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Research Article

Study of Spatial Variability of Groundwater Depth in Sirsa District of Western Agro Climatic Zone of Haryana

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ABSTRACT

Groundwater plays a vital role in agriculture and industry in various sectors across India, especially in Haryana's Sirsa district, where groundwater plays a vital role. Approximately 50% of the irrigated land is dependent on groundwater, while 60% of the food production is dependent on groundwater. The depletion of groundwater in Haryana is a major concern due to population growth and increasing water demand, which is further aggravated by water-intensive crops. Even though Haryana accounts for 1.4 % of the country's geographical area, food production in Haryana contributes significantly to the nation's GDP. The study concentrates on Haryana, where groundwater plays a key role, especially in the Sirsa district, where the availability of surface water is limited. From 1974 to 2022, there is a worrying trend of decreasing groundwater levels in the Sirsa district in four blocks, which is mainly attributed to unregulated groundwater extraction, especially for agriculture, which results in ecological damage. Sustainable water management strategies need to be implemented in order to mitigate groundwater depletion and ensure long-term agri-sustainability and water security in Haryana. These strategies include changing cropping patterns, awareness campaigns, conjunctive water use, rainwater harvesting, and minimizing conveyance and application losses. By taking these steps, we have a chance to reduce groundwater depletion and ensure long-term agri-sustainability and overall water.

Keywords: *Groundwater, fluctuation, groundwater decline, groundwater recharge, management strategies.*

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INTRODUCTION

Groundwater is an important water source in many parts of India. Approximately 50% of the total irrigated area depends on groundwater, and about 60% of irrigated food production depends on irrigation from groundwater wells (Dangar et al., 2021). We know the importance of groundwater, and we also know that humans are entirely dependent on it. Domestic and public water supplies in rural and urban areas rely on wells and groundwater. Farmers also use groundwater to irrigate crops and animals (Singha & Sitchler, 2022). Industry and commerce also rely on groundwater for their processes and procedures. Other industries rely on groundwater to produce electricity, food, beverages, paper, and materials. Due to increased population density, water consumption from the ground is increased, and pressure on it also increases, leading to a decrease in groundwater level (Simlandy, 2015). This has resulted in declining groundwater levels/water tables in various parts of the country. One of the major causes of the decline in groundwater tables is the introduction of water-intensive crops such as paddy and sugarcane into the cropping pattern in certain regions (Shankar et al., 2011). Intensive withdrawals of groundwater in excess of natural recharge over the years have affected the environment, causing a continuous fluctuation in water table levels. More than half of the world's population depends on groundwater for survival (Omvir & Sharma, 2010). Water storage is a serious problem in many parts of India, including the semi-arid region of Southern Haryana. The usable groundwater resource is a dynamic resource that is recharged annually and periodically from rainfall, irrigation returns flow, canal seepage, influent seepage, etc. (Chatterjee et al., 2009).

Over the past few decades, Haryana, situated in the northwestern part of India, has witnessed a significant surge in the utilization of groundwater for agricultural purposes (Bhalla, 2007; Hira, 2009). Despite encompassing only 1.4% of the country's geographical area and 2.5% of its cultivated land, Haryana currently contributes 6.9% of India's total food production (Anonymous, 2012). The Sirsa district, located in the western agro-climatic zone of Haryana, relies heavily on agriculture for its economy. This region's inadequate rainfall and limited canal infrastructure restrict surface water availability, leading to negligible water conservation practices. The annual net recharge of groundwater in this area is considerably lower than its discharge, emphasizing the critical importance of maintaining a substantial groundwater supply. Due to the natural physiography, high population density, and intensive agricultural activities, the groundwater levels in the Sirsa district are at a high risk. Therefore, this study aims to examine the spatial and temporal variations in groundwater levels from 1974 to 2022, providing insights into the characteristics of the groundwater system. The goal is to facilitate efficient utilization of this resource, ensuring long-term sustainability in agriculture and contributing to the food security of the state and the country.

STUDY AREA

Sirsa district is located between the latitudes of 29°14' N to 30°0' N and the longitudes of 74°27' E to 75°18' E, covering an area of 4264.19 km^2, which is 9.7% of the state area. The average annual rainfall in the district is 367.4 mm. The rainfall in the district generally increases from west to east. The average number of rainy days is 20. The terrain of Sirsa district may be broadly classified from north to south into three major types, *i.e.* Haryana plain, alluvial bed of Ghaggar or Nali and dune tract, whereas Haryana plain covers over 65 per cent of the area of the district (Anonymous, 2023d). The location map of the Sirsa district of the western agro-climatic zone of Haryana, India, is shown in Fig. 1.

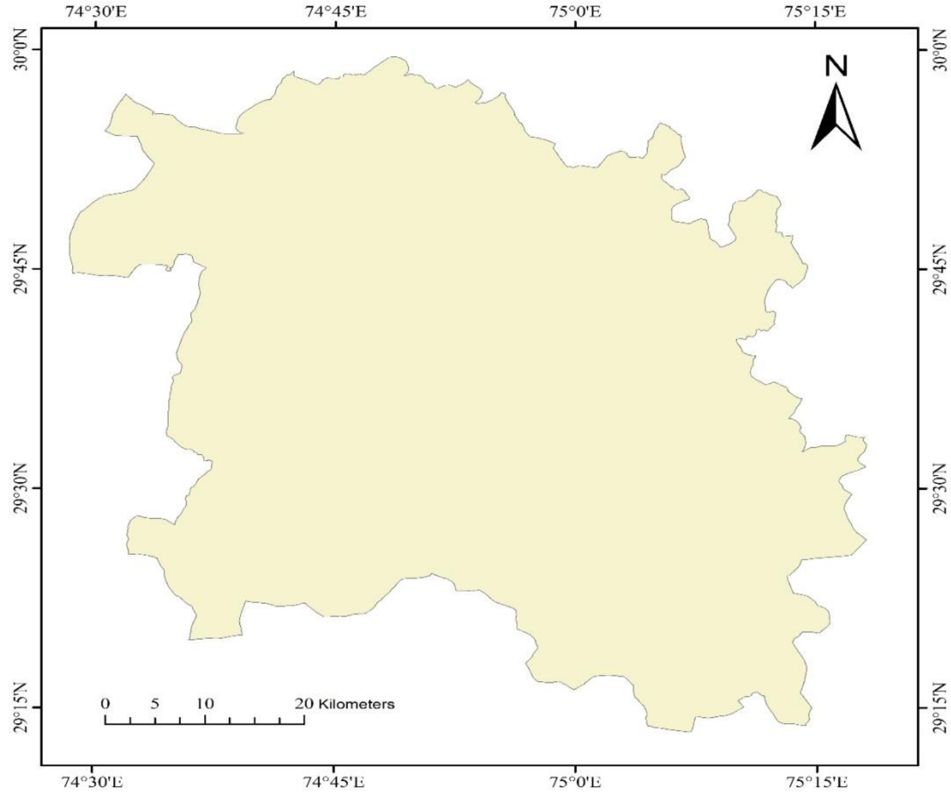


Fig. 1: Location map of Sirsa district of the western agro-climatic zone of Haryana, India

MATERIALS AND METHODS

Data collection:

This study was conducted based on secondary groundwater data procured from 1974 to 2022. Location-wise groundwater level data for the period 1974 to 2022 was obtained from the regular monitoring of observation wells by the Groundwater Cell Section, Department of Irrigation and Water Resources, Government of Haryana. The data was analyzed and interpreted to examine the trend, fluctuation, and dynamics of groundwater levels.

Preparation of thematic maps

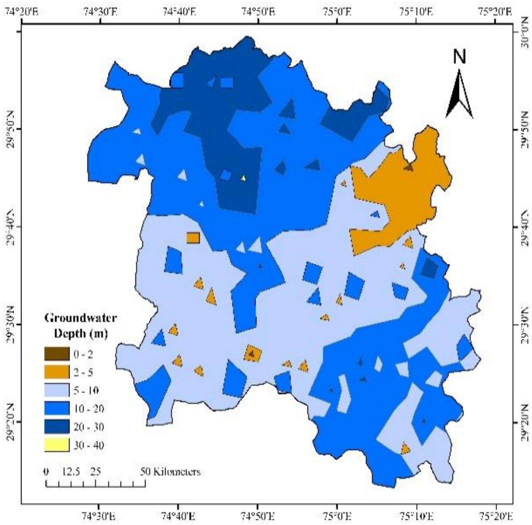
A thematic map is a map that portrays the geographic pattern of a particular subject matter (groundwater depth in this case) in a geographic area. It involves using map symbols to visualize selected properties of geographic features that are not naturally visible. The groundwater depth of observation wells obtained from the Groundwater Cell was used in the GIS interface. The spatial distribution maps were prepared for groundwater depth at the intervals of 10 years, *i.e.* 1974, 1984, 1994, 2004, 2014 and 2022. Groundwater depth fluctuation maps were also prepared to compare water table depth at 10, 20, 30, 40 and 49-year intervals with reference to groundwater depth of 1974 as a base year. The maps were prepared using the IDW (Inverse Distance Weightage) technique of interpolating the Spatial Analyst Tool in ArcGIS. Then, the maps were analyzed to examine the rise or fall of the water table in the region and to delineate over-exploited and critical areas.

RESULTS AND DISCUSSION

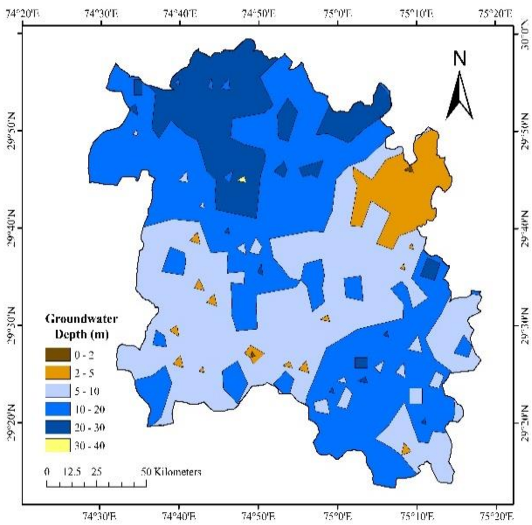
Spatial variations of groundwater depth for the period 1974-2022

The spatial distribution map of groundwater depth at a 10-year interval for Sirsa district of western agro-climatic zone of Haryana for the period 1974-2022 was prepared in ArcGIS and is shown in Fig. 2. Comparing maps of the years 1974, 1984, 1994, 2004, 2014, and 2022, it is observed that the majority of the study area showed a decline in groundwater levels over the years.

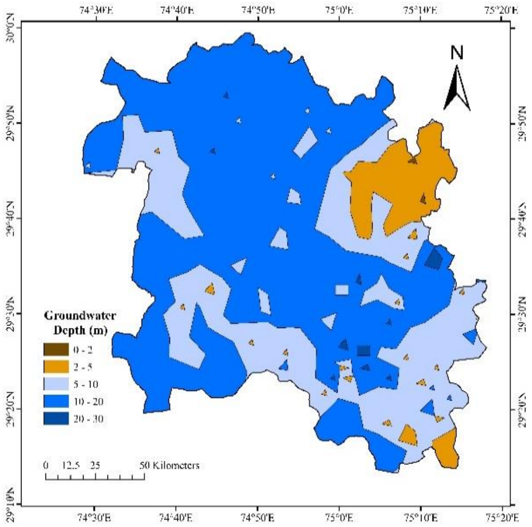
Analysis of the area under different groundwater depths in the study area revealed that there was no area under the 0-2 m range in 2022. The area in 2-5 m decreased from 6.56% in 1974 to 1.77% in 2022. The 5-10 m depth range area fluctuated but decreased from 1974 to 2022. It declined from 39.14% in 1974 to 8.28% in 2022. This decline reveals the possibility of shifting groundwater towards deeper and shallower aquifers. However, 10-20 m depth range also showed an increase in area, from 42.71% in 1974 to 47.50% in 2022. This reflects that a larger portion of the study area now relies on shallow groundwater, possibly due to increased agricultural water demand or changes in land use patterns. The percentage of area under deeper depth, *i.e.*, 20-30 m range, is also increased from 11.53% in 1974 to 13.77% in 2022. There is an interesting increase from 0.01% in 1974 to 16.50% in 2022 in the 30-40 m depth range. This could be influenced by factors such as irrigation practices and land development. However, the area under groundwater depths, *i.e.*, 40-60, 60-80 and 80-100 m, were 11.36, 0.79 and 0.03%, respectively, in the year 2022, whereas in 1974, there were no areas under these depths.



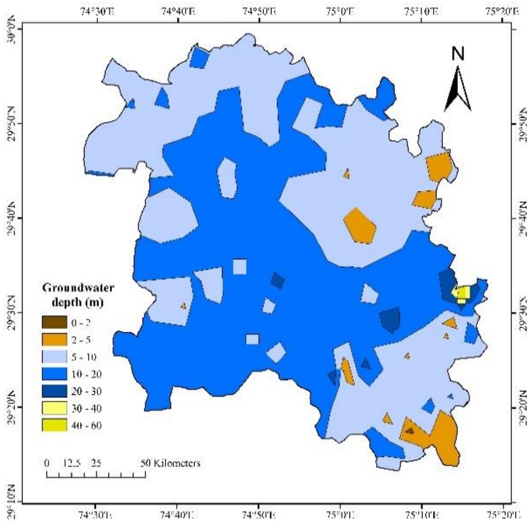
1974



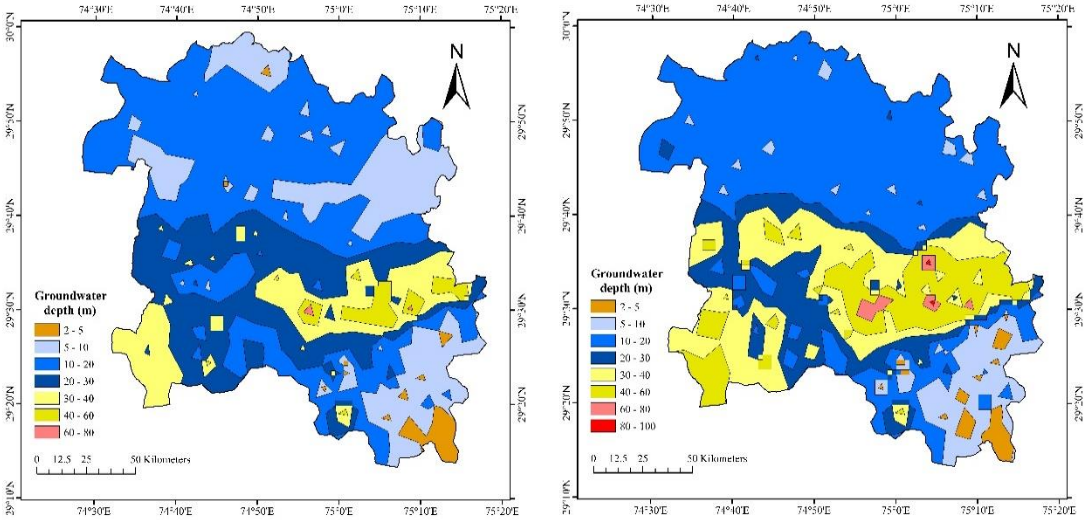
1984



1994



2004



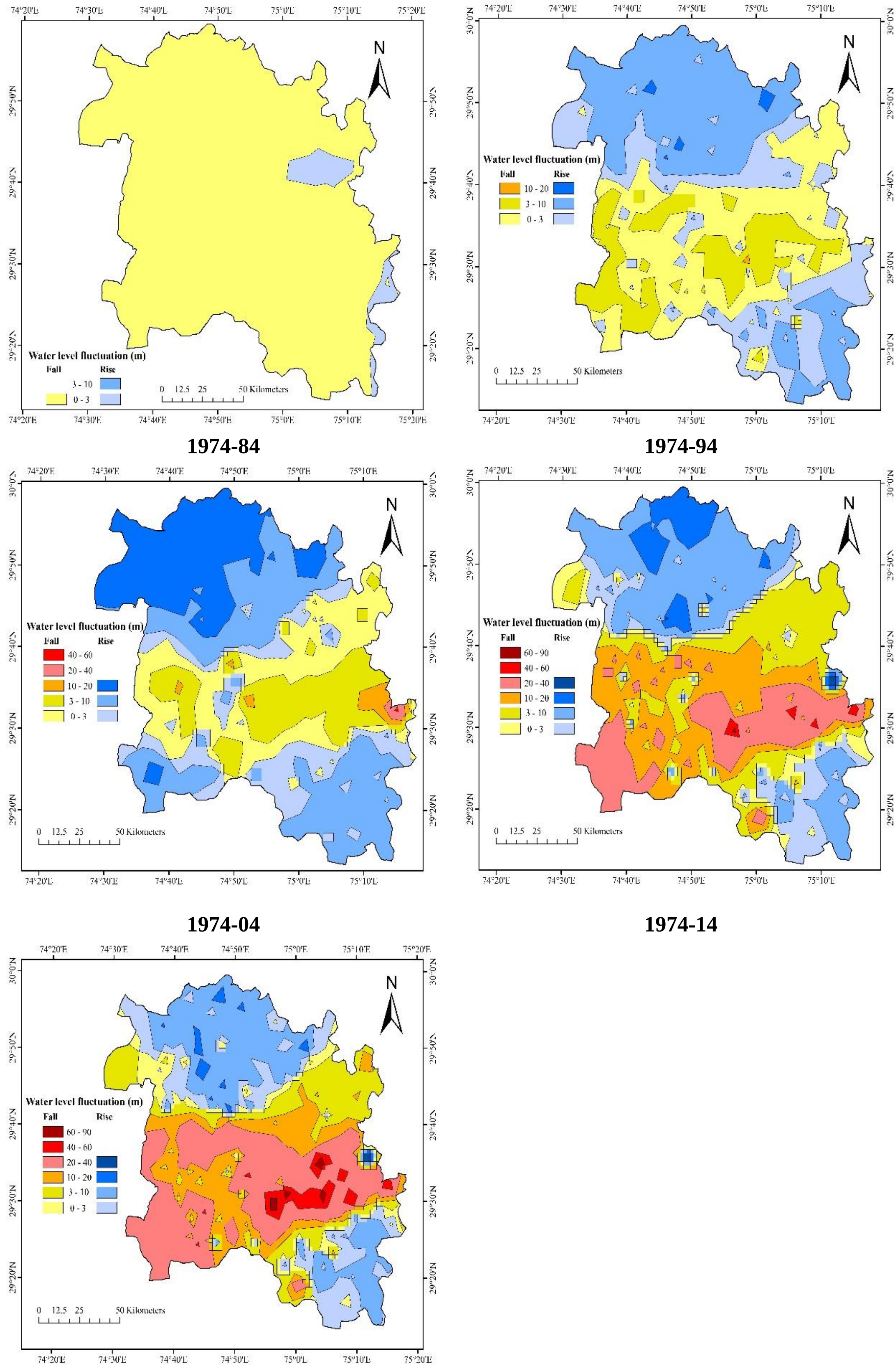
2014 **2022**

Fig. 2: Spatial distribution of groundwater depth in Sirsa district of the western agro-climatic zone of Haryana for the period 1974-2022

This shows an emerging dependence on even deeper groundwater sources, possibly due to the diminishing availability of shallower resources. In 1974, the maximum area lied under 10-20 m depth (42.71%), whereas in 2022, the maximum area also lied under 10-20 m groundwater depth (47.50%).

Spatial and temporal variations of groundwater fluctuations in Sirsa district

To visualize the spatial variation of groundwater fluctuation at 10, 20, 30, 40, 49 year interval, fluctuation maps were prepared by using the groundwater level data at the village level, as shown in Fig. 3. For declining trend, it reveals that the maximum (26.51%) and minimum area (0.34%) lies in the range of 20-40 m and 60-90 m fluctuation, respectively, whereas in a rising trend, the maximum (22.07%) and minimum (0.08%) area lies in the range of 3-10 m and 20-40 m fluctuation, respectively. Overall, 64% area to the total lies in a falling trend, while the remaining area, *i.e.*, 36%, lies in a rising trend, which reveals that the maximum area for groundwater levels in the Sirsa district of the western agro-climatic zone of Haryana is under the declining trend from 1974-2022. For blockwise average groundwater fluctuation (Fig. 4), the depth of water table declined in four blocks (*i.e.*, Baragudha, Ellanabad, Sirsa, Raina) of the districts for the year 2022. The maximum and minimum rise in groundwater levels were observed in Dabwali block (9.19 m) during the period 1974-2004 and Nathushri Chopta block (0.97 m) during the period 1974-2014, respectively, while the maximum and minimum decline in groundwater levels were observed in Sirsa block (40.25 m) during the period 1974-2022 and Baragudha block (0.16 m) during the period 1974-1994, respectively. Negative fluctuation was observed in Dabwali, Nathushri and Odhan blocks till 1984; after that, positive fluctuation was recorded in these blocks.



1974-84 **1974-94**

1974-04 **1974-14**

1974-22

Fig. 3: Groundwater level fluctuation in Sirsa district of the western agro-climatic zone of Haryana

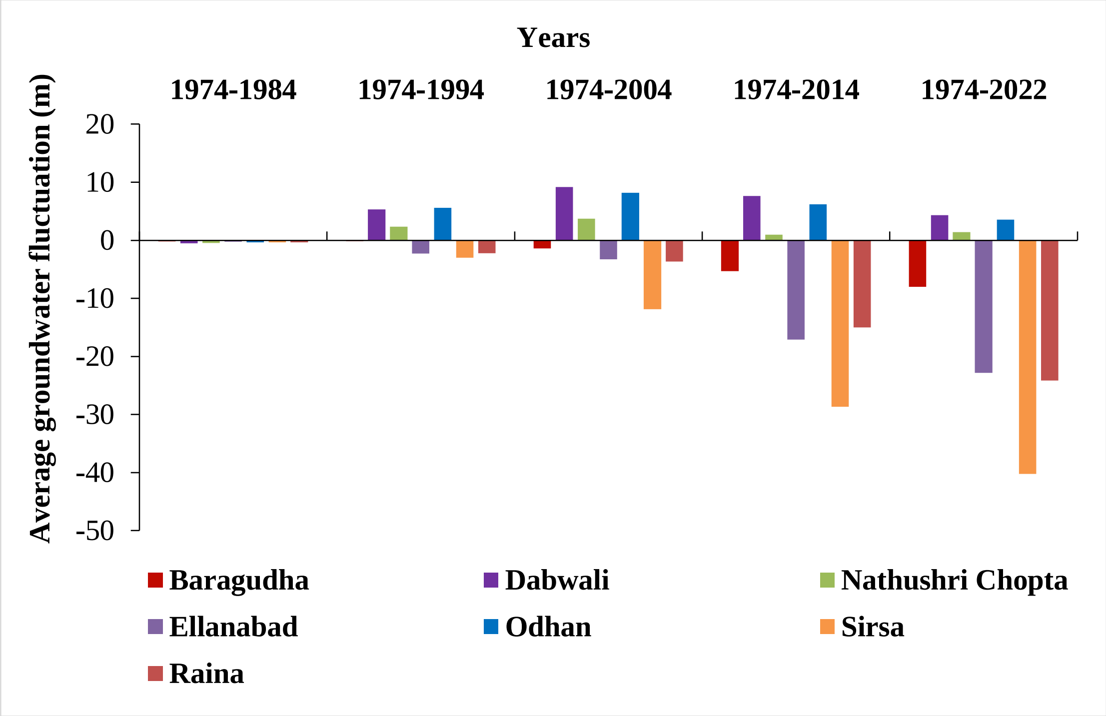


Fig. 4: Blockwise average groundwater fluctuation for Sirsa district of the western agro-climatic zone of Haryana for the period 1974-2022

CONCLUSION

The development plan for a region should be well-balanced, ensuring equilibrium between water withdrawal and replenishment. To formulate an effective plan, a thorough evaluation of long-term changes in the depth to the water table and the magnitude and rate of depletion is crucial. This study focuses on the assessment of these parameters in Sirsa district, located in the western agro-climatic zone of Haryana, covering the period from 1974 to 2022. The depth of the water table has shown a decline in the district's four blocks (Baragudha, Ellanabad, Sirsa, Raina) in the year 2022. Notably, 64% of the total area is experiencing a decreasing trend, while the remaining 36% is witnessing an increasing trend. This indicates that a significant portion of the groundwater levels in Sirsa district have been on a declining trend over the 1974-2022 period. Generally, water levels in the district are deeper. The reduction in the depth to the water table is directly linked to changes in the volume of groundwater storage and the magnitude of depletion. Besides depletion concerns, the escalating demand for water and competition among various industries necessitate implementing integrated management strategies. Irrigation and agricultural practices are identified as key components of an ecological strategy. Unfortunately, farmers have been extracting groundwater in an unsystematic manner due to limited surface water availability, resulting in ecological system degradation. To address this challenge, several solutions are proposed: (i) shifting cropping patterns, (ii) raising awareness about water-efficient practices, (iii) adopting conjunctive water use, (iv) implementing rainwater harvesting and artificial recharge, (v) reducing conveyance losses, (vi) minimizing application losses, and (vii) optimizing water resource distribution. Implementing these techniques may, to some extent, mitigate groundwater depletion in the region.

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Conflict of Interest:
There is no such evidence of conflict of interest.

Author Contribution

All authors have participated in critically revising of the entire manuscript and approval of the final manuscript.

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