmers are essential to mitigate groundwater depletion and ensure long-term water security in the region.***

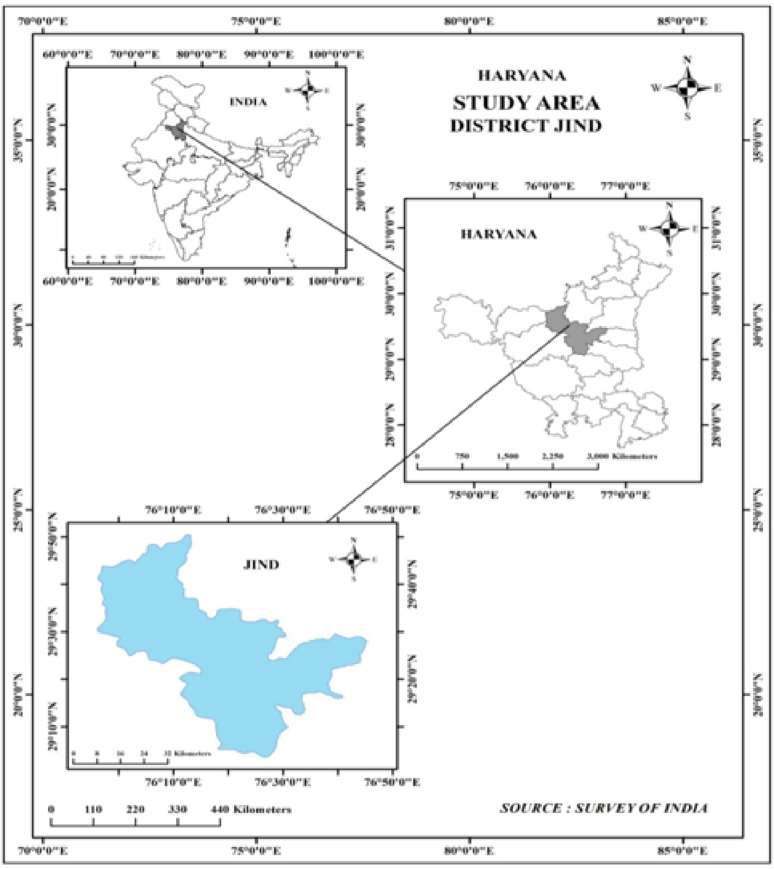
Keywords: Groundwater depletion, Jind district, Indo-Gangetic Plains, Spatiotemporal Pattern, Central Ground Water Board

1. Introduction

The planet's greatest unfrozen freshwater reserve, groundwater, is a vital but delicate resource. Groundwater provides municipal water to about half of the world's metropolitan population (Sun et al., 2025). Rising population, expansion of irrigated agriculture and rapid economic development are continuously increasing the global demand for water (Wada et al., 2008). Surface water in India is limited year-round due to climatic and geographical diversity, making groundwater an essential resource for drinking, agriculture, and other needs, especially in semi-arid regions (Gaur et al., 2024; Siebert et al., 2010). India relies heavily on groundwater, more than any other country, and this is becoming a growing concern. With a population of 1.4 billion- and a large share depending on farming for their income- shrinking water resources are starting to affect both livelihoods and food production in significant ways (Zumbish, 2024). India's food security depends on groundwater irrigation, which will probably become even more crucial in the upcoming decades as a result of climate change (Bhattarai et al., 2021). At the planning and management levels, groundwater depletion seems to be the most serious issue getting the least attention (Gahlawat, 2022). Haryana, being a predominantly agrarian state, is facing a critical groundwater crisis, with an alarming depletion rate of approximately 60.6% cm per year (Raghav & Rastogi, 2025). In light of this concern, the present study aims to analyze the long-term trends in groundwater levels in one of the agriculturally developed districts of the state, namely Jind, over the period from 2000 to 2024.

2. Study Area

Jind district is located in the central part of Haryana and forms a part of the Indo-Gangetic alluvial plains. The district covers an area of approximately 2702 square kilometers and had a population of 13,32,042 as per the Census of 2011. It is bounded by Panipat and Kaithal in the north, Hisar in the west, Rohtak in the south, and Sonipat in the east. The region is characterized by flat topography, alluvial soils, and a subtropical monsoon climate with hot summers, a wet monsoon season, and cool winters. About 80 percent of the annual rainfall occurs during the monsoon months (June to September). Agriculture is the backbone of the district's economy, with crops such as wheat, rice, and cotton dominating the agricultural landscape. Administratively, the district is divided into seven blocks: Narwana, Uchana, Alewa, Jind, Julana, Safidon, and Pillukhera.



3. Objectives

- To analyze the present status of groundwater level in the district.
- To evaluate the change in the depth of groundwater level from 2000-2024.
- To suggest the appropriate measures for the improvement of groundwater depletion.

4. Research Methodology

The study adopts a mixed-method approach integrating both qualitative and quantitative techniques. To achieve the objectives of the research, primary and secondary source of data is used. Primary data is collected from the selected blocks and villages in Jind. Secondary data was assessed from the Haryana Water Resource Atlas 2025. The temporal trend of ground water depth from 2000 to 2024, analyzed through the simple linear regression method.

The linear regression method used to analyze the annual trend in ground water table is given below:

$$Y = mx + c$$

Where m is the rate of change in ground water table and c is the Y-intercept of the line

5. Result and Discussion

5.1 Depth-wise Distribution of Groundwater Levels

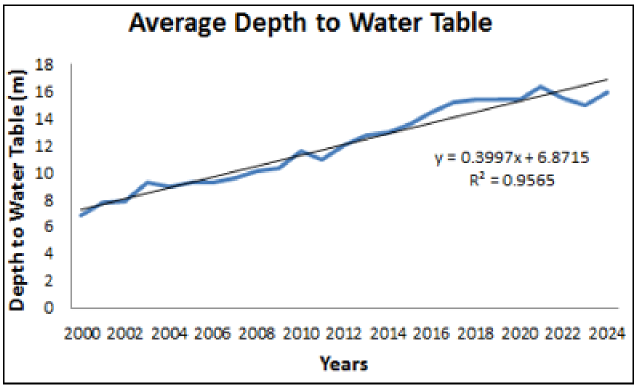
The analysis of groundwater level data for Jind district (2024) reveals significant spatial and depth-wise variations, indicating a critical groundwater situation. The data, covering 307 villages across different administrative blocks, has been categorized into various depth ranges measured in meters below ground level (mbgl).The distribution of groundwater levels shows that a majority of villages fall within deeper groundwater categories. Approximately 52 percent of villages (159 out of 307) are concentrated in the 10–30 mbgl range, indicating moderate to severe groundwater depletion. Within this category, 88 villages fall in the 10–20 mbgl range, while 71 villages fall in the 20–30 mbgl range. Furthermore, 30 villages record groundwater levels deeper than 30 mbgl, representing areas of extreme depletion where groundwater extraction becomes increasingly difficult and costly. In contrast, shallow groundwater levels are almost absent. No village falls within the 0–1.5 mbgl range, and only 7 villages are found in the 1.5–3 mbgl category. Although 57 villages fall within the 3–5 mbgl range, this proportion remains relatively small compared to deeper categories. This uneven distribution clearly indicates limited groundwater recharge and excessive withdrawal, leading to a declining water table across the district.

Blocks	Categorization	No. of Villages	No. of Villages having water table meters below ground level						
			0-1.5	1.51-3.0	3.01-5.0	5.01-10.0	10.01-20.0	20.01-30.0	>30.01
Ujhana	Over-Exploited	20	0	0	0	2	4	4	10
Jind	Over-Exploited	71	0	0	4	7	17	34	9
Julana	Safe	39	0	7	28	3	1	0	0
Uchana	Over-Exploited	46	0	0	3	6	34	2	1
Safidon	Over-Exploited	45	0	0	2	9	14	20	0
Narwana	Safe	38	0	0	13	20	5	0	0
Alewa	Over-Exploited	20	0	0	0	0	2	8	10
Pillukhera	Semi-Critical	28	0	0	7	7	11	3	0
Total		307	0	7	57	54	88	71	30

Source: Haryana Water Resources Atlas, 2025.

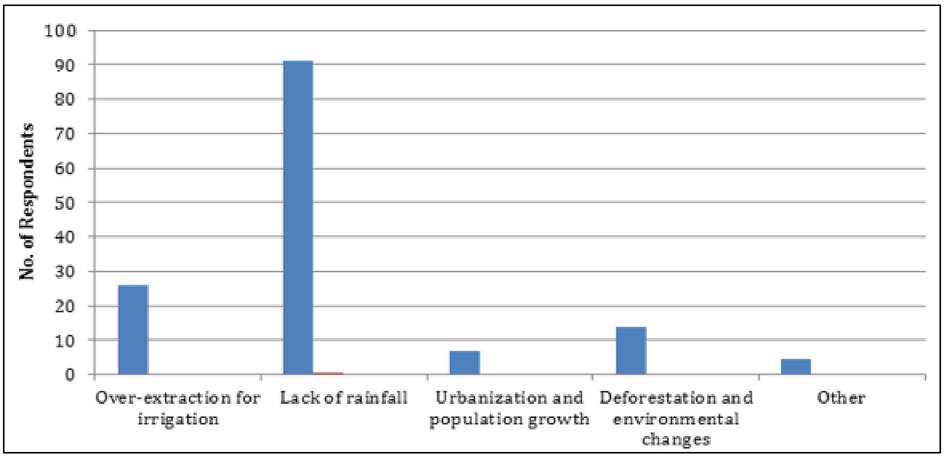
5.2 Temporal Trend in Average Depth to Water Table Pre-Monsoon 2000-2024 (m)

The temporal analysis of water table depth from 2000 to 2024 indicates a consistent increasing trend over the study period. The depth to groundwater increased from 6.84 m in 2000 to 15.92 m in 2024, reflecting a substantial decline in groundwater levels. The Simple Linear Regression analysis shows a strong linear relationship between year and water table depth, with a high coefficient of determination ($R^2 \approx 0.96$). This indicates that the variation in groundwater depth is largely explained by temporal progression. The slope of the regression line is +0.372 m/year, suggesting that the water table depth has been increasing at an average rate of approximately 0.37 meters per year (≈ 3.7 meters per decade). This steady rise highlights a continuous depletion of groundwater resources over time. Overall, the trend line demonstrates a clear and strong upward trajectory, confirming a persistent long-term decline in groundwater levels throughout the study period.



5.3 Main drivers of ground water depletion

According to the survey data, the main cause of groundwater depletion is inadequate rainfall (54%), followed by over-extraction for irrigation (18%). Urbanization and population growth contribute 10%, while deforestation and environmental changes account for just 1%. A small portion (5%) of respondents identified other causes. This reveals that both natural factors and human activities significantly influence groundwater decline.



Source: Primary survey in district Jind, 2025

5.4 Suggested Measures

5.4.1 Rainwater Harvesting and Artificial Recharge

The promotion of rainwater harvesting structures such as check dams, percolation tanks, recharge wells, and farm ponds can significantly enhance groundwater recharge. Rooftop rainwater harvesting should be made mandatory in both rural and urban areas. Additionally, restoration of traditional water bodies like village ponds can improve local hydrological balance.

5.4.2 Crop Diversification

A shift from water-intensive crops such as paddy and sugarcane to less water-consuming crops like millets, pulses, and oilseeds is essential. Crop diversification not only reduces groundwater extraction but also improves soil health and agricultural sustainability.

5.4.3 Efficient Irrigation Techniques

The adoption of modern irrigation methods, including drip and sprinkler systems, can reduce water wastage.

Techniques such as laser land leveling and scientific irrigation scheduling based on soil moisture conditions can further enhance water use efficiency.

5.4.4 Regulation of Groundwater Extraction

Strict enforcement of groundwater regulations is necessary to control over-extraction. Measures such as registration of tube wells, installation of water meters, and monitoring of groundwater use can help in maintaining sustainable withdrawal levels.

5.4.5 Wastewater Reuse and Recycling

Treated wastewater can be utilized for irrigation and industrial purposes, thereby reducing the demand for freshwater. Establishment of sewage treatment plants (STPs) in urban areas of the district can support this initiative.

5.4.6 Strengthening Canal Irrigation System

Improvement and expansion of canal irrigation infrastructure can reduce reliance on groundwater. Ensuring equitable and efficient distribution of canal water is crucial for balanced water resource utilization.

5.4.7 Awareness and Community Participation

Educating farmers and local communities about water conservation practices is vital. Active involvement of Panchayati Raj institutions and local stakeholders can promote sustainable groundwater management practices.

5.4.8 Technological Interventions

The use of remote sensing and Geographic Information Systems (GIS) can help in monitoring groundwater levels and identifying recharge zones. Smart irrigation technologies and real-time data systems can support efficient water management.

6. Conclusion

The study clearly demonstrates that groundwater depletion in Jind district is a severe and persistent problem. Despite seasonal fluctuations and occasional recharge, the overall trend indicates a continuous decline in groundwater levels. The combined impact of agricultural practices, policy factors, and climatic variability has created an unsustainable situation. Immediate and coordinated efforts are required to manage groundwater resources effectively and ensure long-term sustainability.

References

[1] Bhattarai, N., Pollack, A., Lobell, D. B., Fishman, R., Singh, B., Dar, A., & Jain, M. (2021). The impact of groundwater depletion on agricultural production in India. *Environmental Research Letters*, *16*(8), 085003.

[2] Gahlawat, A. (2022). A Study of groundwater depletion and its impact on agriculture in Eastern Haryana. *International Journal of Geography Geology and Environment*, *4*(1), 141–144. https://doi.org/10.22271/27067483.2022.v4.i1b.99

[3] Gaur, S., Kumar, P., & Sangwan, V. (2024). Assessment of Spatial and Temporal Dynamics of Groundwater in Bhiwani District, Haryana - A Decadal Analysis. In *The Deccan Geographer* (Vol. 62, Issue 4, pp. 144–152).

[4] Raghav, B. S., & Rastogi, A. G. (2025). Status of Groundwater Table in Haryana State of India and its Implications for Sustainability of Agriculture. *Environment and Ecology*, *43*(4), 1090-1098.

[5] Siebert, S., Burke, J., Faures, J. M., Frenken, K., Hoogeveen, J., Döll, P., & Portmann, F. T. (2010). Groundwater use for irrigation–a global inventory. *Hydrology and earth system sciences*, *14*(10), 1863-1880.

[6] Sun, S., Liu, H., Konar, M., Fu, G., Fang, C., Huang, Z., ... & Tang, Q. (2025). Urban groundwater supplies facing dual pressures of depletion and contamination in China. *Proceedings of the National Academy of Sciences*, *122*(8), e2412338122.

[7] Wada, Y., Van Beek, L. P., Van Kempen, C. M., Reckman, J. W., Vasak, S., & Bierkens, M. F. (2010). Global depletion of groundwater resources. *Geophysical research letters*, *37*(20).

[8] Zumbish. (2024, April 24). India will be losing groundwater three times faster in 2041-2080, finds study. *Down to Earth*. https://www.downtoearth.org.in/water/india-will-be-losing-groundwater-three-times-faster-in-2041-2080-finds-study-91503